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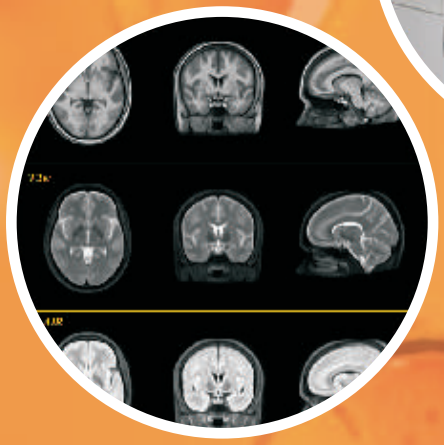
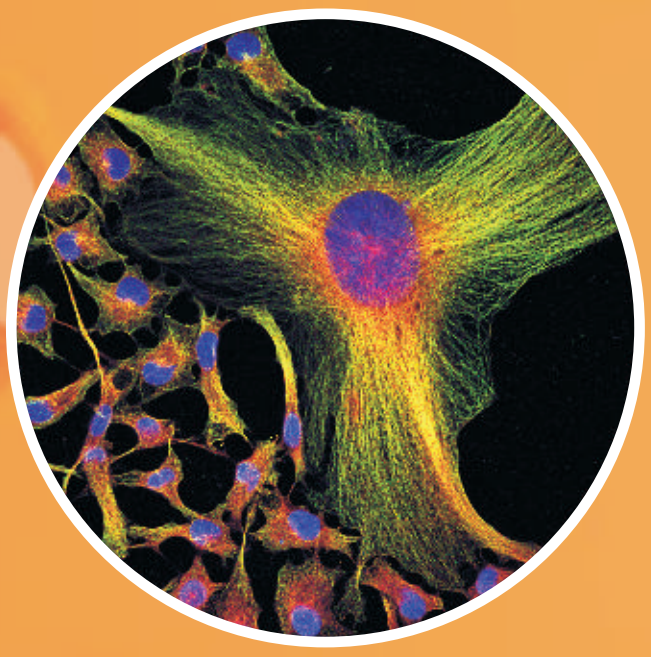
Annual Report

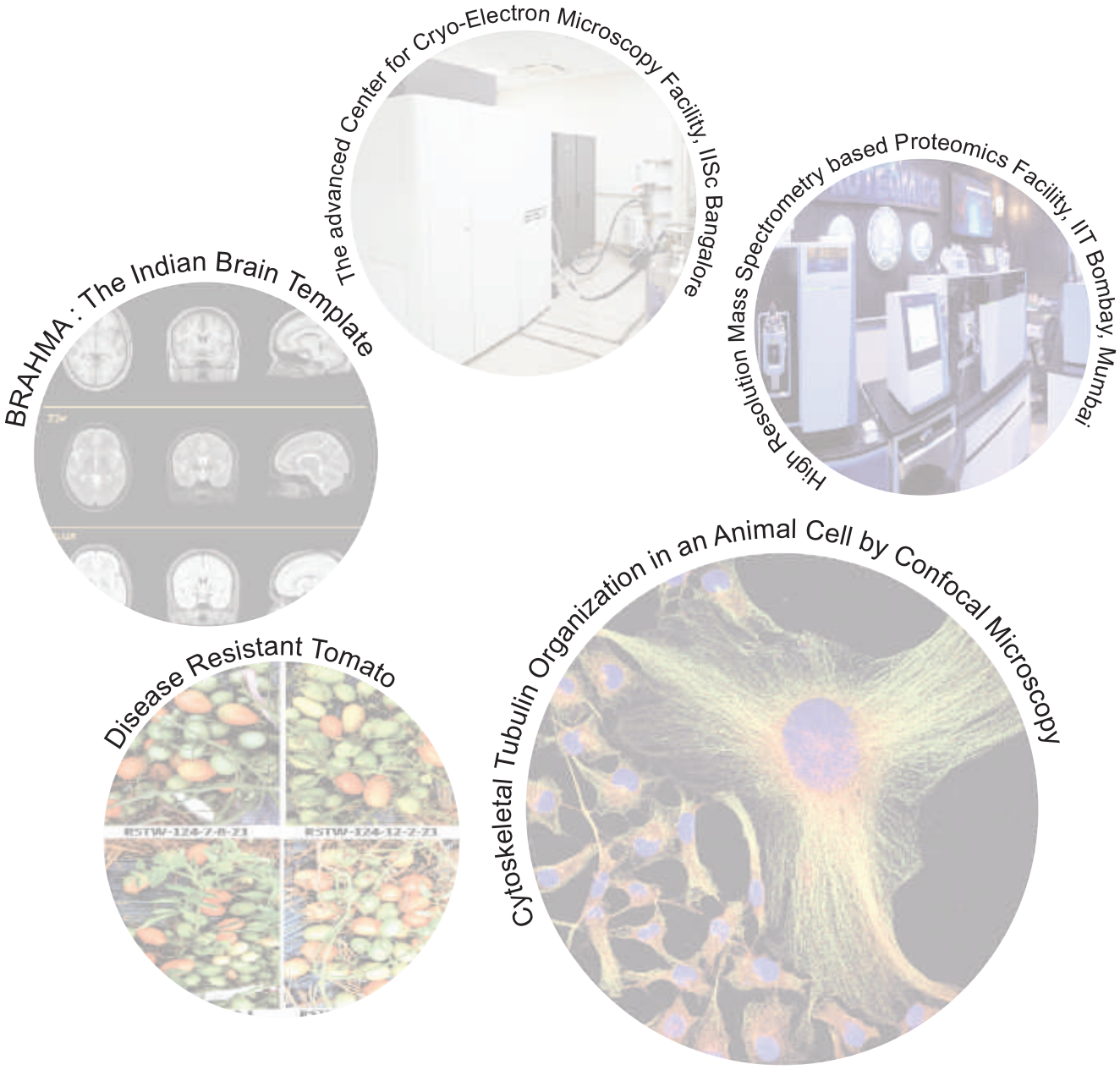
2019-2020





Department of Biotechnology

Ministry of Science & Technology
Government of India



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ANNUAL REPORT

2019-2020

Department of Biotechnology

Ministry of Science & Technology

Government of India

Contents

01

OVERVIEW

The Department of Biotechnology (DBT) set up more than three decades ago under the aegis of Ministry of Science and Technology has been instrumental in creating a strong foundation for Biotechnology sector to contribute towards nation building. Department has been committed towards creation of policy framework, promotion of excellence and innovation, support discovery research, fundamental and applied research in areas of agriculture, affordable healthcare & medical biotechnology, animal and aquatic sciences, environmental safety, new generation bio-fuels, nutritional security besides, impetus is also on taking the fruits of biotechnology to the community at a large. To drive these niche area programs there is a need to have skilled manpower at various levels. Department is committed towards capacity building and nurturing talent by supporting various programmes. These efforts are furthered both at national and international level, through high quality research and translational activities of the 16 Autonomous Institutes each having a specific mandate. Support was imparted for carrying research & development in dedicated mandated areas in these institutes which are spread across the country. Focus has also been on supporting and nurturing start up ecosystem and entrepreneurship in multidisciplinary areas of Biotechnology through its various schemes and programmes across the country.

The major achievement in terms of project supported, publications, patents and technologies generated in 2019-20

Publications	2568
Patents Granted	44
Patents Filed	68
Technologies Developed	59
Technologies Transferred	13
Products/Technologies Commercialized	27
Projects Supported under various schemes and Programs	3260

Building Capacities: Human Resource Development, Training and Workshops, Infrastructure & Biotechnology Science Clusters

In order to build and nurture a strong research ecosystem, there is a need for creating right kind of manpower with requisite skill set. Hence, impetus has been on supporting various schemes under Human Resource Development Programme which include postgraduate teaching programme, star college scheme for strengthening of undergraduate science education, short term training courses for upgrading the skill of mid-career scientists and UG & PG teachers engaged in teaching and R&D, skill vigyan programme for imparting skill based training to young students, biotech industrial training programme for apprenticeship.

- ***Star College Scheme***: During the year colleges which showed potential towards excellence were supported both under rural and urban category. 159 Colleges supported under Star College Scheme for strengthening undergraduate science education.
- ***PG Programs***: 72 Postgraduate Teaching Courses supported in various disciplines across the country in universities/institutions to impart quality education.
- ***BITP*** : Department of Biotechnology is supporting Biotech Industrial Training Programme (BITTP) for providing hands-on training for six months to fresh graduate and post graduate Biotechnology students. This year the Department has adopted apprenticeship modal for implementation of this programme. Linkages have been developed with Life Science Sector Skill Developemnet Council (LSSSDC), New Delhi for selection of partnering industries for providing apprenticeship in Biotechnology sectors. Based on the specific training imparted to students it helps Biotech Industry to select students for specific job roles.
- ***Skill Vigyan Program***: Department initiated skill vigyan program with an objective to provide hands-on-training in tools and techniques in Biotechnology and allied areas to generate skilled manpower. This program has been designed for providing skill training under four categories in partnership with State Science and Technology Councils of respective states. Efforts are being made to partner with all states and UTs to implement the Skill Vigyan programme across the country. Department is also supporting the Biotechnology Finishing School Programme.
- ***National Fellowships and Awards***: To nurture the talent, various fellowships and awards were given to deserving candidates for doctoral and post-doctoral research in frontier areas of biotechnology and life

sciences; 960 Fellows supported under DBT-JRF Program for Doctoral Research, 185 Post-Doctoral Fellows supported under DBT-RA Programme; Career advancement and reorientation for women scientists (BioCare); Under DBT BRITE Awards, 15 young scientists were selected for Har Gobind Khorana Innovative Young Biotechnologist Award (IYBA) awards, 10 mid-career scientists for S Ramachandran National Bioscience Award for Career Development, 5 senior scientists for Tata Innovation Awards etc. 3 women scientists were awarded, one in senior category and two in junior category.

Awards for recognizing the contribution of Researchers in Biotechnology in 2019-20

Har Gobind Khorana-Innovative Young Biotechnologist Award	15
S. Ramachandran-National Bioscience Award for Career Development	10
Janaki Ammal-National Women Bioscientist Award, Senior : 1, Junior : 2.	3
Biotech Product, Process Development and Commercialization Award	5
B-ACER	11

- ***International Fellowships and Awards***: Department lays strong impetus on giving wider exposure to young students and scientists at international platform, Khorana internship program supported 49 students for summer internship in various institutions across US. Under Newton-Bhabha Placement Programme for short term training of PhD students outside the country, 34 students were selected to work at different institutions in UK, under the Bharat Boston Bioscience Beginning (B4), Department is generating critical mass of trained and skilled manpower required for overall development and growth of Biotechnology in the country. Under DBT-TWAS Fellowship, 47 students and postdocs were supported from third world countries to carry out their PhD and postdoctoral research at Indian institutions across the country.
- ***Indo-US Genome Engineering/ Editing Technologies Initiative (GETin) Program:*** This 'Indo-U.S. Genome Engineering/Editing Technologies Initiative (GETin) overseas fellowship provides opportunity to Indian students and scientists to get trained at leading US institutions, in the frontline area of Genome Engineering/Editing. So far under the program 10 PhD student interns, 9 postdoctoral Fellows & 2 visiting Fellows have been selected for being fostered and trained in U.S. labs.
- ***Revesrse Brain Drain (Brain Gain):*** Ramalingaswami Re-entry Fellowship Programme continued to bring best Indian scientists working abroad to pursue their research interests in life sciences, biotechnology and other related areas in India; 63 fellows were selected. DBT-Wellcome Trust Fellowship was provided to 35 talented scientists in various cutting edge research areas under biomedical research.
- Researchers and scientists/Faculty was also supported for organizing conference/symposium/seminar, travel support to the young researchers for presenting their research work outside the country. 5 foldscope workshops covering 53 aspirational districts in 12 states were supported about, 300 teachers and > 2000 students were trained.

Glimpses of Foldscope workshops organized for aspirational districts by DBT

- 3rd Nobel Prize Series India, 2019 was organized at Mohali in September, 2019 and 2500 students and research scholars as well as 900 odd teachers and young faculties participated.

Public lecture by Prof. Serge Haroche Nobel laureate 2012, Physics during 3rd Nobel Prize series 2019

Human Resource Development Programmes supported during the year

- 72 Postgraduate Teaching Courses supported
- 159 Colleges supported under Star College Scheme for strengthening of Undergraduate science education
- 7 new infrastructure facilities for R&D and capacity building created
- Six State S&T Councils supported under Skill Vigyan DBT-State Partnership
- 960 Fellows supported under DBT-JRF Program for Doctoral Research
- 185 Post-Doctoral Fellows supported under DBT-RA Programme
- 35 Fellows awarded DBT-Wellcome Trust Fellowship
- 47 fellowship awarded under DBT-TWAS Fellowship Programme
- 49 UG & PG Students supported under Khorana Programme for Scholars
- 34 PhD Students selected for short term training in UK under Newton Bhabha PhD placement Programme.
- Supported 5 Foldscope workshops covering 53 aspirational districts in 12 states, trained about 300 teachers and > 2000 students
- Organized 3rd Nobel Prize Series India 2019 and 2500 students and research scholars as well as 900 odd teachers and young faculty participated
- 63 Fellows selected, 43 joined and 40 absorbed as regular faculty under Ramalingaswami Re-entry Fellowship Programme.

- **Building a vibrant Ecosystem for connecting University Research and Industry**

  The Department of Biotechnology has made an enormous effort towards establishing and creating research related infrastructural facilities (National

Facilities) at several universities/institutions across India during the year through its two schemes DBT-Boost to University Interdisciplinary Life Science Departments for Education and Research Programme (DBT-BUILDER) and DBT - Scientific Infrastructure Access for Harnessing Academia University Research Joint Collaboration, (DBT-SAHAJ). Some of the significant achievements under the infrastructure development for connecting university research and industry so far include Life Time Imaging Facility at RGCB, Thiruvananthapuram; Central Molecular Laboratory for diagnosis, prognosis and treatment of various disorders at Govind Ballabh Pant Institute of Postgraduate Medical Education and Research (GIPMER), New Delhi; Biophysical Characterization Facility at Institute of Life Sciences (ILS), Bhubaneswar and National Institute of Science Education and Research (NISER), Bhubaneswar; High Resolution Mass Spectrometry based Proteomics Research and Training Facility at IIT, Bombay; Advanced Centre for Cryo-electron microscopy at the IISc, Bangalore; Advanced Research Platform for Crop Sciences (ARPCS) at the NIPGR, New Delhi and Advanced Research and Education in Diagnostics at IIT Bombay established.

Infrastructure – Major Facilities Created and Supported

Location	Institute	Facility
New initiatives during this year		
Thiruvananthapuram, Kerala	Rajiv Gandhi Centre for Biotechnology	Fast Life Time Imaging Facility
New Delhi	Govind Ballabh Pant Institute of Postgraduate Medical Education and Research (GIPMER)	Central Molecular Laboratory
Bhubaneswar, Odisha	Institute of Life Sciences (ILS), and National Institute of Science Education and Research (NISER)	Bioactive Biophysical Characterization Facility
Ongoing facilities supported during this year		
Mumbai, Maharashtra	Indian Institute of Technology , Bombay	High Resolution Mass Spectrometry based Proteomics Research and Training Facility
Mumbai, Maharashtra	Indian Institute of Technology , Bombay	Infrastructure Facility for Advanced Research and Education in Diagnostics
Bangalore, Karnataka	Indian Institute of Science (IISc)	Advanced Centre for Cryo-electron microscopy
New Delhi	National Institute of Plant Genome Research (NIPGR)	Advanced Research Platform for Crop Sciences (ARPCS)
Haryana	RCB, Faridabad	Access to Macromolecular crystallography beamlines at European Synchrotron Radiation Facility (ESRF) Grenoble, France

Research and Development, Demonstration and Translational activities

The impetus of the Department has been always on supporting basic fundamental research along with addressing hard pressing research questions under various cutting edge research areas. These include Agriculture and Allied areas; Health Care & Medical Biotechnology; Bioenergy, Bioresources & Environment; Bioinformatics & Computational Biology; Nanotechnology etc.

New initiatives:

- Pan India network Project "Genome India" has been launched for cataloguing the genetic variation in Indian population. The aim is to start with and execute whole genome sequencing and subsequent data analysis of 10,000 individuals representing the country's diverse population. 20 national institutions in the country are collaborating in this project. This will help build an exhaustive catalogue of genetic variations in the Indian population and aid in the designing of a genome wide association chip for Indian population which will facilitate further large-scale genetic studies in a cost-effective manner.
- The Unique Methods of Management of Inherited Disorders Program (UMMID) was launched and NIDAN Kendras were set up in Government hospitals in four States for comprehensive clinical care including diagnosis, management, multidisciplinary care, counseling, prenatal testing in new born babies.
- Department launched an ambitious Mission Program on Antimicrobial Resistance with the vision to develop indigenous and cost-effective therapies against AMR.
- The DBT jointly with ICMR and CDSCO has formulated the guidelines for evaluation of nanopharmaceuticals in the country.
- Initiated programme on applications of Artificial Intelligence (AI) for affordable and accessible Healthcare - Big Data and Genomics in areas of cancer, tuberculosis and pulmonary diseases, diabetic & cardiovascular diseases, ophthalmological diseases, neurological disorders and methods/ drug development.
- DBT initiated focused programme on Turmeric with an aim to generate high-quality raw material for developing nutraceutical products / dietary supplements from turmeric for global market and develop curcumin and curcuminoids-based therapeutic drugs.

Support also continued on International Collaboration; Entrepreneurship Development; Special Programs, Northeastern Regions, Autonomous Institutes etc.

Agriculture and Allied Areas: The focus has been on knowledge generation, development of new crop varieties for increase in crop productivity, resistance to biotic and abiotic stress, improve nutritional quality etc. During the year, new initiatives taken are as follows:

- Department has established National Genomics and Genotyping facilities at NIPGR, New Delhi for genotyping plant resources in public private partnership (PPP) mode.
- Twelve rice varieties were targeted for improved tolerance to biotic and abiotic stresses and 249 advanced multiple QTL introgressed breeding lines were developed through marker assisted selection.
- Improved variety (DBG 4) of groundnut with high oil quality and productivity developed at UAS, Dharwad has completed two years of multi-location trials. A simple and cost effective method for evaluation of cold-tolerance in chickpea based on pod development at lower temperature was developed by CSK-HPKV Palampur.
- Department has initiated a major network program on characterization, evaluation, genetic enhancement and generation of genomic resources for accelerated utilization and improvement of major crops including pulses. Besides, a network on Pathogenomics of Plant Viruses has also been initiated.

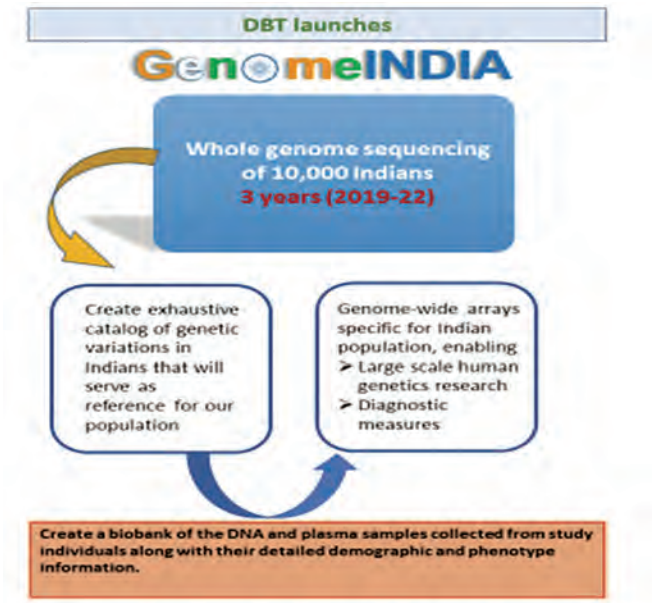
Livestock Genomics: Under Animal Biotechnology Cattle Genomics program has been initiated with an aim to develop high density and low density SNP chips. Highly segregating SNPs will be selected for developing breed specific low SNP chip required for genomic selection. Diagnostic Kits for Canine Parvovirus, B and T cell lymphoma, Evan Syndrome, haemolytic anemia and Haemoprotozoan parasites have developed under Canine Health Project. Two technologies have been commercialized *viz.,* vaccine for Canine Parvo Virus and PCR based diagnostic technology for canine haemoprotozan diseases.

Aquaculture and Marine Biotechnology: Major focus was on whole genome sequence of economically important fish species *Labeo rohita* (Rohu) and *Cirrhinus mrigala* (Magur) was completed and submitted to NCBI genome database. A "Germplasm resource Centre for Marine Ornamental Invertebrates" was established at Centre for Marine Living Resources & Ecology, Lakshadweep. Complete genome sequence and *de novo* assembly of *Halomonas malpeensis* PRIM 29T, a novel bacterium isolated from west coast of India was carried out. The bacterial genome has shown presence of genes coding for industrially important metabolites.

Health Care & Medical Biotechnology

Department is continuously supporting fundamental research in modern biology at various institutions across the country in order to create knowledge towards understanding the cellular and molecular phenomenon and deviations to understand the disease biology at various levels. DBT is engaged in advancing research and promoting innovation through applications of nano-biotechnology to address issues in healthcare.

- Application of Artificial Intelligence (AI) for affordable and accessible healthcare- Big Data and Genomics in areas of cancer, tuberculosis and pulmonary diseases, diabetic & cardiovascular diseases, ophthalmological diseases, neurological disorders and methods/ drug development.
- PAN India network programme "Genome India" was launched with an aim to catalogue genetic variation in Indian population. Department has recently initiated pan India network Genome India project for cataloguing the genetic variation in Indian population. The goal is to start with and execute whole genome sequencing and subsequent data analysis of 10,000 individuals representing the country's diverse population. 20 national institutions in the country are collaborating in this project. This will help build an exhaustive catalogue of genetic variations in the Indian population and aid in the designing of a genome wide association chip for Indian population which will facilitate further large-scale genetic studies in a cost-effective manner.



Genomic information is the backbone to fully harvest the fruits of new advancements in medical science such as Precision Healthcare

- A major programme was launched as Unique Methods of Management of Inherited Disorders (UMMID) and NIDAN Kendras (National Inherited Disorders AdministratioN Kendras) were set up in Government hospitals in four States for comprehensive clinical care including diagnosis, management, multidisciplinary care, counseling, prenatal testing in new born babies. Seven aspirational districts namely Mewat, Haryana; Yadgir, Karnataka; Haridwar, Uttarakhand; Washim & Nandurbar, Maharashtra; Ranchi, Jharkhand; Shrawasti, Uttar Pradesh have been identified for screening of 10,000 pregnant women and 5000 new born babies per year in each district for diagnosis of inherited genetic diseases and to provide comprehensive clinical care. This initiative was officially launched by the Honorable Minister Dr Harsh Vardhan on 23rd October 2019 in New Delhi.

- Anti Microbial Mission (AMR) to develop indigenous and cost effective therapies etc. Considering Antimicrobial Resistance as a global threat, the Department has launched an ambitious Mission Program on Antimicrobial Resistance with the vision to develop indigenous and cost-effective therapies against AMR; categorization of AMR-specific pathogen priority list of India; establishment of Bio-repository for AMR-specific pathogens and development of rapid and cost-effective diagnostic kits to identify AMR-specific pathogens. India has partnered with Global AMR R&D Hub as a member of Board of Members through the Department of Biotechnology, Ministry of Science & Technology, Government of India. This expands the global partnership working to address challenges and improve coordination and collaboration in global AMR R&D to 17 countries, the European Commission, two philanthropic foundations and four international organizations (WHO, FAO, OIE and OECD) as observers.

  Some of the missions already initiated received major impetus during the year under Atal Jai Anusandhan Biotech Mission - Undertaking Nationally Relevant Technology Innovation **(UNaTI),** which is expected to transform Health, Agriculture and Energy sectors during the next 5 years. This mission includes:

- **GARBH-Ini** - GARBH-Ini (Interdisciplinary Group for Advanced Research on BirtH outcomes–a DBT India Initiative)-This cohort study is being carried out to acquire fundamental knowledge about preterm birth which can then be used to develop prediction tools for the same. Under this program, a biorepository of bio-specimens and ultrasound images has also been established which will be very useful to address critical research questions on preterm birth and birth outcomes.

- **Ind-CEPI - This is a Mission to develop affordable vaccines for** emerging infectious diseases caused by viruses such as Ebola, Zika, Chikungunya, Nipah and SARS **diseases. The Mission aims to support vaccine development and associated competencies/technologies for potential outbreak threats in alignment with the priority list of World Health Organization**

(WHO). This also includes enhancement of surveillance frameworks and logistics for use of new vaccines, strengthening of infrastructure for vaccine development through industry-academia interface and enabling skill development and capacity building activities.

Department has continued its quest to find answers to hard pressing issues related to human health hence continues supporting projects under Basic, Diagnostic/Biomarkers, Nanotechnology & Therapeutics, Animal model systems for the development of chemotherapeutic agents, target identification, synthetic chemistry for target inhibition, genetics & epigenetics of nationally relevant cancers, cancer stem cells and its use in diagnosis & therapeutics.

- **Cohort studies, Bio-banks, Bio-repositories and Clinical Trials:** During the recent years, the Department has supported various cohort studies; establishment of Bio-banks; Bio-repositories and Clinical Trial facilities for various diseases across the country. Cohort studies on cerebral stroke biology, adult health and brain aging, dementia, stem cell technology, TB, HIV, maternal & child health, young adolescents, trajectories for healthy life, renal biology, chronic kidney diseases, cancer, systemic lupus erythematosus and genetics of healthy people have been supported by the Department under various ongoing programs. Along with support to cohort studies, the Department extended its support for the establishment of Bio-repositories on these diseases. Considering, bio-banking as an essential tool to provide access to high quality human biomaterial for fundamental and translational research, the Department facilitated the establishment of bio-bank on microbial cultures, antimicrobial resistant pathogens and liver diseases. Similarly, Clinical Trials for various diseases also being supported by the Department as per the need.

R&D Collaboration through Partnerships

A Joint Centre for Cancer Biology & Therapeutics (CCBT) supported by Medical Research Council (MRC) at National Centre for Biological Sciences (NCBS) has created several first-in-class lead compounds that modulate targets originally considered undruggable. The work provided a proof-of-concept for a new strategy to interrupt intracellular signaling by inhibiting the recognition of site- specific protein phosphorylation for cancer treatment.

DBT has also supported a 'Dementia Science Programme' that is aimed at collecting reliable data regarding prevalence, incidence, biomarkers and risk and protective factors. The programme aims to establish long-term population-based cohorts besides hospital-based cohorts who will be followed up. The Standard operating Procedures (SOP) have been finalized and pilot studies were conducted by NIMHANS-Prevalence site and by INCLEN at Palwal (prevalence site).

- ***Cancer Biology Research*** (CBR) received lot of impetus during the year. Individual investigators and institutions are being supported to carry out basic, applied and clinical research to develop new methods for prevention and treatment disease in the area of Breast Cancer, Cervical Cancer, Lung Cancer, Prostate Cancer, Oral Cancer, Retinoblastoma, Multiple Myeloma, Head & Neck Cancer, Myeloid Leukaemia, Chronic Myeloid Leukaemia and Ovarian Cancer etc. DBT also supported projects under Basic, Diagnostic/ Biomarkers, Nanotechnology & Therapeutics, Animal model systems for the development of chemotherapeutic agents, target identification, synthetic chemistry for target inhibition, genetics & epigenetics of nationally relevant cancers, cancer stem cells and its use in diagnosis & therapeutics. Support was provided to individual investigators and also in the form of Centres of Excellence.

- ***DBT-DAE Partnership for Cancer Research***: The Department of Biotechnology (DBT) and the Department of Atomic Energy signed a MoU on 2^{2nd} May, 2019 for supporting joint activities in the area of cancer. Joint collaborative research and clinical trials are envisaged under the already implemented Cancer Network Program (CNP). The MoU shall help in strengthening various initiatives specifically development of new and affordable technologies, conducting clinical trials, and training of manpower and infrastructure development.

- ***DBT-CRUK Bilateral Research Initiative for Affordable Approaches to Cancer:*** DBT and Cancer Research UK (CRUK) signed a Memorandum of Understanding (MoU) for a Cancer Research Initiative, "Affordable Approaches to Cancer". This was

signed during the Inaugural Researchers Summit held in New Delhi (14th -16th November, 2018). DBT and CRUK partnered to launch a £ 10 million, 5- year research initiative focussed on finding affordable cure to cancer. Further, DBT, CRUK and DBT/ Wellcome Trust India Alliance have signed a tripartite agreement that sets out the terms and conditions by which the India Alliance will undertake grant funded activities for the second and the third phase of India-UK Cancer Research Initiative.

- *International Cancer Genome Consortium (ICGC) DBT-India Project*: India is one of the 7 founding members of ICGC. Now, 40 countries are participating in this consortium. There are two participating institutions including Advanced Centre for Treatment, Research & Education in Cancer (ACTREC), Mumbai and National Institute of Biomedical Genomics (NIBMG), Kalyani. The research has led to the identification of certain signatures in oral cancer as biomarkers for early detection. 435 cases have been recruited so far with biobanking, standard treatment and follow up. Comprehensive genomic studies have been completed on tumor and normal pairs; SNP Array (350 cases); Whole Exome (200 cases); Whole Genome (200 cases); Mythylome (100 cases); Transcriptome (44 cases).

- National Alliance for Translational Research in Autoimmune Diseases (NATRAD): The Department is formulating a national consortium for research on autoimmune diseases, which is an unmet need in the country. A pre-conception meeting for this consortium was convened in June in CSIR-IICB and was attended by representatives from almost all major clinical and basic immunology departments in the nation, viz. IICB, SGPGI, NCCS, NII, IGIB, CDRI, PGIMER, CMC Vellore, IPGMER, AFMC, ISI, IIT-KGP, IISER-Kol, BHU etc. The intended direction of NATRAD will be to undertake basic research on disease mechanisms, cohort development for prospective studies, clinico-pathological stratification for heterogeneity of clinical presentation and therapeutic responses, clinical trials for new therapies, preclinical validation of novel technologies and disease awareness programs. NATRAD proposes to focus on five major autoimmune diseases in the country including Systemic Lupus, Psoriasis, Rheumatoid Arthritis, Inflammatory Bowel Disease and Type 1 Diabetes

Clean Energy Mission - Innovative Technology interventions for Swachh Bharat

Bioenergy and Bioresources and Environmental Biotechnology: Department initiated major R&D effort towards development of alternative fuels. Focus is on development of 2nd generation biofuels. A platform has been created to connect more than 200 scientists working in biofuel area via its five Centers of Excellence set up across the country, extramural projects, fellowship schemes and International co-operation. R&D in advanced biofuels has been promoted through various schemes/ programmes which includes 2nd generation ethanol production (pretreatment of biomass, indigenous enzyme development, scale-up and fermentation of xylose & glucose), algal biorefinery, bio-diesel, bio-butanol, biohydrogen, biogas, methanol) etc. During the year, DBT-ICT Centre has successfully demonstrated 2G ethanol production technology with rice straw and cotton stalk. Trials have been completed at 5 tons/day of rice straw and cotton stalk to yield 185L/ ton and 213L/ ton of ethanol. ICGEB has developed an enzyme preparation for hydrolysis of pretreated biomass for 2G Ethanol production and has been granted US patent for process and product development.

National Bioresources Development Programme: Focus continued on research for bioprospecting, inventorization and characterization, value addition, sustainable utilization of bioresouces, capacity building and awareness generation. The Department has initiated Network Programme on Marine Bioresource and Biotechnology in collaboration CSIR institutions, Ministry of Earth Sciences and other institutions/ universities working in areas of marine biology in the country. Department is providing research support across the country towards developing products and processes from medicinal and aromatic plants following multi-disciplinary approach.

Turmeric Mission

During the year major new initiative was taken to develop a

Mission programme on turmeric with the aim to generate high-quality raw material for developing nutraceutical products / dietary supplements from turmeric for global market. The focus would be on following major components of Mission Programme on Turmeric:

(a) Turmeric as a whole (including biodiversity studies, genetic improvement, developing elite varieties, agro-technologies, and post-harvest processing so as to generate high-quality raw material for developing nutraceutical products / dietary supplements for global market); and

(b) Curcuminoids (initially on testing in animal model systems, standardization of extracts, bioactive fractions enriched with curcumin and curcuminoids, production of GMP grade curcumin, and thereafter efficacy studies in selected disease conditions such as arthritic pain, cancer and infectious disease, so as to generate enough high-quality scientific data).

- ***Environmental Biotechnology***: R&D support continued in areas of bioremediation, waste management, forest conservation, resource utilization and climate change mitigation. During the year, a major network project was implemented for on-site bioremediation of petroleum contaminated soils. Department's impetus has been towards understanding the cause of human diseases at genetic and molecular level which would enable the development of innovative therapies or preventive measures and early detection in areas of enormous importance for public health.

Knowledge Generation, Discovery Research, New Tools and Technologies

The main focus areas of the knowledge generation, discovery research, new tools and technologies include Basic Research in Modern Biology, Nanobiotechnology, Genome Editing Technologies & their application and Theoretical and Computational Biology (Bioinformatics, Artificial Intelligence and Big Data etc.). Efforts have been made to encourage R&D programs in emerging genome engineering technologies and their applications. DBT is also supporting projects and programmes under bioinformatics for more than three decades as one of the thrust areas of Biotechnology. Bioinformatics programme has given impetus to the development of new knowledge and discovery research.

Theoretical and Computational Biology (Bioinformatics, AI and Big Data)

The Department has been supporting projects and programs under bioinformatics for more than three decades. This program has played a pivotal role in the development of Bioinformatics in the country through establishing the necessary infrastructure including the 'Supercomputer' facility. However, during the year need was felt to revamp the program and take the best forward.

- ***Revamping of BTISNet:*** DBT has a major focus also on bioinformatics for more than three decades. This program has laid foundation for development of new knowledge and discovery research. Keeping in view, a paradigm shift in information technology and biological research due to generation of large scale biological data by high-throughput platforms particularly with the advent of cost effective next generation sequencing platforms, DBT has decided to revamp BTISNet with establishment of new set of centres involving data driven research, applications of artificial intelligence, machine learning, high-throughput data related informatics etc. in various sectors of life sciences. Revamping of BTISNet of DBT is planned with a focused attempt to engage best expertise in network mode in development of advanced computational tools and technologies and developed national network projects in various areas of Bioinformatics and Computational Biology; apart from the core theme of the proposed centre.

- ***Manav: Human Atlas Initiative*:** Department has supported '"MANAV: Human Atlas Initiative" for construction of world's most comprehensive human atlas till date by assimilating all the known macro-level and micro-level information from scientific literature and public databases. The proposed human map refers to a computational representation, which will provide knowledge in holistic fashion from inter-organ dependencies to intra-organ, tissue level, cell and sub-

cellular level biological reactions. MANAV can serve as analogous to the 'human reference genome' and will have applications such as patient-specific support for medical/treatment decisions, understanding of pre-clinical and clinical assessment of healthcare products and personal health forecasting.

MANAV: Development of most comprehensive and integrated human map from existing scientific literature & databases

Nanobiotechnology

A need was felt to have specific guidelines that will help in regulatory process pertaining to Nano products focusing on 'Capacity Building for Translational Research' to create an enabling ecosystem for product development in the field of nanopharma, Hon'ble Minister of Science & Technology has recently released the "Guidelines for evaluation of Nanopharmaceuticals in India" developed by DBT jointly with ICMR and CDSCO. Further, Designing of Nano-Agri Input and Nano-Agri Products have emerged as the new concept under the domain of 'minimal usage with maximum effect' for agricultural and food applications. Guidelines for "Evaluation of Nano Based Agri Inputs and Food Products in India" have been finalized and would be released soon.

"Guidelines for Evaluation of Nanopharmaceuticals in India": At a Glance

- *Jointly developed by DBT, ICMR and CDSCO*
- *Apply to the nanopharmaceuticals in the form of finished formulation as well as Active Pharmaceutical Ingredient (API) of a new molecule or an already approved molecule with altered nanoscale dimensions*
- *Facilitate translational research in line with the regulatory requirements*
- Provide transparent, consistent and predictable regulatory pathways for nanopharmaceuticals in India.

Genome Editing Technologies & Their Applications

Recognizing the power of Genome editing techniques to study and manipulate the genome, DBT has been engaged in promoting research and innovation in genome engineering technology and its applications with a vision to foster innovation and promote development of Genome-wide analysis and Engineering Technologies to make them accessible and affordable for wider use in Life Sciences. During the year, some of the important projects supported are synthesis and biochemical evaluations of nucleobase modified tropolonyl-ribose nucleoside in CRISPR-RNA, development of high-throughput genome editing tools for targeted genome-wide knockout mutant in *Brassica napus*, deciphering osteopontin driven regulator(s) of metastasis in triple negative breast cancer using dead cas9-based tools, identification of optimal therapeutic window for efficacious intervention in a Zebrafish model of fragile X syndrome, and development of a cell culture based genome engineered platform for the production of a high value anti-cancer metabolite, *Podophyllotoxin* in *Podophyllum hexandrum*. More than 30 research publications emanated out from the R&D projects supported under the program.

***Artificial Intelligence*:** Artificial intelligence (AI) aims to mimic human cognitive functions. It is bringing a paradigm shift to healthcare, powered by increasing availability of healthcare data and rapid progress of analytics techniques. Considering the importance of AI, a call for proposal on Artificial Intelligence Applications for Affordable and Accessible Healthcare - Big Data and Genomics was issued. A total of 22 projects are being supported in the areas of cancer, tuberculosis and pulmonary diseases, diabetic &

cardiovascular diseases, ophthalmological diseases, neurological disorders and methods/ drug development. A project on Imaging BioBank for Cancer is also being initiated with an intent to develop AI tools and database for advance research in cancer and will also be aimed at cancer diagnosis/ prognosis and cancer care.

Building International Collaborations And Partnerships

The Department is implementing various international collaborative programs with a number of countries and philanthropic organizations in different areas of biotechnology for developing strategic partnerships, strengthens universities/institutes towards globalizing its programs and help students, faculty and scientists to become more competitive at international platform. Department has fostered international collaborations with various countries like Australia, Brazil, Cancer Research UK (CRUK), Costa Rica, Cuba, European Union (EU), Finland, France, Germany, Russia, South Africa, South Korea Switzerland , Spain, Sweden , United Kingdom (UK), United States of America, besides, partnering with many philanthropic agencies.

During the year, the Department under the initiative of 'Global Stars Initiative in Field of One Health' has announced the 1st joint collaborative call with the EUREKA. Under EUREKA initiative three joint proposals were implemented with UK, Netherlands and Spain. The Department has also launched Phase II of the Global Research Programme (GRP) addressing the health needs of women and children in the most disadvantaged populations globally in partnership with DFID-ESRC-MRC, UK. A joint workshop under Indo-Swedish collaboration was organized on Digital Healthcare to enhance the cooperation across academia and start-ups in Digital Healthcare across both the countries. The 2nd joint DBT-DFG call was announced for fundamental research in biotechnology.

International Collaborations

India-Sweden Joint Committee on Science &Technology

Special Programme

The Department has undertaken focused program for improving livelihood towards of small & marginal communities in selected aspirational districts. So far, 09 Rural Bio Resource Complex Innovation Hubs to address pertinent issues related to health and nutrition, agriculture & allied areas using biotechnological tools, techniques and processes have been supported in 11 Aspirational districts in 7 states. Currently, 8 more are in pipeline. Department is supporting Biotech-Krishi Innovation Science Application Network Programme (Biotech-KISAN) in a mission mode. The program aims to create platform for self-employment generation among the target population by diffusion of proven and field-tested technologies through demonstration, training and extension activities. This program has made significant progress during the year by expanding its activities in 92 Aspirational Districts. The efforts have been continued towards establishing Biotech-KISAN Hub in each of 15 agro-climatic zones of the country under the leadership of a champion, who will act as the Facilitator. Each Hub will create a network by developing strong linkages with top quality scientific institutions / State Agricultural Universities (SAUs) / Krishi Vigyan Kendras (KVKs) / existing state agriculture extension services / system and other Farmers' organizations in the region as well as linkages with leading international institutions / organizations. Biotech-KISAN Hub will also have a tinkering laboratory.

Promotion of Biotechnology in North Eastern Region (NER)

Research & Development in Biotechnology has a potential to create solutions for many of the problems which NER is

facing presently. Keeping this in view, the Department has been supporting and implementing various schemes and programs specially designed for the North Eastern Region of the country. During the year, fifty six Twinning R & D projects were implemented. Major network program/s on NER-Banana varieties has been initiated in 18 institutes across NER. During this year, the DBT has taken initiative on developing Phyto pharmaceuticals Mission Programme in North East Region using modern scientific tools following DCGI- CDSCO protocols. DBT has initiated a scheme for establishing "Biotechnology Labs in Senior Secondary schools (BLiSS)" in NER. The BLiSS programme which is currently comprises of 88 schools has strengthened the practical teaching within the schools by imparting excellent practical trainings for their students as per their syllabus in class 11th and 12th.

Training of NER students under Chemical Ecology Programme

Autonomous Institutions

The Department has set up 16 theme based autonomous institutions and also supporting one International Centre. These institutions facilitate flow of knowledge from basic science to translational research in Healthcare, Agriculture, Bioresource and Basic & Emerging Biotechnologies etc. These institutes are also playing an important role towards capacity building, training for upgradation of skills of young scientists, students and researchers. These, institutions are also involved in outreach activities for popularization of science among students and dissemination of knowledge.

- National Institute of Immunology (NII), New Delhi has initiated flagship Programme on Immuno Engineering for creating novel tools in the areas of Synthetic Immunology, Nanotechnology, Artificial Immune Systems, High Definition Cellular and Molecular Imaging, Biomaterials and Microfabrication.
- National Centre for Cell Sciences (NCCS), Pune has isolated new bacterial species isolated from a hypersaline lake in India, and identified and named after Dr. Renu Swarup in recognition of her invaluable role in simplifying some of the provisions of the Biodiversity Act 2002. Team of Scientists at NCCS, Pune has decoded the structure of two key brain receptors from the orphan delta family of glutamate receptor ion channels.
- Centre for DNA Fingerprinting and Diagnostics (CDFD) Hyderabad has initiated a flagship programme on Development of Genomic Technologies for Predictive Genetic Health and Forensic Profiling.
- National Institute of Plant Genome Research (NIPGR), New Delhi has developed a molecular marker for and used in marker assisted selection to make an extra large seeded derivative of the commercially important kabuli variety of Chickpea KAK2. NIPGR has also initiated a flagship program entitled "Ímparting Sheath Blight Disease Tolerance in Rice". The objective of flagship program is to develop newer varieties of Rice that have enhanced tolerance to sheath blight through molecular breeding, genome editing and transgenic approaches.
- Team of Scientists at National Brain Research Centre (NBRC), Manesar has identified the specific microRNAs that regulate the functions of human neural stem cells thereby affecting their stemness, and overall development of the human brain. NBRC scientists have developed a specialized tool (brain template) called BRAHMA for integrating inputs from neuroimaging data and the clinical information to help in diagnosis of various brain diseases such as Alzheimer's and Parkinson's. During the year, NBRC has initiated a flagship program on comparative mapping of common mental disorders (CMD) over the lifespan, which aims to understand how information processing networks in the brain are affected in common mental disorders such as anxiety, depression, obsessive-compulsive disorder and post-traumatic stress disorder.
- Institute of Bioresources & Sustainable Development (IBSD) has taken several new initiatives that include a

focused research program on bioenergy, product development, black rice improvement, development of super-foods applying microbial process, development of bio-pesticides, research on conservation of endangered plants and animals and other programs of value addition which can create more employment, institute of bioresources and sustainable development has set up a Rural Bioresource Complex at Ri Bhoi District, Meghalaya under the aspirational district program for benefit of local population. IBSD has trained 1770 farmers and unemployed youths in orchid production to promote orchid based bio-entrepreneurship.

- Institute of Life Sciences (ILS), Bhubaneswar started a comprehensive flagship program on "Tribal Health and Nutrition". ILS has established "omics" based research pipelines as well as storage and data management structures and collection and analysis of samples from Tiljora village of Sundergarh district of Odisha inhabited by 6 ethnic tribes. The ILS has also implemented a program for Economic Empowerment of Tribal Farming Communities in Nabarangapur of Odisha focusing on enhancing productivity and profitability of the farming system, establishing nutrition gardens and imparting nutritional literacy, and training and capacity building for value addition and income generating activities. ILS has launched two products during the year (a) QuikSort Magnetic Cell Separation Kit for purification of different cell types from human PBMC and mouse splenocytes and (b) Mono- and Poly-clonal antibodies for non-structural proteins (nsP1, nsP2, nsP3 and nsP4) of Chikungunya virus.

- The technology for management of Oral Mucositis jointly developed by Rajiv Gandhi Centre for Biotechnology (RGCB) and Regional Cancer Centre, Trivandrum was transferred to Ceego Laboratories for commercialization. RGCB invented a low cost strip that identifies the type of poisonous snake from the blood within 2 minutes of a snake bite. Utroside B, a potent anti-hepatocellular carcinoma molecule developed by RGCB Trivandrum was transferred to the multinational company, Q Biomed. During the year, RGCB has started the M.Sc. Biotechnology Program with three unique specializations - Disease Biology, Molecular Diagnostics & DNA Profiling and Molecular Plant Sciences for manpower development.

- Regional Centre for Biotechnology (RCB) conferred PhD to 14 students. A total of 219 students from these recognized centres stood registered for their respective programs with RCB in 2019. RCB Flagship Research Program on the development of antivirals has been initiated harnessing the expertise of the in-house structural biologists and virologists. During 2019, RCB scientists published 65 research articles in Journals of national and international repute. The RCB has initiated flagship research program on the development of prophylactics and therapeutics against viral diseases highly prevalent in the Indian population.

- Translational Health Science and Technology Institute (THSTI), Faridabad scientists published 60 original research articles, filed 11 patent applications and developed one technology (A novel "Integrative Expression Vector" developed in collaboration with M/s Bioheaven 360).

- Institute for Stem Cell Science and Regenerative Medicine (instem), Bengaluru scientists had set up a startup which primarily focuses on the development of on-demand, bio-responsive deliverables to reduce pathologies associated with chronic inflammation. The product under development minimizes exposure to toxic pesticides through skin contact and inhalation, during the spraying of pesticides. This is of relevance to the farming community. This effort was also recognized by the Gandhian Young Technological Innovation Award – 2019, BIRAC- SRISTI.

- National Institute of Biomedical Genomics (NIBMG), Kalyani has established the technology of single cell RNA sequencing based on both high throughput 3'-end counts (Chromium, 10X Genomics) and full length transcript sequencing (SMART-Seq2). Presently, work on single cell sequencing is being conducted on oral cancer.

- National Agri-Food Biotechnology Institute (NABI), Mohali has developed a novel edible coating

formulation based on wheat straw polysaccharide and stearic acid esterified oat bran polysaccharide for the post-harvest shelf life improvement of perishable fruit crops (Apple, Peach and Banana). Further, a major research initiative in the form of institutional flagship program was initiated on nutritional biofortification of Wheat to enhance the traits such as micronutrient, protein etc along with six other co-partners.

- Center of Innovative and Applied Bioprocessing (CIAB) has licensed two technologies: (i) processes for development of tomato based seasoning/spice-mix and beverage and ii) iron fortified or iron added turmeric as a value added product for improving iron nutrition to M/s Aamztofaamz Technosolutions Pvt. Ltd, Mohali. DBT funded flagship programme on utilization of rice residues for value added product development was also initiated along with INST, Mohali. Further, an Indo-Sweden project on development and validation of technology for production of high energy density biocoal from rice straw and other agri-biomasses was initiated with the support of PSA, GoI. CIAB has initiated a flagship programme on utilization of rice residues for value added product development.

- National Institute of Animal Biotechnology (NIAB), Hyderabad scientists developed a novel aptamer based lateral flow assay for detection of presence of tetracycline in milk within 5 minutes. NIAB has also initiated working towards development of biosensors for detection of pesticides in animal feeds.

- International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi scientists published 100 publications in peer reviewed journals. Institute has filed five national and one international Patent in 2019. ICGEB developed overexpressing transgenic rice that minimizes the phosphate loss and contributes to weed management in the agriculture.

Flagship programs of DBT Autonomous Institutions

Name of Institute	Flagship Programme
NII, New Delhi	Immuno Engineering : Cell Therapy Platform
CDFD, Hyderabad	Development of Genomic Technologies for predictive genetic health and forensic profiling
NIPGR, New Delhi	Imparting sheath blight disease tolerance in rice
NBRC, Manesar	Comparative mapping of common mental disorders (CMD) over lifespan
IBSD, Imphal	Conservation, Propagation, Mass Multiplication and Research & Development activities of Selected Orchids, *Prunus* and *Parkia* species for developing biobased entrepreneurship in North East India
ILS,Bhubhaneshwar	A research initiative to uplift health and well-beingof Tribal communities of Odisha
RCB, Faridabad	Development of small molecular antivirus against chikungunya and Japanese encephalitis virus
THSTI, Faridabad	Inter-Institutional program or maternal, neonatal and infant sciences :GARBH-INI– interdisciplinary Group for Advanced Research on BirtH outcomes - DBT India Initiative
InStem, Bangalore	Leveraging stem cell technologies to facility discover for Human disease biology in India
NIBMG, Kalyani	Integrating Multi-Omics Data Using Big Data Analytics to Infer Optimal Wellness Trajectories for Management of NCDsAdv(SS)
NABI, Mohali	Development of Bio-fortified and Protein rich Wheat
CIAB	Utilization of Rice Residues for Value Added Product Development
NIAB, Hyderabad	Genomics assisted pathobiology to identify novel targets for diagnosis and therapeutic intervention (s) of Japanese encephalitis and Leptospirosis

Promoting Entrepreneurship and Industrial Growth

Indian bio-economy is expected to grow from USD 64 Bn in FY 2019-20 to USD 150 Bn by 2025. This growth trajectory for the sector is an outcome of GoI's constant effort and initiatives to promote this sector making India a global Biotech leader. The focus has been primarily on Startup India ecosystem and promotion of Make in India concept.

Startup India: Startup India is a flagship initiative of the Government of India, intended to build a strong eco-system for nurturing innovation and startups in the country that will drive sustainable economic growth and generate large scale employment opportunities. The Department of Biotechnology and Biotechnology Industry Research Assistance Council (BIRAC), a not-for-profit Section 8, Schedule B, Public Sector Enterprise endeavours to scale up the number of startups in the sector by handholding them from ideation to commercialization of their products/ technologies. 45 Bioincubators have been setup across India creating total incubation space of 4,85,000+ sq. ft.

- Make in India: DBT established a Make-in-India Facilitation Cell for Biotechnology Sector in 2016 with the following mandate:
- Facilitating Investments
- Fostering Innovations
- Protecting Intellectual Property
- Building best in class infrastructure
- Ease of doing Business
- Providing Employment in Manufacturing Sector
- State Partnerships to Expand Biotech Innovation Ecosystem
- Create Global Start-ups Connect

DBT and BIRAC organized Global Bio-India 2019 from 21st – 23rd November 2019 at Aerocity, Delhi in partnership with Confederation of Indian Industry (CII), Association of Biotechnology Led Enterprises (ABLE) and Invest India. This event is a testimony of growing prowess of biotechnology sector in the country and showcase to International community. The three-day long event witnessed a rich technical program of 40 sessions, CEO roundtables, workshops, product launches, etc. It attracted 3000+ delegates, 190 exhibitors, 25+ countries, 300+ start-ups, 50+ incubators, 60+ Research Institutes, 800+ business meetings scheduling and representation from 10+ states. There were over 60 government, research and educational institutions that took part in the event.

Glimpses of Global Bio-India 2019

- ***DBT Biodesign Program:*** Innovation is the key to address the unmet clinical needs. The demand for medical devices and implants is growing rapidly globally as well as in India. Realising the need to foster and promote development of indigenous affordable medical technologies, DBT established biodesign centers across the country. They are- School of International Biodesign (SIB) programme jointly at AIIMS and IIT Delhi; Healthcare Technology Innovation Centre, IIT-Madras; Centre for Bioscience and Bioengineering, IISc., Bangalore. All the centers have attained commendable success in promoting the med-tech ecosystem in the country.
- ***Biotechnology Science Clusters:*** Considering the importance of Cluster in economic development of any region, the multi institutional regional clusters were established by the Department as an initial step towards accelerating innovation. This was in principle approved as a part of the National Biotechnology Strategy that aims to develop India as a world-class bio-manufacturing hub by creating a technology development and translation network across the country. Four Bioclusters were established at Faridabad, Bangalore, Pune and Kalyani.

Biotechnology Parks & Incubators

To promote equitable opportunities in biotechnology sector across the scale of the country, the Department of Biotechnology partnered with various State Governments to

establish Biotech Parks since 2003 and helps to translate research into products and services by providing necessary infrastructure support. The parks have been facilitating networking amongst various biotech stakeholders and providing entrepreneurial opportunities even in remote places of India. Presently Four parks are on-going including Biotechnology Incubation Centre, Cochin, Kerala has major infrastructure facilities and houses 22 incubatees; Biotech Park Technology Incubation Centre, Guwahati, Assam has 8 incubatees and 6 have graduated. The park has major infrastructure facilities for fermentation, micropropogation, herbal extraction, bioprocessing unit; Industrial Biotechnology Parks (IBTPs), Jammu & Kashmir- Two Industrial Biotechnology Parks have been recently set-up focusing on medicinal & aromatic products, enzymes/value-added biomolecules; Chhattisgarh Biotech Park -interfaces research institutes with industry for bio-resource based product commercialization.

Public Sector Undertakings

Biotechnology Industry Research Assistant Council (BIRAC), since its inception supported 1000+ Startups, Entrepreneurs & SMEs creating Intellectual wealth (185+ IP filed) and a robust pipeline of 130+ commercialized products and technologies across the country. BIRAC's BioNEST program has supported 45 Bio-incubators creating a total space of 4,85,000+ sq. ft that is expected to grow to 50 by Mar 2020. BIRAC is playing is a significant role in improvement of innovation chain and start up ecosystem for affordable product development in the country. The Biotech Start up ecosystem supported by BIRAC is now enriched with 2500+ Biotech Startups in the country. Neurotouch, Smart Scope , Mobile X-ray , SPLAT , MushD+ , Sanmitra Hand Cranked Defibrillator, oral nutraceutical, Paratuberculosis Point of care diagnostics, Virtual Reality Goggles and SeeSound App are the new products commercialized during the year.

BIBCOL has supplied 180.46 million doses of bOPV to Ministry of Health and Family Welfare during the year 2018-19 and has turnover of Rs. 83.64 crores. However for the year 2019-20 it is expected to make supply of 183.39 million doses of

bOPV and expected turnover is of Rs. 85.90 crores. In addition to bOPV in vaccine segment, BIBCOL has been manufacturing and marketing dispersible Zinc Tablet and Diarrhea Treatment Kit in Pharmaceutical segment. BIBCOL is in process of developing a vaccine candidate like Oral Cholera Vaccine and setting up the facility for production of plasma fractionation facility for production of plasma derived medicines (PDMs). In this regards BIBCOL has signed MOU with NII, THSTI and IVI Korea for development of vaccines and bio therapeutics.

Regulation

Department of Biotechnology has launched the web portal Indian Biosafety Knowledge Portal (IBKP) in line with Government of India's easing doing business and digital India, The platform provides new scientific information on biotechnology and allow online submission of applications and their tracking. IBKP also provide India's Biosafety Regulatory information for scientific community. The process of import / export and exchange of materials has been simplified in consultation with the Stakeholders and the revised Simplified procedure for Import/Export and Exchange of materials has been issued in January, 2020. Accordingly, the timelines for approval process has been reduced.

Administration and Finance

The administration is responsible for providing a good and ambient atmosphere for in-house scientists, officers and staff. All the logistic supports were also provided by administration for organizing the scientific meetings, Task Force, Expert and Steering Committee meetings. The internal infrastructure of the Department has been renovated and modernized during the year. More than 50 employees of the Department were deputed for various training programmes conducted by the Institute of Secretariat Training & Management (ISTM), National Institute of Financial Management (NIFM), Faridabad, Indian Institute of Public Administration, New Delhi and Administrative Staff College of India, Hyderabad for upgradation of their skills in relevant fields. DBT-Establishment section has recruited 21 Scientist 'C'. During the year, Swachhta Pakhwada and Swachhta Hi Seva (SHS) Campaign were organized and Department has been made Single Use Plastic free. The Department of Biotechnology Group 'C' (Non-Gazetted, Non-Ministerial) Posts Recruitment Rules, 2019 for the Non-Statutory Departmental Canteen of this Department have been notified in the Gazette of India

02

BUILDING CAPACITIES

HUMAN RESOURCE DEVELOPMENT, TRAINING AND WORKSHOPS

RESEARCH RESOURCES, SERVICE FACILITITES AND PLATFORMS

BIOTECHNOLOGY SCIENCE CLUSTERS

Human Resource Development Programme

The Human Resource Development Programme at the Department of Biotechnology is aimed at holistic development and support for students and scientists working in the area of Biotechnology. Since its inception, the Department has been supporting Biotechnology teaching at postgraduate level in niche areas of Biotechnology. The Department has been involved in capacity building to enhance the Biotechnology ecosystem through DBT-STAR College scheme, Skill Vigyan Programme under State Partnership through Science and Technology Councils, Biotechnology Finishing Schools, DBT-JRF, DBT-RA, Awards for Young and Distinguished Scientists and short term trainings for Mid-Career Scientists, etc. The Department has also been conducting workshops for students and researchers. There are a number of international partnerships being supported to build capacity in cutting edge technologies and priority areas.

Significant achievements:

(A) Teaching Programmes:

(i) Postgraduate Teaching Programmes (M.Sc./ M.Tech./M.V.Sc.):

Postgraduate Teaching Programme in Biotechnology and allied areas has been initiated to ensure high standard of teaching and to generate critical mass of trained manpower in the country. This programme has been implemented on the basis of core faculty strength, expertise, infrastructural facilities, R&D grants received by university on competitive funding basis, nearby institutions engaged in biotechnology R&D. This program has been expanded in general biotechnology as well in specialized areas depending on the demand. These include medical, agricultural, marine, veterinary, industrial biotechnology, bioprocess technology computational biology, food science, bioinformatics and nutrition biology. The Department at present is supporting 72 Postgraduate courses in universities/ institutes offering M.Sc. /M.Tech./M.V.Sc. teaching programmes in biotechnology and allied areas. To ensure admission of quality students, selection was made through All India Combined Entrance Examination for Biotechnology (CEEB) conducted by Jawaharlal Nehru University, New Delhi, IIT-JAM and individual University level examination. Financial support is provided for establishment of laboratory equipment facility essentially required for class room teaching, recurring grants for consumables, studentship, books and journals, travel, visiting faculty, contingency, thesis grant for in-house dissertation, equipment maintenance etc. In-house dissertation has been made mandatory for all the participating institutions and Department is providing thesis grant of Rs. 50,000/- per student to ensure intensive hands on training. All selected candidates are paid studentships under DBT support. A total of 92 research articles in peer reviewed journals of national and international repute have come out from dissertation of M.Sc./M.Tech. students. During the year, independent evaluation of DBT-HRD scheme was conducted by Thematic Working Group on HRD and it recommended continuation of programme beyond 14th Finance Commission with fresh selection of universities/institutes for support under DBT-PG Teaching Programme. Based on the recommendations, the Department issued an advertisement for submission of proposals for support under DBT PG Teaching Programme. A total of 178 proposals have been received under DBT PG Teaching Programme for support beyond 14th Finance Commission.

Location of universities/ institutes offering DBT supported Postgraduate Teaching Courses in Biotechnology in the country

(ii) Skill Vigyan Programme (Skill Development Programme) in Biotechnology: This programme has been implemented with an objective to provide hands-on-training in tools and techniques in Biotechnology and allied areas to generate skilled manpower. This programme has been designed for providing skill training under four categories (i) Skill training for students (ii) Technician training (iii) Faculty training and (iv) Entrepreneurship training. The programme has been implemented in six states *viz*., Arunachal Pradesh, Himachal Pradesh, Meghalaya, Odisha, Punjab and Uttarakhand in partnership with State Science and Technology Councils of respective states. The proposals of other 5 States *viz*., Karnataka, Telangana, Gujarat, West Bengal and Andhra Pradesh are in pipeline. Efforts are being made to partner with all states and UTs to implement the Skill Vigyan programme across the country. During the year 2019-20, support to 15 Certificate/Diploma courses in areas of Biotechnology has been continued.

(iii) Star College Scheme:

Aim of this scheme is to support colleges and universities offering undergraduate education to improve science teaching across the country. Its mandate is to improve critical thinking and encourage 'hands on' experimental work at undergraduate (College) level in science subjects. The objective of the scheme is that it would encourage more students to opt for science as a career. Through this scheme the Department identifies colleges with a potential for excellence and provides support for developing infrastructure for academics and laboratory activities. This support is in turn expected to invigorate teaching and provide unique exposure to students for doing more experiment based science. The Star College Scheme is a pan India scheme that envisages a Star College in every district of the country, especially aspirational districts and strives to provide equitable benefits to students from all sections of society. To realize this objective, the Department engages in dialogue with the State Governments to identify colleges that can be considered for support under this scheme. Since inception (2008), the Department has supported over 260 undergraduate colleges across the country. Apart from financial support, colleges benefit tremendously from guidance received during Advisory Committee meetings, mentoring, Task Force meetings and learning from peers from other colleges.

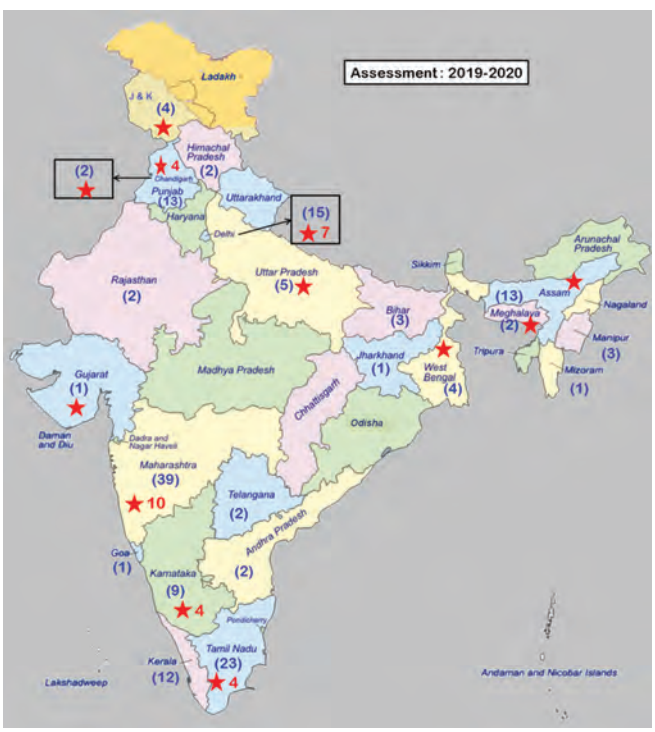
Major Initiatives under Star College scheme during 2019-20:

- Review meeting cum Coordinator's Meet was conducted in the month of April 2019 to evaluate performance of colleges presently being supported under the scheme through poster and oral presentations. 108 colleges from 16 different states participated in this meeting. This meeting was conducted with an aim to facilitate interaction and knowledge sharing among different colleges from across the country. Additionally, colleges who had completed 9 years under this scheme shared their learning with co-ordinators from other colleges present,

thereby guiding and motivating them to achieve the maximum possible under the scheme.

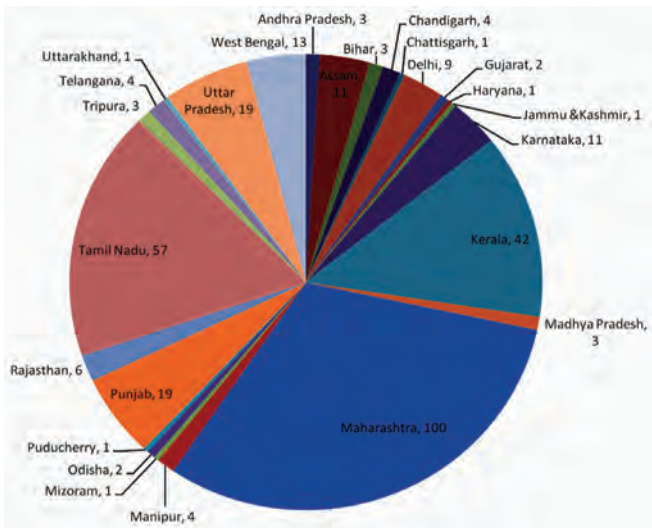
- Over the years, the Department realized that colleges from both urban and rural areas were applying for support under the Star College scheme. Therefore, 2 categories of colleges "Urban" and "Rural" were created in 2018 to ensure that applicants were provided a fair playing field and that location of a college and access to facilities would not be a determinant for securing the grant. This year, 321 proposals were received from colleges across the country. Out of these, 138 proposals were from colleges under "Rural Category".

- During this year, the Department has supported 789 Science Departments in 159 Colleges across the Country under the DBT Star College Scheme which has benefitted approximately 25000 Students. 41 colleges supported during this year belong to rural areas. Out of the 159 Colleges supported, 36 were accorded Star Status after completion of 3 years of initial support. Notably, 35 Women colleges across the country were amongst the colleges supported this year.



*Map of India depicting number of Colleges presently being supported under the Star College Scheme (159) and colleges accorded with Star Status (36) (depicted as *) in different states during 2019-2020.*

- The Department had also organized Brainstorming sessions in Bihar and Uttar Pradesh during 2018 and 2019 respectively, in order to encourage more proposals from these states (since it was observed that no proposals were received from these states over the years). Consequently, the Department received proposals from Bihar and Uttar Pradesh during 2019-20.



Distribution of proposals received from different states during 2019-2020.

Advisory meeting in Colleges supported under DBT-Star College Scheme

(iv) **Biotechnology Finishing School Programme:** The Department jointly with Department of Information Technology, Biotechnology and Science &Technology, Government of Karnataka is supporting "Biotech Finishing School Programme" (Biotechnology Skill Enhancement Programme - BiSEP). During the year, 477 applications were received and 405 candidates appeared in entrance exam and 82 candidates were selected at national level for admission in BiSEP programme under DBT support. Selection process is very stringent and all selected students are paid fellowship of Rs. 10,000/month.

(B) National Fellowship Programmes:

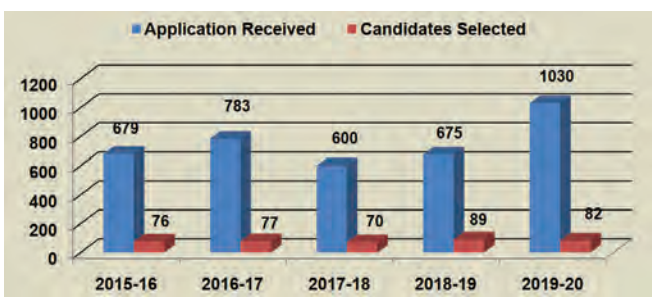
(i) DBT Junior Research Fellowship (DBT- JRF) Programme:

Department is providing fellowships to biotechnology students for pursuing doctoral research in universities and / or research institutions across the country. The fellows are selected via all India level examination conducted across the country and based on the merit, top 500 candidates are listed under category-I who are eligible to avail fellowship under DBT-JRF at any university/institute in India once they are registered for PhD while candidates which fall under category-II are eligible for fellowship equivalent to NET qualification from the extramural R&D project funds at universities/ institutes as the case may be. During 2019-20, a total of 17,897 applications were received, 10,691 students appeared for the online examination organized at 57centers located in 52 cities across the country. Under Category-I, 267 students were selected for award of DBT-JRF and in Category-II, 209 students were selected. This year, a total of 870 ongoing students and 96 newly joined students have been supported under DBT-JRF Programme.

Map showing location of DBT-JRF Exam Centres for Biotechnology Eligibility Test, 2019

(ii) DBT Research Associateship (DBT- RA) Programme

DBT Research Associateship programme was started in year 2001 for post-doctoral research in Biotechnology and allied areas at premier institutions across the country. This programme is being coordinated by Indian Institute of Science, Bangalore. The fellowship is initially awarded for a period of two years and support can be extended for 1-2 years based on review of progress. During the year 2019-20, in response to two advertisements, a total of 1030 applications were received, out of which 267 candidates appeared for the interview. 82 candidates were awarded the Research-Associateship.



Number of Applicants vs. selected under DBT-RA Programme in last 5-years.

(C) Programmes for North Eastern States (NER):

Department has made a special provision in HRD scheme during 2010 for providing support to students/ Research fellows with domicile of North-Eastern States or those who have studied for past 3 years in university/

institute in NER states under two programmes viz., DBT-RA and DBT-BITP.

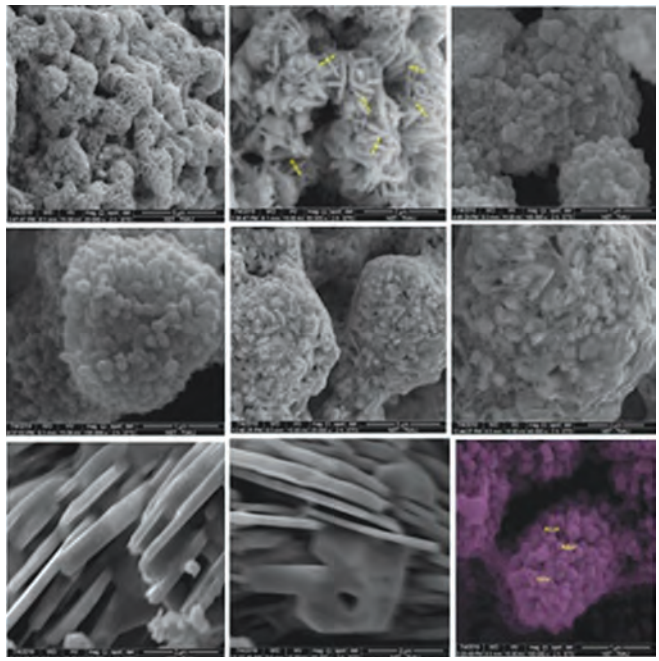
(i) **DBT-RA for North East:** During the year, a total of 96 applications were received and 16 candidates were selected for award of DBT-RA Fellowship from NER.

(ii) **DBT-BITP NER:** Department is providing industrial training to fresh B.Tech /M.Sc./M.Tech students of biotechnology from North Eastern States for a period of 6 months. There is a provision for placement of 100 candidates in industries for training under BITP-NER. During the year, a total of 79 applications were received and 17 candidates were selected for training.

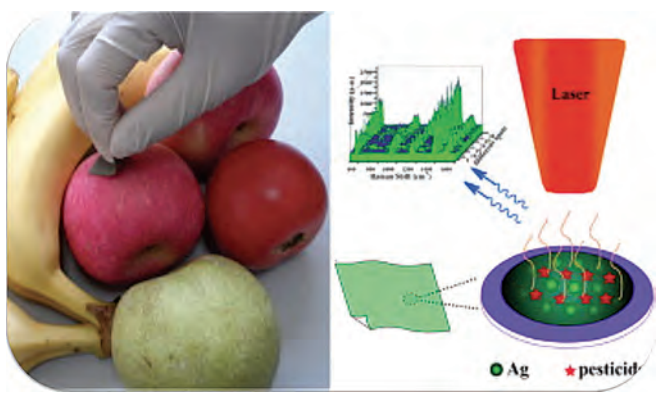
(D) Building Critical Mass of Science Leaders

(i) **Ramalingaswami Re-entry Fellowship:** The idea behind starting Ramalingaswami Re-entry Fellowship in 2006-07 was to attract high quality Indian brains working abroad to pursue their research interests in life sciences, biotechnology and other related areas in India. Besides, this will create a pool of highly skilled and trained researchers working on cutting edge technologies in Indian laboratories. By seeing the success of the scheme in past years, number of the fellowships have now been increased from 50 to 75 per year from 2017-18 onwards. So far, 409 fellows have been supported under this program in various Indian Laboratories, out of which, 250 fellows sought regular faculty positions. During the year 63 candidates were selected, 43 have joined and 40 absorbed as regular faculty. As evident from the increasing number of applications for the fellowship, more and more young scientists want to relocate and serve the Nation. With the enabling ecosystem provided to young researchers they have been able to perform well. Fellows have published their research work in peer reviewed national and International scientific journals; developed new technologies; filed patents and created a few spin of companies. Some of the success stories by fellows are as follows:

- **Efficient detection of multicomponent pesticide residues in fruits and vegetables:** Synthesis of morphologically different Ag/metal oxide (CeO_2, $LaFeO_3$, TiO_2 and WO_3) nanostructure materials were achieved for the efficient detection of the pesticides in fruits and vegetables.



A

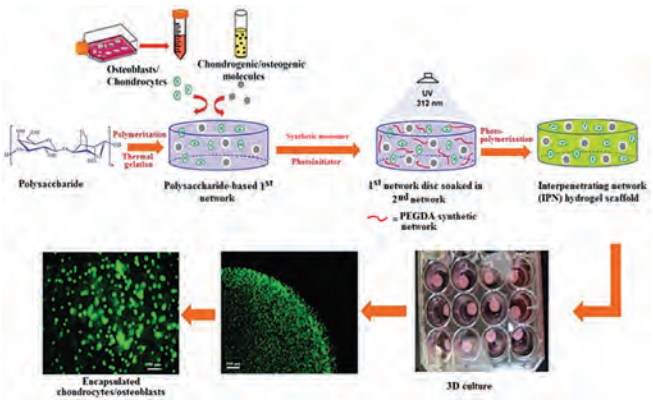


B

(A) Ag/metal oxide nanostructure materials.
(B) Application: Pesticide Residue detection

- **Development of Biomimetic and bilayered interpenetrating network (IPN) hydrogel to provide a chondrogenic and osteogenic signalling approach:** The novel signalling approach include incorporation of short chain peptide/ transforming growth factor beta (TGF-â1) and chondroitin sulphate as, cartilage molecules known for their ability to promote chondrogenesis and bone morphogenetic protein-2 (BMP-2) to promote osteogenesis along with hydroxyapatite (HAp) coated

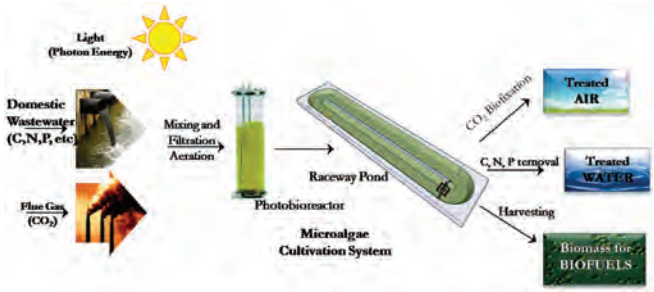
microspheres to provide nucleation sites for secreted calcium and accelerated subchondral bone formation.This approach will form a 3D bilayered IPN scaffold for osteochondral tissue engineering.



Schematic diagram showing the formation of mechanically strong IPN scaffold containing chondrocytes/osteoblasts along with chondrogenic/osteogenic signals. Confocal images demonstrated the long term survivability of encapsulated chondrocytes/osteoblasts in a 3D IPN hydrogel system.

- **Dissecting Genetic Diversity of Capsaicinoids Complex (pungency) and Yield Component Traits in the Genome of BhutJolokia, the Hottest Native Chili Pepper of North East India:** *Pun 1*, *AMT*, *ACS*, *ACL*, *KAS* and *BCAT are the genes found to be* expressed very high in different varieties of Bhut Jolokia and linked to the pungency of the chilli.

- **Microalgal biorefinery concept for bioenergy production vis-à-vis wastewater and fuel gas bioremediation:** Among various proposed technologies, biological carbon sequestration through microalgae has an added benefit of producing useful biomass using the sequestered carbon, which can substitute petroleum for raw materials and fuel production. Not only microalgae are extremely effective in sequestering undesirable carbon dioxide, they are known to accumulate high levels of lipids under certain conditions. Micro-algal oils have all the necessary characteristics to be usable as various liquid transportation fuels ranging from biodiesel to jet fuel.



Schematic diagram of microalgae based waste water treatment plant

(ii) DBT- Wellcome Trust Fellowship: Biomedical Research Career Programme:

The DBT/WT India Alliance (IA) has been promoting high-quality, internationally competent biomedical research in India for the past 10 years. Moving ahead, IA's strategic plan is directed to invest in basic biomedical, clinical, and public health research to tackle health challenges, strengthen India's research ecosystem to drive discovery and innovation, and engage with stakeholders to improve health for all.

IA is now set on a path to advance discovery and innovation to improve health in India. In 2019, IA launched, in addition to existing Fellowship programme, new funding programmes to support collaborative and interdisciplinary research (Team Science Grants; TSG), clinical research centres (CRC), and clinical research training (Clinical Research Training Programme; CRTP) with an aim to promote excellence, innovation and enhance India's health research ecosystem. Besides, it also played a major role in implementation of Affordable Approaches to Cancer Initiative - A joint research programme of Cancer Research UK and the Department of Biotechnology. Further, IA initiated the India Research Management Initiative (IRMI), with a mission to strengthen research ecosystems in India by building capacity for research management and creating a community of clinical practice. Under IRMI, funding opportunities like the IRMI Research Management Fellowships, IRMI Institutional Grants and IRMI INORMS 2020 Travel Grants are available.

During 2019-2020, 35 Fellowships, two CRC grants, two TSGs and 19 CRTPs were awarded. Additionally, IA Fellows received prestigious national and international awards and recognitions during 2019.

Name of India Alliance Fellows and their affiliation	Award/Recognition/Honor
Dr. Tavpritesh Sethi, IIIT, Delhi	"AI for Social Good Faculty Award" from Google
Dr. Kayarat Saikrishnan, IISER, Pune Dr. Subba Rao GangiSetti, IISc, Bengaluru Dr. Santosh Chauhan, ILS, Bhubaneswar Dr. G. Venkatasubramanian , NIMHANS, Bengaluru Dr. Benu Brata Das, IACS, Kolkata Dr. Kausik Chakraborty, CSIR-IGIB, New Delhi	S. Ramachandran National Bioscience Award for Career Development 2019
Dr. Kavita Babu, IISc, Bengaluru	Janaki Ammal National Women Bio-scientists Award
Dr. Arun Shukla, IIT, Kanpur	Sun Pharma Research Award 2019 in Pharmaceutical Sciences
Dr. Satyait Mayor, NCBS, Bengaluru	Chevalier de l'Ordre national du Mérite
Dr. Siddhesh S. Kamat, IISER , Pune	EMBO Young Investigator
Dr. Kayarat Saikrishnan, IISER, Pune Dr. Soumen Basak, NII, New Delhi, Dr. Dhiraj Kumar, ICGEB, New Delhi	Shanti Swarup Bhatnagar Prize for Science and Technology
Dr. Dorcas BC Gandhi, CMCH, Ludhiana	Emerging Leaders Award by the World Heart Federation and Young Investigator Award by the World Stroke Organization
Dr. Uma Ramakrishnan, NCBS, Bengaluru	INSA Fellow 2020

A total of 128 publications in high-ranking international journals were attributed to IA funding on Europe Pubmed Central in 2019. In 2019-20, IA organized six one-day Science Communication (SciComm101) workshops that trained around 300 Masters, PhD and Postdocs from around the country. Through its India EMBO symposia funding scheme, five scientific meetings were funded in India that aim to address discovery and innovation in life sciences through an interdisciplinary approach.

IA also anchored and supported various Science Communication and Public Engagement projects:

- India Science Media Fellowship in partnership with Nature India: Fellowships aimed at strengthening journalistic and public understanding on issues related to but not limited to the interface between science (biomedicine, biodiversity, health, environment and allied areas) and society.
- SciComm Webinar Series in collaboration with the International AIDS Vaccine Initiative (IAVI): a series of webinars on various aspects of science communication for scientists, science communicators and journalists based in India and Africa

- The Explorer Series: A Pan-India popular science talks series specially designed to expose and inspire the young students to the excitement and value of science.
- A theatre piece around mental health: Aksar, Yunhi... Aisa Lagta Hai (Often, Sometimes, It Feels Like This). Organised by It's Ok To Talk, Sangath, the programme explored the multiple silences that exist around mental health in India.
- Exploring Mental Health in the Indian Science Scene: A media project by the Life of Science that aimed to explore different scenarios and perspectives on mental health in Indian academia and start conversations on mental well-being that would lead to framing of well-rounded policies to promote mental health and curb harassment at research institutions in the country.
- Grassroots comics Workshops on Antibiotic Resistance; A series of events and workshops in Delhi and Bangalore to engage and partner with young children and medical students to raise awareness about the perils of antibiotic resistance.
- Tackling unwanted guests in the brain - Encephalitis awareness for school children: A special programme on World Encephalitis day by India Alliance Fellow Chitra P. in Bangalore was organized to engage school children, teachers and parents on Encephalitis, its causes, symptoms and preventive measures.

One of the Webinars organized by India Alliance in the SciComm webinar series

Children participating in an event organized on World Encephalitis Day in Bangalore

School students at the Explorer Series in IIT Jodhpur

(E) International Fellowship:

(i) DBT-TWAS Fellowship Programme: The Department of Biotechnology and The World Academy of Sciences (TWAS) provide Biotechnology fellowships to foreign scholars from developing countries who wish to pursue research in newly emerging areas in biotechnology for which facilities are available in the premiere research Laboratories/ Institutes in India. The Department provides fellowship and contingency grant to fellows. The fellowships are tenable in Institutes in India. The fellowships are provided in three categories:

a. Full-Time Postgraduate Fellowship to pursue a PhD research programme in India.

b. Sandwich Postgraduate Fellowship to the students (registered for PhD in their own countries) for training in India to help in their PhD.

c. DBT-TWAS Postdoctoral Fellowship to pursue a postdoctoral research programme in India.

During the year, 47 researchers have availed this fellowship for fulltime PhD and post doctoral research. 25 papers have been published.

A Conclave bringing together fellows supported under the programme was organized in August, 2019 at Chennai, India. As a step to further the international research collaborations and to strengthen the research activities among the developing nations, DBT embarked upon the initiative of organizing this conclave for the DBT-TWAS Fellows. The main aim of the conclave was to assess the performance of fellows and try to understand their concerns and make the programme better in near future.

First Conclave of DBT-TWAS Fellowship Programme

(ii) DBT Energy Biosciences Overseas Fellowship and Chair: The "Energy Biosciences Fellowship and Chair program" is aimed at engaging senior scientists of Indian origin working in modern biological sciences, and who are desirous of pursuing, complementing and enhancing the quality of R&D in energy-related biosciences in Indian institutions. The overall aim of the programme is to strengthen the research, capacity building and develop skilled human resources to fulfill the country's growing demand in biofuel and bioenergy area. Since 2009, eleven awardees with diverse expertise have returned to India and are working/have worked with the DBT Bioenergy Centres and other Indian Institutes. Out of eleven, seven awardees got regular positions in premier institutes of India and more than 65 papers have been published in journals of international repute.Total of 7 patents have been filed in the area of biofuels and bioenergy and four processes have been developed for production of cellulases , glucose tolerant â-glucosidase enzyme, novel triacylglycerol lipase (rc-TGL). During the year 2019-20, 2 Chairs and 3 Fellows availed the fellowship.

(iii) Newton Bhabha PhD Placement Programme:

Under the flagship Newton Bhabha PhD Placement programme 2019-20, the Department along with British Council, New Delhi offered short term placements to 34 Indian candidates to pursue part of their PhD research in UK.

(iv) Building Bharat-Boston Biosciences (B4) Programme: Building Bharat-Boston Biosciences (B4) Program", is a second phase of the earlier "Boston Bangalore Biosciences Beginnings (B4) Program". The Lakshmi Mittal and Family South Asia Institute, Harvard University (Mittal Institute), is collaborating with IBAB, Bengaluru, India and IISER, Pune, India for the implementation of this program. The aim of B4 is to link up Institutions in India and Boston to promote research and creation of new knowledge in Biosciences through collaboration between the two countries, in the emerging areas of Biosciences.

Department supported the following activities under DBT B4 Programme:

B4-Fellowships: Up to eight Science and Technology Fellowships for eighteen months in the fields related

to biosciences at Harvard and other institutions in the Boston area. 5 fellows have been placed in laboratories at Harvard and Boston University.

B4-Workshops: There is a provision of two workshops per year, each spanning for two weeks (Young Scientists Development Course) on topics related to Biosciences that includes interdisciplinary learning for young scientists of India. During the year, a workshop on Bioimaging was organized at IISER-Pune. 25 doctoral and post-doctoral fellows participated in this workshop.

B4-Semianrs: Two seminars annually (In country seminars), each held in a city in India to highlight the work of the returning visiting scientists. During the year, a seminar 'Preparing young Indian scientists for life sciences in the 21st century' was organized at NIPGR, New Delhi. About 120 participants including faculty and students from NIPGR, NII, AIIMS and other institutions in Delhi benefited from this seminar. The second seminar, 'Life Sciences in the next decade' was organized at IISER-Pune and was attended by about 150 students and faculty.

(v) Khorana Programme for Scholars: The objectives of the programme is to provide an opportunity to Indian UG and PG students to gain exposure and access to world class research facilities at different laboratories in the USA for internship. It promotes research and capacity building in frontline areas of biotechnology being implemented through Indo-US S&T Forum (IUSSTF). 49 students were selected for support during 2019-20 under this programme.

(F) Training Programmes:

(i) Short Term Training Programme for Mid-career Scientists and UG & PG Teachers

Department is supporting short term training programme of 2-3 weeks duration for 20-25 participants to upgrade skills of mid-career scientists including young faculty teaching at undergraduate & post-graduate level so as to keep them abridged with latest tools & technologies in biotechnology and allied areas. During the year, 9 training courses were selected by the Department for support.

(ii) Biotech Industrial Training Programme (BITP):

Department of Biotechnology is supporting Biotech Industrial Training Programme (BITP) for providing hands-on training for six months to fresh B.E./B.Tech./ M.Sc./M.Tech. Biotechnology students. The objective of this program is to impart skill based training to students so that their employability increases in relevant industries. To give more impetus to this programme, the Department has adopted apprenticeship model for implementation from this year (2019-20). Linkages have been developed with Life Science Sector Skill Development Council (LSSSDC), New Delhi for selection of partnering industries for providing apprenticeship in Biotechnology sectors. There is provision to select 800 students/year under DBT-BITP Apprenticeship Program. Stipend is paid to all selected candidates for six months period.

During the year, a total of 1654 applications were received, out of which 1295 candidates appeared in online test, 1019 candidates were shortlisted for interview. Based on interview, 480 candidates were finally selected for industrial training. 50 companies have been registered on apprenticeship portal for imparting industrial training. Based on the specific training imparted to students it helps Biotech industry to select students for specific job roles.

(G) Workshops

(i) IndiaBioscience-Young Investigator meetings and students workshops: Department has supported IndiaBioscience project with the objective to catalyze transformation in key areas of life sciences and biotechnology for mentoring to excel research activities, recruitment of trained manpower, quality education, outreach and science popularization through Young Investigator Meetings (YIM) for young investigators (Teachers and Scientists), workshops for Postgraduate, PhD and Post-Doctoral Fellows and Webinars. IndiaBioscience has also created life science and biotechnology researchers' data base for reference and connecting with science community. During the year, 5 webinars on diverse topics in areas of biotechnology, one Regional Young Investigator Meeting and three national level students' workshops were organized on various themes/topics.

(ii) **Foldscope: Microscopy for all:** The Foldscope invented by an Indian scientist Dr. Manu Prakash at Stanford University and brought to India after signing of a Statement of Intent between the Department of Biotechnology, Government of India and Prakash Lab (Stanford University), USA. Under initiative of "microscope for every child" the Department has organized a number of workshops and distributed Foldscopes to the resource constraint schools and colleges across the country including north eastern region of India. During the year 2019-2020, DBT organized 5 (five) foldscope workshops covering 53 aspirational districts in 12 states, trained 300 teachers and more than 2000 students on use of foldscope as an educational tool

(iii) **Nobel Prize Series, India-2019:** The Department of Biotechnology has an ongoing collaboration with the Nobel Media AB to hold the Nobel Prize Series in India over five years. First two events were organised in Gujarat and Goa respectively in 2017 and 2018. In this series the 3rd Nobel Prize Series India 2019 was organised by Department and Nobel Media AB, Sweden in partnership with the Government of Punjab from 11th -13th September, 2019 at National Agri-Food Biotechnology Institute (NABI), Mohali, Punjab Agriculture University (PAU), Ludhiana, Punjab and at Delhi. The theme of the event was "Teaching and Learning". In this event more than 2500 students and research scholars as well as 900 odd teachers and young faculties participated and were enlightened about Science/Nobel Prize and its impact on the society.

Glimpses of Foldscope workshops organized for aspirational districts by DBT

Press Meet with dignitaries at 3rd Nobel Prize series 2019.

3rd Nobel Prize series 2019 attnded by students and teachers.

Public lecture by Prof. Serge Haroche Nobel laureate 2012, Physics during 3rd Nobel Prize series 2019.

(iv) **Human Frontier Science Programme organization (HFSPO):** India is one of the member HFSPO. The overall objectives of the programme is to support innovative, cutting edge high risk research in frontiers of life sciences and promoting international collaboration in the spirit of science without borders. HFSPO support investigators under four categories - Research grant, Long term fellowship, Cross disciplinary fellowship, Career development awards. In 2019, five Indians received support from HFSPO grants and fellowship under various categories for conducting joint collaborative research.

(v) **European Molecular Biology Organization (EMBO):** The Department of Biotechnology, EMBO and the EMBC has an ongoing cooperation agreement to strengthen the scientific interaction and collaborative research between India and Europe. India is a EMBC Associate Member since 2016. The cooperation has led researchers/ academicians working in India to participate in all EMBO programmes and activities. Under this, Indian scientists received support from EMBO in 2019 under various categories including: EMBO Young Investigator Programme-1, EMBO Global Investigator Network-3, EMBO Fellowships-3, EMBO Advanced Fellowships-1, EMBO Short-Term Fellowships-24, EMBO Courses & Workshops-2, EMBO Practical Courses-1, India-EMBO Symposia funded by EMBO-3, EMBO Keynote Lectures-1, EMBO Laboratory Leadership Courses-2 for international level scientific training /lectures.

(H) DBT Awards - Recognizing Excellence:

(i) **Tata Innovation Fellowship:** The Department initiated the TATA Innovation Fellowship scheme in 2006 to recognize and reward scientists up to 55 years of age, with outstanding track record in biological sciences, commitment to find innovative solutions to major problems in healthcare, agriculture and other areas related to life sciences and biotechnology. Each year up to 5 fellowships are given. Each awardee receives, in addition to regular salary, a fellowship @ Rs. 25,000/- per month and a contingency grant of Rs. 6.00 lakh per annum. The duration of the fellowship is initially for three years which can be extended further by two years on a fresh appraisal. From its inception to March, 2019, 61 scientists have been awarded the fellowship.The process for selection of Tata Innovation Fellows for this year 2019-20 is underway.

(ii) **Har Gobind Khorana-Innovative Young Biotechnologist Award (IYBA):** The Innovative Young Biotechnologist Award (IYBA), initiated in 2005, is a career-oriented award to nurture outstanding young scientists with innovative ideas and desirous of pursuing research in cutting edge areas of biotechnology. The awards are conferred to scientists below the 35 years of age, subject to certain relaxations in cases of women, OBC, SC/ST and differently abled. Scientists on a soft position are also eligible to apply for the award. The award carries a fellowship of Rs.1.00 lakh/annum for candidates who are on permanent faculty position and Rs.75000/- per month for those candidates who do not have a regular faculty position along with a project grant to pursue their research. During the last five years, DBT has awarded fifty two young scientists under this scheme. During this year, 15 candidates were selected for the award (Table A).

Table A: Details of selected 'Har Govind Khorana- Innovative Young Biotechnologist Awardees' (IYBA)-2019-20

S. No.	Name of Awardees	Affiliation	R&D Activity Selected for Award
1.	Dr. Anjana Badrinarayanan	National Centre for Biological Sciences, Bangalore	Characterization of a novel translesion-synthesis repair pathway in bacteria:*Mechanism of action, regulation and impact on stress-induced mutagenesis*
2.	Dr. Anshika Srivastava	Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS), Lucknow	Probing the dynamic balance of histone H2AUb1 regulatory axisin hypertrophic cardiomyopathy and early heart development
3.	Dr. Appu Kumar Singh	Indian Institute of Technology, Kanpur	Temperature-sensitive TRP ion channels as Biological thermometers to gauge the pain
4.	Dr. Atul Kumar	Indian Institute of Science Education and Research Bhopal, Bhopal	Understanding the regulatory mechanism of Parkinsons & development of synthetic nanobody
5.	Dr. Devanjan Sinha	Banaras Hindu University, Varanasi	Niche partitioning in Stem Cell populations through a Redox sensitive mitochondrial reprogramming pathway
6.	Dr. Dharmaraja Allimuthu	Indian Institute of Technology, Kanpur	CYCLIC-PROATCs Triggered by chemical or photocaged forspatiotemporally controlled degradation of intracellular proteins in cancer
7.	Dr. Jaya Prakash	Indian Institute of Science, Bangalore	Quantitative portable handheld multi-modal optoacoustic ultrasound (OPUS) imaging system
8.	Dr. Karishma S Kaushik	DBT Institute of Bioinformatics and Biotechnology, Savitribai	A human-relevant, biomimetic, microengineered platform for accelerated

		Phule Pune University, Pune	and high-throughput pre-clinical testing of chronic wound infection therapeutics
9.	Dr. Mayuri Rege	Ramnarain Ruia Autonomous College, Mumbai	Light induced protein production in *Pichia pastoris*
10.	Dr. Mini Jose Deepak	Centre for Neuroscience, Indian Institute of Science, Bangalore	Investigating the role of Shootin 1 in neuronal polarity establishment
11.	Dr. Priyanka Singh	Indian Institute of Technology (IIT) Jodhpur, Karwar, Jodhpur	Elucidating the role of centrosome protein CEP152 in primary microcephaly
12.	Dr. Rachit Agarwal	Indian Institute of Science, Bengaluru	Rapamycin carrier based sustained delivery for treatment of Osteoarthritis
13.	Dr. Sharmistha Sinha	Institute of Nano Science and Technology, Mohali	Understanding the Forces Involved in the Packing of Enzymes Inside the Bacterial Microcompartments for the Development of Novel Encapsulated Bio-Systems
14.	Dr. Suchetan Pal	Indian Institute of Technology, Bhilai	Glucose-responsive DNA capsule for insulin delivery
15.	Dr. Susmita Roy	Indian Institute of Science Education and Research Kolkata (IISER), Kolkata	A Structural Topology-based Electrostatic Model (STEM) of RNA to investigate functional conformational changes of bacterial and viral RNAs

(iii) **S. Ramachandran-National Bioscience Award for Career Development:** National Bioscience Award for Career Development is conferred in recognition of outstanding contributions of scientists below 45 years of age who are engaged in basic and applied research in Biological Sciences including Biotechnology, Agricultural, Medical, and Environmental Sciences and all other allied areas. The award recognizes the significant contributions made by scientists in their respective domain research areas with potential for product and technology development. A maximum of 10 awards are conferred every year. Each Award carries a cash prize of Rs 2.00 lakh, a citation trophy along with project research grant of Rs 15.00 lakhs (Rs.5.00 lakhs/year) for a period of 3 years. During the year, a total of 10 awardees were selected **(Table B)**.

Table B: Details of selected 'S. Ramachandran - National Bioscience Award for Career Development' (S. R. - NBACD) – 2019

S. No.	Name of Awardees	Affiliation	R&D Activity Selected for Award
1.	Dr. Benu Brata Das	Indian Association for the Cultivation of Science, Kolkata	Exploring the Role of Tyrosyl DNA phosphodiesterase I (TDP1) in Transcription-induced DNA damage and resolution of R-loop

2.	Dr. Chandrima Das	Saha Institute of Nuclear Physics, Kolkata	Investigating the functional interplay between key transcription factor TCF7l2 and epigenetic regulator TCF19 to modulate metabolic gene expression programs during Endoplasmic Reticulum stress
3.	Dr. G. Venkatasubramanian	National Institute of Mental Health and Neurosciences, Bengaluru	Translational Research on Brain Connectivity in Schizophrenia: Neuromodulatory Effects of transcranial Direct Current Stimulation
4.	Dr. Kausik Chakraborty	CSIR-Institute of Genomics and Integrative Biology, Delhi.	Understanding the folding mechanism of specific enzymes in presence of their ligands
5.	Dr. Kayarat Saikrishnan	Indian Institutes of Science Education and Research (IISER), Pune	Mechanism of DNA translocation by NTP-dependent restriction enzymes
6.	Dr. N. Ravi Sundaresan	Indian Institute of Science (IISc.), Bangalore	Activation of Sirtuin 2 deacetylase as a strategy to treat Cardiomyopathy due to anthracyclines
7.	Dr. Naveen C. Bisht	National Institute of Plant Genome Research, New Delhi	Investigating the molecular-genetic basis of multifunctional glucosinolate transporters (GTR1/GTR2) in Brassica crops
8.	Dr. Santosh Chauhan	Institute of Life Sciences, Bhubaneswar	Understanding the Role of IRGM in controlling autoimmune diseases
9.	Dr. Subba Rao Gangi Setty	Indian Institute of Science, Bangalore	Role of small GTPases in modulating human pigmentation
10.	Dr. Tapas Kumar Manna	Indian Institutes of Science Education and Research (IISER),Thiruvananthapuram	The role of colonic hepatic Tumor Over-expressed Gene (chTOG) in regulation of kinetochore size and fidelity of mitotic chromosome segregation

(iv) **Janaki Ammal-National Women Bioscientist Award:** The Department recognizes the contributions of senior and young women scientists in the country who are working in the areas of Biology and Biotechnology. The Janaki Ammal-National Women Bioscientist Award is conferred under two categories- Senior category and Young category. The senior category award recognizes life time contributions of scientists, who have made significant contribution in basic/ translational research with benefit to the society. The Award carries a cash prize of Rs 5.00 lakh along with citation and a gold medal. The young category award is given to women scientists below 45 years of age who are active researchers with focus on basic and applied research in various fields of modern biology and biotechnology. Each award carries a cash prize of Rs

1.00 lakh with citation and a gold medal and Research Grant of Rs 5.00 lakhs per annum for a period of 5 years. One scientist under senior category and two scientists under young category were selected for 2019-20 (**Table C**).

Table C: Details of selected 'Janaki Ammal - National Women Bioscientist Award' (J. M. -NWBA)- 2019

Senior Category			
S. No.	Name of Awardees	Affiliation	R&D Activity Selected for Award
1.	Dr. E V Soniya	Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram	Characterization of Type III PKS from Indian Bael, a polyketide synthase involved in quinolone biosynthetic pathway for the production of medicinal natural compounds
Young Category			
1.	Dr. Kavita Babu	Indian Institute of Science (IISc.), Bangalore	Characterizing the signaling functions of Cell adhesion molecules at the synapse
2.	Dr. Shilpee Dutt	Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), Kharghar, Navi Mumbai	Defining GCN5 as marker for resistance onset and delineating evolution of molecular pathways during acquired resistance in AML

(v) **Biotech Product, Process Development and Commercialization Award:** The aim of the Biotech Product & Process Commercialization Award is to recognize scientists/innovators/entrepreneurs/ institutions/companies both in public as well as private sector who are working towards development and commercialization of process/technology/product in the areas of modern biology and biotechnology. Up to five awards are given every year. Each award carries a cash prize of Rs. 2.00 lakh along with a citation and trophy, however, if the product is commercialized and has much higher utility, cash award of Rs.5.00 lakh is given to the awardee. The award is given in an individual/team category as well as under institutional category. During the year, five awards with a cash prize of Rs.2.00 lakhs each were conferred during Global Bio Summit-2019 on 22nd November, 2019 by Hon'ble Minister of Railway and Minister of Commerce, Shri Piyush Goyal **(Table D).**

Table D: Details of selected 'DBT-Biotech Product, Process Development and Commercialization Awardees-2019

S. No.	Name of Awardees	Affiliation	R&D Activity Selected for Award
Individual/Team Category			
1	Dr. Vijay K Choudhary & Team	Professor, University of Delhi, South Campus And Director, CIIDERT, New Delhi	Development of a phage-displayed naive human antibody library for the discovery of therapeutic antibodies

	Dr. Amita Gupta Dr. Vaishali Verma	Associate Professor, University of Delhi, South Campus, New Delhi Scientist, CIIDERT, New Delhi	
2	Dr. Soma Chattopadhyay	Scientist-E Institute of Life Sciences, Bhubaneshwar	Development and characterization of polyclonal and monoclonal antibodies against the four essential non-structural proteins namely nsP1, nsP2, nsP3 and nsP4 of Chikungunya virus
3	Dr. Rachna Dave	Founder MicroGO LLP, Chennai	Development of technology for safe and save food, water and health built on patented platform Tubele™
Institutional Category			
4	Gennova Biopharmaceuticals Limited	Hanjawadi, Pune, Maharastra	Development of tenectase; a 3rd generation thrombolytic glycoprotein for Acute Ischemic Stroke (AIS)
5	Embio Limited	Hiranandani Garden, Powai, Mumbai, Maharastra	Manufacture of a chiral intermediate R-phenyl Acetyl Corbinol (R-PAC) by a greener efficient biotransformation process using a category-1 GMO yeast at a scale of 36KL

(vi) **Distinguished Biotechnology Research Professorship Award:** The Department has instituted Distinguished Biotechnology Research Professorship Award Scheme to utilize the expertise of superannuated distinguished scientists, who are still scientifically active and capable of making significant research contribution in biological sciences, biotechnology and related fields. The Scheme enables distinguished scientists to pursue their research interests in their institution within India. A maximum of 5 awards can conferred at any point of time. Currently 3 positions are filled under the said scheme and selection procedure for 2 vacant positions is underway.

(vii) **BioCARe: A Mission Programme of the Department for empowering and nurturing Women Scientists of India**

With the vision of the Department to promote women in science and in an attempt to enhance the participation of Women Scientists in Biotechnology Research, the Department launched Biotechnology Career Advancement and Re-orientation Programme (BioCARe) for women scientists in the year 2011. The programme is mainly for Career Development of employed/ unemployed women scientists for whom it is the first extramural research grant. The scheme is open for all areas of Life Sciences. This scheme gives opportunity to unemployed women scientists those having a break in career to be back to the main stream by getting their first grant as the Principal Investigator. The purpose of the scheme is to build capacities for women Scientists employed fulltime at universities/ Institutes or unemployed women scientists so as to help them undertake independent R&D projects. Five calls have been announced and 361 women scientists have been supported so far. 250 papers have been published. 11 patents have been filed. 32 women scientists who were unemployed at the time of getting this BioCARe project have got permanent employment in various universities, Institutes, Colleges and

Industries including one in abroad as Research Scientist. 145 poster presentations have been made and 26 have won awards at various platforms. In the year 2019-20, 46 women scientists were supported; 5 papers have been published; 7 Women Scientists got permanent employment in Universities, Institutes and Industries after getting BioCARe project. The data presented indicates that talent pool of women researches need recognition and support so that they can restart their careers as independent researchers through this scheme.

International Summit on Women in STEM– "Visualizing the Future: New Skylines"

The Department organized - International Summit on Women in STEM–"Visualizing the Future: New Skylines" on 23rd and 24th January 2020, New Delhi. The Summit was organized with the overall aim to boost the participation of women in STEM field for development of scientific career. Different sessions of the summit included mechanisms of leadership building, empowering women through networking, career opportunities and interactive exercises with scientists. Discussion and interactive sessions between aspiring young, mid-career and senior scientists in the STEM field were held to understand the future requirement of women's employment and career progression. Keynote speakers were renowned women scientists in STEM from different countries, young as well as established women scientists, science communicators and entrepreneurs from India. Around 400 participants from different STEM field across the globe participated in the event including scientists, socialists, entrepreneurs, researchers, teachers and students. Posters were presented by women scientists and students. The summit actually provided a good platform for young students and researchers to interact and network with leaders in the field, to develop ideas and generate a future action plan for making career in STEM fields.

Launch of Booklet of Women in STEM Summit, 2020

(ii) **Bioenergy-Awards for Cutting Edge Research (B-ACER):** Recognizing that clean and efficient energy, environmental protection and energy security are among the biggest challenges both for India and the United States; the Department of Biotechnology, and the Indo-U.S. Science and Technology Forum are committed to tackling these issues by building capacity in these frontier areas. To nurture future innovators and thought leaders in the priority areas of Biofuel and Bioenergy, the Bioenergy-Awards for Cutting Edge Research (B-ACER) - a dynamic and transformative program was developed in 2015-16 to foster contacts between students and scientists from India and the United States. The objective of the B-ACER program is to broaden intellectual horizons by introducing top Indian students and young faculty to scientific and innovation ecosystems of leading U.S. institutions. It was envisaged that such an interaction would enable the creation of sustainable and vibrant linkages between the two nations, as well as build long-term Indo-American science and technology relationships. The B-ACER Program has successfully completed three years and is currently in its fourth year of implementation. Under the fourth call announced in year 2019, 7 Interns and 4 Fellows have been selected for Award. There are 5 publications in the year 2019-20.

(iii) **Indian Biological Engineering Competition (IBEC) for participating in International Genetically Engineered Machine (iGEM) Competition:** Indian Biological Engineering Competition (iBEC) similar to IGEM is organised by DBT which is a pre competition for selecting best teams for further support to participate in iGEM. DBT has been coordinating the programme for the last 4 years and a conclave is being organised to bring together all teams (students and mentors) who have participated from India in the iGEM competition so far. Total 5 proposals were selected for financial support. The student teams got a better insight from other groups and innovative ideas about potential applications of Biological engineering with exposure to interesting workshops by companies like Ginko Bioworks, IDT, NASA etc.

To participate in iGEM Competition 2019, student teams of following 5 institutes were selected for further support from DBT:

1. MIT School of Engineering, Pune
2. IISER Pune
3. Shiv Nadar University, Gr. Noida
4. IISER, Tirupati
5. IISc Bangalore

In the IGEM Competition 2019, out of the 5 teams (25 students) supported by DBT. 4 teams have won the medals IISc, Bangalore , IISER Tirupati have won Gold Medals and Shiv Nadar University, Noida and IISER Pune got Silver medals .

(I) **Popularization & Promotion of Biotechnology:**

DBT-CTEP Programme: To popularize Biotechnology activities in India, Department of Biotechnology (DBT), Government of India provides financial assistance towards organizing Conference, Travel, Exhibition and Popular Lectures (CTEP). Travel support is provided to researchers for presenting their papers in the conferences which are being organized outside the country. It also extends support for organizing DBT stalls in Exhibitions held in India and abroad. Financial support is also provided for organising popular lectures. During the year 409 proposals were recommended under CTEP.

Glimpses of the 107th Indian Science Congress Pride of India 2020 (supported under CTEP).

Research Resources, Service Facilities and Platform (Infrastructure)

The Department of Biotechnology has made an enormous effort towards establishing and creating research related infrastructural facilities (National Facilities) in several universities/institutions across India during the year through its two schemes DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research Programme (DBT-BUILDER) and DBT - Scientific Infrastructure Access for Harnessing Academia University Research Joint Collaboration, (DBT-SAHAJ) .

Objectives: The major objectives under this programme are:

- Promote, upgrade and establish new biotech facilities/ infrastructure viz. animal house; gene banks; repositories for microbes, plants, model organisms and infectious organisms etc
- Augmentation of research activities of scientific community at regional, national and international level.
- Promote growth of life science and biotechnology in the university system
- Linking research to education at every opportunity through creation/reengineering/ remodeling/up-gradation of life science departments in central/state universities.

Facilities created during the year are as follows:

Fast Life Time Imaging Facility at Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram, Kerala

The facility envisages promoting biomedical research using life time imaging modalities and facilitating advanced training in life time imaging applications for Indian researchers.

The facility has a high-throughput spinning Disc Confocal imaging facility for real-time imaging of cells, tissues and organoids for research and drug screening application and training.

Central Molecular Laboratory at Govind Ballabh Pant Institute of Postgraduate Medical Education and Research (GIPMER), New Delhi

Molecular testing has emerged as a key component for understanding disease process and development of newer modalities aiding in diagnosis, prognosis and treatment of various disorders. Additionally, the perspective of cancer genomics has shifted from single gene to genome wide study. While the perspective of cancer genomics has shifted from single gene to genome wide study, candidate gene approach considering few genetic loci for disease risk has not led to fruitful outcomes. In view of the above, the Central Molecular Laboratory facility at GIPMER, New Delhi has been established to facilitate studies focused on diagnosis for precision medicine in order to understand the disease process and utilize it as Clinical Research Facility at G.B Pant Hospital, New Delhi.

Bioactive Bhubaneswar Biophysical Characterization Facility at Institute of Life Sciences (ILS), Bhubaneswar and National Institute of Science Education and Research (NISER), Bhubaneswar

The project is a multi-institutional one which envisages creation of research facilities at two institutes of Bhubaneshwar, Odhisha – Institute of Life Sciences (an autonomous institute of DBT) and National Institute of Science Education and Research (an institute under the Department Of Atomic Energy).

An analytical Ultra Centrifuge (AUC) is being installed at ILS, Bhubaneshwar to carry out experiments related to sedimentation velocity and sedimentation equilibrium in order to obtain the binding stoichiometry in different biomolecular complexes, oligomeric status of proteins, to analyse precise molecular mass of protein/complex samples and characterize the binding parameters.

The proposed in-house X-Ray Diffractometer (XRD) at ILS, Bhubaneshwar will allow screening of macromolecular crystals for diffraction quality and for standardization of cryo protectant conditions for the obtained crystals, to be sent for diffraction data collection at a suitable synchrotron source. The facility will also allow collection of high resolution data

from crystals for determination of macromolecular structure.

A Cryo- Transmission Electron Microscope (Cryo-TEM) will be installed at NISER, Bhubaneswar to solve structures of complex protein assemblies involved in cell division, membrane protein complexes, chromatin assemblies and several other large protein complexes.

High Resolution Mass Spectrometry based Proteomics Research and Training Facility, Indian Institute of Technology, Bombay (IIT-B)

The facility was established to facilitate Liquid Chromatography-High Resolution Mass Spectrometry (LC-HRMS) based proteomics experiments in order to advance service platform for extensive discovery, targeted and quantitative proteomics analysis for internal and external users. The facility also envisages imparting training in advanced proteomics by conducting proteomics courses and workshops to provide training to academia and industry. The facility functions on a self-sustainable model by generating revenues through fee-for-service to run the facility successfully in long-term, after the support from DBT is over. This facility has trained 5 Technical Assistants and 8 Ph.D students during this year. 4 workshops have also been held. Further, this facility has contributed to 3 publications, 1 book chapter, 5 M.Sc dissertations, and 6 Ph.D theses. 60 researchers from different institutes across the country have availed this National Facility.

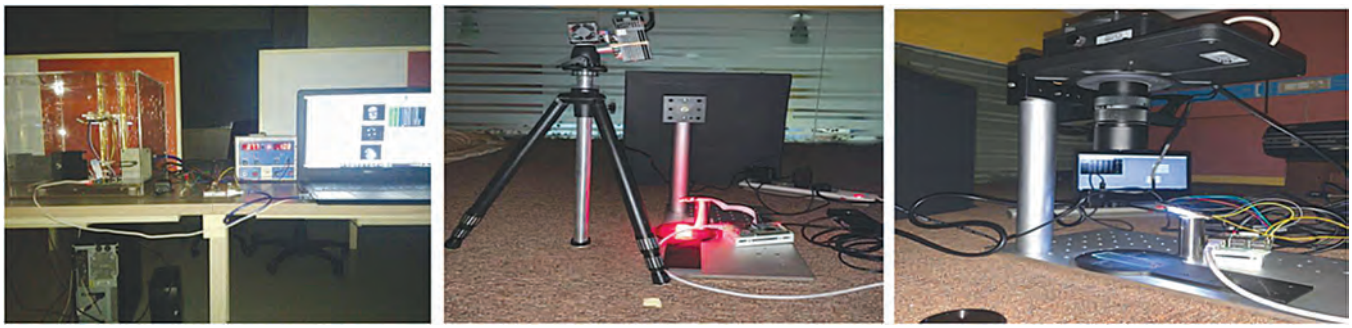
HR-MS Proteomics and Metabolomics Workshop at IIT Bombay

Advanced Centre for Cryo-electron microscopy at the Indian Institute of Science (IISc), Bangalore: The objective of this project was to establish an advanced, biological cryo-electron microscopy facility, to study the structure and function of important bio molecules and shall be accessible to users from all over the country for training and research purposes. The facility was successfully established in November 2018 and is equipped with a Talos Arctica 200 kV cryo-Transmission Electron Microscope. This facility is now heavily being used by multiple research groups from all over the country. Several PhD students and postdoctoral fellows from multiple research groups from IISc and other institutions are frequently using this facility. Furthermore, this facility has also attracted a number of industry partners such as Lupin Pharmaceuticals, Inc. Bangalore, Sun Pharmaceutical Industries Ltd., Alembic Pharmaceuticals Ltd., NATCO Pharma Limited. The facility has catered to the needs of various disciplines (biological and non-biological) such as Organic Chemistry, Solid State Chemistry, Applied Physics to name a few. During this year, 35 research groups and more than 70 researchers/students have accessed this facility. Researchers from across the country can book this facility through an online booking. A trained EM manager and two postdoctoral fellows have been assigned to prepare cryo-EM samples and help in data collection.

Advanced Research Platform for Crop Sciences (ARPCS) at the National Institute of Plant Genome Research (NIPGR), New Delhi: The ARPCS, a centralized facility at NIPGR was funded to enable systematic *in planta* functional characterization of newly identified candidate genes/pathways that have potential to contribute to many of the useful agronomic traits. The facility which has state-of-art facilities such as Plant Growth Chambers, Green House, *in-vivo* plant imaging equipment, automated DNA Sequencer, to name a few, was inaugurated recently on 30th November 2019. This National Facility is operating on a self-sustainable use and pay model according to fixed rates and consumables provided. A new technology entitled "Untargeted protein identification in DDA mode, protein identification from 1-DE, 2-DE and gel free samples, identification of interacting protein partners, Phospho protein analysis" has been developed within this short span of time.

A glimpse of Mass spectrometers and data processing systems available at the facility

Infrastructure Facility for Advanced Research and Education in Diagnostics, Indian Institute of Technology , Bombay (IIT-B): In this project, twenty investigators across various departments at IIT Bombay have collaborated to set-up a state-of-the-art infrastructure facility on diagnostics at the Wadhwani Research Centre for Bioengineering (WRCB) at IIT Bombay. The main objectives of the project are to promote interdisciplinary translational research, providing education/training and building a state of the- art infrastructure facility for research. This year, investigators have developed proof-of-concept platform technologies for assessing biomarkers, and built prototypes of devices for biomarkers validation and detection. The major facilities included are an Immuno histochemistry facility, Pilot scale fermentor facility for microbial and animal cell cultures, Device Fabrication and DC/AC/RF testing facility and a facility for Broadband Optical interferometry and microscopy. This facility has resulted in 8 publications, 1 patent, and development of 11 technologies. 16 researchers have also been trained.



Facilities available under Microarray platform technologies for in-situ, on-chip protein expression classifier for biomarker discovery. (L-R) Integrated System Prototype, Fluorescence acquisition & analysis system and Ultra low light intensity imaging system

Access to Macromolecular crystallography beamlines at European Synchrotron Radiation Facility (ESRF) Grenoble, France: The ESRF, located in Grenoble, France, is the world's most intense X-ray source and a centre of excellence for fundamental and innovation-driven research in condensed and living matter science. Access to such a facility is currently very limited nationally & internationally. Considering the vast areas of application of this facility, such as drug-discovery, identification and characterization of novel proteins etc. the Department of Biotechnology, Ministry of Science and Technology entered into a phase wise agreement with the European Molecular Biology Laboratory (EMBL) and the European Synchrotron Radiation Facility (ESRF), through its Autonomous Institute, RCB, Faridabad, in 2008. This collaboration has resulted in Publications 300 research papers in international peer-reviewed journals, submission of nearly 700 structures in the Protein Data Bank, 300 Ph.D theses involving experiments based on X-ray diffraction data, training of more than 375 researchers from across 25 different institutes/ universities across India. Considering the immense contribution made by this facility, the Department is currently in process to extend this collaboration for duration of 3 years.

Other activities: 2 Calls for Proposal were announced by the Department in October 2019 to invite proposals from Universities under DBT-BUILDER and from research institutes under DBT-SAHAJ. A total of 184 proposals were received from across the country. Further segregation of proposals revealed that 115 proposals for support were received under DBT-BUILDER and 69 proposals under DBT-SAHAJ. The Department is in the process of screening the proposals received for further consideration of support.

The Advanced Proteomics Facility was inaugurated on 4th May, 2019.

The Metabolomics Facility at NIPGR, was inaugurated on 4th December, 2019

The Metabolomics Facility at NIPGR, was inaugurated on 4th December, 2019

Biotechnology Science Cluster

Clusters approach has been successful worldwide in driving high quality innovation and entrepreneurship in a region. Considering the importance of Cluster in economic development of any region, the multi institutional regional clusters were established by the Department as an initial step towards accelerating innovation. This principle was approved as a part of the National Biotechnology Strategy that aims to develop India as a world-class bio-manufacturing hub by creating a technology development and translation network across the country. So far four Bioclusters have been established at Faridabad, Bangalore, Pune and Kalyani. The Bangalore Cluster is a joint collaboration between inStem, and NCBS Bangalore with IBAB, Bangalore and C-CAMP as allied partners. The NCR Biotech Science Cluster has been set up at Faridabad by bringing THSTI & RCB, Faridabad; NII & NIPGR New Delhi; and NBRC, Manesar together as partnering institutions. The Pune Bio-Cluster venture is spearheaded by the National Centre for Cell Science (NCCS) and Indian Institute of Science Education and Research (IISER), Pune. The Kalyani Cluster is a partnership between six institutions namely National Institute of Biomedical Genomics (NIBMG), Kalyani (Nodal Centre), Indian Statistical Institute (ISI), Kolkata, Bose Institute (BI), Kolkata, CSIR-Indian Institute of Chemical Biology (IICB), Kolkata, Tata Medical Centre (TMC), Kolkata and Indian Institute of Science Education and Research (IISER), Kolkata

The System Medicine Cluster (SyMeC), Kalyani, West Bengal: The Kalyani Cluster in West Bengal focuses on Systems Medicine through a successful cross-talk between doctors, basic scientists and biotechnologists to enable deeper understanding of diseases at the level of biological systems and thereby accelerate treatment and management of diseases with two major targets:

- Provide improved genomic signatures for prediction of progression, recurrence and failure of standard treatment for improved disease management; identify actionable targets on biological pathways and peptides/ small-molecules to interact with some of the targets.
- Create a platform for multi-disciplinary training to build a cadre of scientific, clinical and technical personnel required to drive and to sustain systems medicine.

Advanced scientific research focussed on two types of cancer, gingivo-buccal oral and cervical cancers, that are most prevalent forms of cancer among men and women in India, respectively are currently underway at the SyMeC Biocluster.

Achievements:

Oral Cancer:

- **Blocking Driver Mutations :** A peptide has been designed to block a key gain-of-function oncogenic mutation in TP53 gene. In addition, work is being

carried out to target the chromatin associated protein PC4 and the transcription factor ETS2 in order to block gain-of-function.

- Integrative Epigenomic Signature of Oral Cancer : Using assays of promoter methylation and transcriptomics, the group has identified that there is significant promoter hypomethylation driven upregulation of CD274 and CD80 that produce immunosuppression in oral cancer. They have also identified that epigenetic modifications lead to dysregulation of some genes by epigenetic modification of the DNMT3B (upregulation) and TET1 (downregulation) genes. These findings enable evaluations of these epigenetic marks as candidate biomarkers for development of oral cancer. Further, the researchers have proactively identified known drugs that can reverse the direction of dysregulation of gene expression caused by promoter methylation.

- Genomic Signatures of Oral Cancer Metastasis: By analysing high-throughput genome sequence data derived from two different tissues from a large number of patients, researchers have found that lymph node metastasis is driven by: (a) specific hotspot somatic mutations in TP53 and CASP8; (b) rare non-silent germline mutations in BRCA2 and FAT1; (c) mutations in mito-G2/M and NHEJ pathway, (d) recurrent deletion of homologous recombination associated DNA repair genes, and (e) chromosomal instability. Oral cancer patients who have mutations in the non-homologous end-joining pathway have longer disease free survival. Five genomic features have a high predictive value of LN metastasis and these features together can serve as a signature of metastasis.This work has been completed and published.

  Researchers have also investigated the association between the immune fabric of the tumor microenvironment in relation to tumor size and lymph node metastasis in OSCC-GB. Based on immunological profiling of 94 patients, it has been observed that high ratio of CD8 (+) to CD4 (+) cells in the tumour centre significantly increases the number of days of survival of a patient. Retrospective samples have been collated to identify genomic signatures in oral tumor biopsies to predict recurrence after treatment. Exome-sequencing from DNA extracted from FFPE blocks has been standardized to analyse the retrospective samples. The work is in progress. With the same objective of identifying genomic signatures to predict recurrence, a set of samples are also being prospectively collected and genomic analyses are being done.

- Non-invasive Signatures in Oral Cancer : Data from assays in metabolites, proteins, microRNA and diversity of microbiome have been generated in saliva collected prospectively from patients of oral cancer. The data are now being analysed. Identifying sequence of omics alterations in the progression from a normal tissue to a pre-cancerous lesion to frank cancer is in progress. Pre-clinical studies on SMAR1-expression levels are being checked by real time PCR and immunohistochemistry. Small molecule stabiliser of SMAR1 will then be tested in oral cancer cell lines and primary culture models.

- Single-cell RNA Sequencing : Since cancers are intrinsically heterogeneous at the cellular level, the nature of cellular diversity at the single-cell level at different stages of cancer is being examined. The hypothesis is that data on cell-type diversity and cell-type changes derived from single-cell RNA Sequencing will be highly predictive of prognosis.

Cervical Cancer:

One of the main aspects of cervical cancer initiative is to screen women in various age-groups for generation of base line data on HPV infection, histopathology, genomic, transcriptomic and epigenomic, and to correlate these with progression and stage of cervical erosion. These baseline data are also being correlated with other metadata, including habits, exposures, SES, etc. Screening of a large number of women who have been recruited in the Kalyani Cohort Study (an initiative of National Institute of Biomedical Genomics, Kalyani) and from other areas of Kolkata, has resulted in the following observations:

- The prevalence of abnormal cytological lesions (ASCUS/AGUS/LSIL/HSIL) recorded in this cohort was 4.92%, while the remaining smears, as interpreted by Pap smear test, were cytologically normal, with varying degrees of inflammation, infections etc.

- The prevalence of HPV infections, HPV16 only, was recorded among 18.18% ASCUS /AGUS samples. HPV infections were substantially higher among women with abnormal lesions (3/14; 21.43%).

- Colposcopy clinics are also being organized, to confirm the severity of the cervical status of women harbouring HPV infections and abnormal cytology along with follow up samples and data collection to track their life-course trajectories.

- To determine the genomic and epigenomic changes across various categories of cervical samples representative of the discrete stages of disease development, whole-exome sequencing and array based methylation analysis are being carried out; these assays have been completed on samples collected from 96 patients. Data analyses are in progress.

  Based on findings of past studies carried out by one of the PIs of SyMeC, further work under the SyMeC project has revealed:

- Cervical cancer (CaCx) cases with episomal and integrated HPV16 are distinct entities at the molecular level. Specifically, CKS1B gene belonging to the significantly enriched pathway "Cell Cycle: G2/M DNA Damage Checkpoint Regulation" in cervical cancers was specifically over expressed in episomalCaCx cases and correlated with decreased expression of a microRNA (miR181c) that targets CKS1b, as opposed to CaCx cases with integrated HPV16. This finding opens up the possibility of repurposing the antidepressant drug fluoxetine, a known inhibitor of CKS1B, in managing cervical cancer patients with episomal HPV16.

- **Study to Establish *in-vivo* Intraperitoneal Metastatic and Orthotopic Cervical Cancer Model**

- **Intra-peritoneal metastatic model in NOD-SCID mice by injecting ME180 human metastatic cells negative for BRCA mutation and positive for HPV:** Work has been initiated at CCMB. SyMec group members have been trained at CMB animal facility to handle and breed nude mice. Nude mice colony is now available for injecting ME180 cells. Optimization of the number of cells to be injected to develop the metastatic model is underway.

- **Intra-peritoneal metastatic syngeneic mouse model in C57BL/6 mice by injecting ID8cells:** Mouse Ovarian Surface Epithelial Cell Line ID8 is frequently used as a syngeneic mouse model for human intraperitoneal metastatic cancer. This model has been initiated at IISER Kolkata transit animal facility at the beginning of January, 2019. Five female mice were mock injected intraperitonially with PBS/BSA and 5 mice with 1 X10 6 ID-8 cells. All mice were monitored for tumor generation. After two months of the injection little swelling has been observed but no such tumor formation noticed. Number of cells to be injected and number of cells to be passaged are being optimized to check their metastatic properties. In addition, currently we are evaluating a more aggressive variant containing vascular epithelial growth factor expressing ID-8 cells to induce metastasis in C57BL/6 female mouse. The growth patterns of these ovarian cancer cells in mice were compared to the established, highly aggressive 4T1 breast cancer model. New established ID-8 VGEF cells grow much faster than the parent ID-8 cells and duplication time is less than 12 hours. Based on the preliminary in vivo experiment it is envisaged that this cell line will be clinically-relevant tool to generate much faster and more dependable metastatic mouse model.

Development of Statistical and Computational Methodologies

- "dropClust2" is a improved version of existing dropClust,

which is resource efficient, with batch effect removal, and is deployed on a web server at dropclust.com. Complete R package with tutorial is also available.

- "Structure-Aware PCA for Single-Cell RNA-Seq Data": Locality-sensitive PCA (LSPCA) has been proposed as a scalable variant of PCA equipped with structure-aware data sampling at its core. Structure-aware sampling provides PCA with a neutral spread of the data, thereby reducing the bias in its principal directions arising from the redundant samples in a data set.

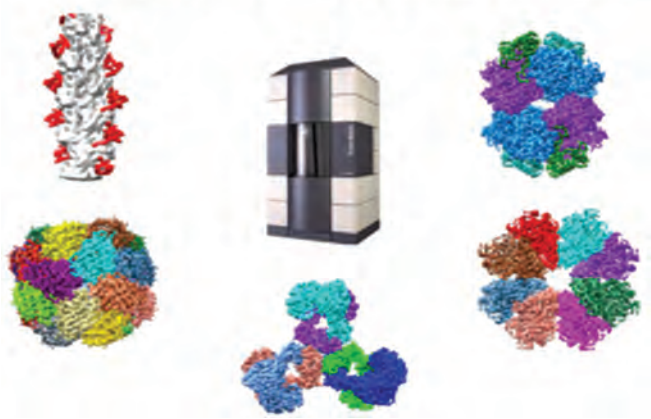
- A database management system is being designed integrating clinical data and mutation data. It is envisaged to integrate transcriptomic and other omics data.

Researchers from SyMeC, Kalyani have published their findings in 7 peer reviewed journals of international repute.

NCR Biotech Science Cluster, Faridabad: The NCR Biotech Science Cluster aims to promote innovation, facilitate public-private partnership for the development of biotechnology business incubators and parks, including partnerships with biotech & pharma entrepreneurs. The leadership developed through this cluster is playing a critical role in creation of a comprehensive ecosystem for accelerating discoveries and facilitating translation of the discoveries in real world solutions in the field of healthcare and agriculture and their commercialization. Various State of- art facility have been established namely the Advanced Technology Platform, Containment laboratories, Small and large animal facilities, 20,000 sqft area Bioincubator and BSL-3 facility. The Cluster is regularly organizing workshops and training courses on available technology platforms and these trainings are open to researchers across the country. So far more than 150 researchers have been imparted training in different areas. A total of 9 companies have been incubated at RCB Bio-incubator.

Bangalore Life Science Cluster, Bangalore: This biocluster is playing a leadership role in the country by developing structural biology infrastructure to complement existing biocluster strengths from molecules to ecosystems and to lay the foundation for integrating multiple large biological data streams into a scalable data framework. Comprehensive resources to clone, express, purify proteins and complexes, sample preparation for microscopy, data collection on the microscope as well as computing resources for analysis of initial data are all available. There is also space set aside for visiting faculty offices and a common computing room with computers connected with high-speed networks to the central storage and computing systems. A National Cryo-EM Facility has been established at this cluster and to build capacity in this technique, several workshops and lectures have been conducted. The users have also been helped from protein purification to structure determination. Many publications in international peer-reviewed journals have emerged out of this support.

National CryoEM facility, B-Life Cluster, Bangalore



Pune Bio-Cluster: The Biotech science cluster at Pune has been conceived as a hub for interactions amongst scientists of Pune and nearby locations. The focus of this cluster is on molecular and cellular imaging extending to whole animal disease models and establishment of a proteomics facility to investigate molecular correlates of human diseases. The Bio-imaging facility at NCCS Pune has three scanning confocal laser microscopes, Zeiss LSM 510 Meta, Olympus FV10i and Leica TCS SP5. These are available for researchers across the country. The facility conducts hands-on training on light microscopy techniques, organizes trainings /workshops on confocal microscopes, image and data

analysis, on image processing and analysis software's like Photoshop, Image J, Fiji, Matlab, Cell Profiler and IrfanView and also on image and data analysis related to morphometrics, particle counting, particle tracking, numeric analysis, statistical analysis etc. The Pune Bio-Cluster was inaugurated in August 2019 by the Secretary, DBT.

03

RESEARCH AND DEVELOPMENT, DEMONSTRATION AND TRANSLATION ACTIVITIES

Agriculture and Allied Areas

The Department has been supporting Agriculture R&D (crops, livestock and fisheries) with an aim to provide improved crop varieties/livestock/fish brood-stock and other products to the farmers and other stakeholders through advancements in biotechnology. Support has been extended to basic research underpinning the understanding of complex problems and blue sky research. The Department has created an ecosystem of Agriculture R&D across the country involving universities/state agriculture universities and national institutions. Various improved crop varieties, markers of therapeutics, vaccines and diagnostics have been developed. Achievements through biotechnology interventions for improved crops, livestock and fisheries are detailed below.

Agriculture Biotechnology

Agriculture Biotechnology program of the department support R&D projects directed at research, translational R&D projects through national networks, centers of excellence, international collaborations, public-private partnership etc. Programmes focuses on developing climate and pest-pathogen resilient varieties for farmers and addressing other emerging problems in wake of climate change and other emerging problems. Programme is fine tuned to address specific needs of farmers, consumers and export markets in terms of varieties/technologies/products. During the financial year 2019-2020, the department has initiated a major mission mode programme on "Characterization of Genetic Resources" in various crops. The mission mode programme is aimed at sequencing/re-sequencing and phenotypic characterization of available germplasm resources in country along with exotic lines from diverse agro climatic regions & elite lines of International Institutes. Oilseeds (Sesame, Linseed, Safflower, Niger), Cereals (Rice and Wheat) and Pulses (Chickpea) are being targeted under this programme. Department has also initiated a major network programme on "Pathogenomics of Plant Viruses" as plant viral diseases are a major cause of crop yield losses around the world. India with its agro climatic diversity provides an ambient environment to the pathogens to flourish which ultimately leads to losses in the agricultural sector in terms of both quality and quantity. R&D in this direction is an important step considering bio-security implications on food security.

R&D Projects: During the year, various R&D projects were supported both in basic and applied areas of research in agriculture biotechnology. Some of the major achievements of the projects supported are as follows:

A. Cereals

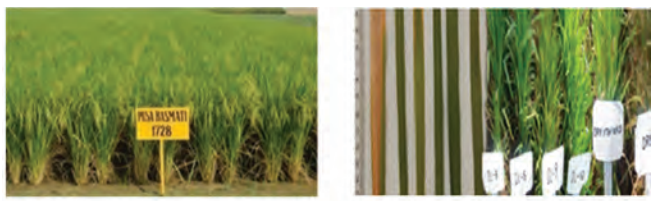
Rice: In the network project entitled "Marker Assisted Introgression of Different Traits to Develop New Generation Rice Varieties"; twelve (12) rice varieties (Improved Swarna-Sub1, Lalat, Naveen, Sahbagidhan, Krishna Hamsa, WGL 14, PR 116, PR 121, CO 43, CR 1009-Sub1, Safri 17 and Dubraj) were targeted for improved tolerance to biotic stresses (to bacterial leaf blight, brown plant hopper, blast, and gall midge) and abiotic stresses (drought, salinity, improved scent, reduced plant height and seedling stage cold tolerance). The project has delivered 249 advanced multiple QTL introgressed breeding lines through marker assisted selection. In the network project "QTL to Variety: Genomics-assisted introgression and field evaluation of rice varieties with genes/QTLs for yield under drought, flood and salt stress" aimed at developing climate smart rice varieties.Two NILs of IR64-Sub1 introgressed with drought tolerance QTL's (*DTY1.1, DTY2.2 and DTY3.1*) were recommended in AICRIP for field trails. NILs of Swarna-sub introgressed with QTL's for drought tolerance (DTY 1.1 and DTY 12.1) are under state varietal trails.CR Dhan802 introgressed with qDTY 2.1 and qDTY 3.1 was released and notified for drought prone areas of Bihar and Madhya Pradesh in the year 2019. Under the network project "Development of high yielding water and labor saving rice varieties for dry direct seeded aerobic conditions utilizing recent discoveries on traits, QTLs, genes and genomic technologies" the advanced breeding lines pyramided with identified QTLs/genes for traits related to DDSR in the background of rice varieties (MTU1010, IR 91648-B-89-B, Improved Lalat and CR dhan 303) have been developed using marker assisted selection. Five MAS derived homozygous lines with 30% yield advantage over the check varieties have also been developed. In the second phase of the network project "Maintenance, Characterization and Use of EMS Induced Mutants of Upland Variety Nagina 22 for Functional Genomics of Rice – Phase II", advanced breeding lines introgressed with the novel AHAS allele in the background of Pusa Basmati 1121, Pusa Basmati 1509, Naveen, Sahabhagidhan, Pooja and Swarna Sub1, ADT 43 and Co-51 were developed. These introgressed varieties are

weedicide resistant and suitable for dry direct seeded rice cultivation. In the project "Marker-assisted introgression of yield-enhancing genes to increase yield potential in rice" being implemented at NRRI, Cuttack, 13 lines introgressed with yield enhancing genes are in the 1st year of AICRIP trials. ICF1lines RMS –ICF1 – 15, RMS –ICF1 – 26 and RMS – ICF1 – 42 introgressed with yield related gene-specific markers (*Gn1a+SCM2+OsSPL14+GW5)* and three bacterial blight resistance genes (Xa21 + xa13 + xa5) are under selection. In the project "Incorporation of biotic stress resistance gene(s) into the genetic background of Pusa Basmati 1509 through marker assisted backcross breeding" at IARI, New Delhi, three bacterial blight and blast resistant NILs namely, Pusa 1847-12-62-90-39-7-15,Pusa 1847-12-62-184-36-9-155 and Pusa1847-12-62-64-12-6-8 have been nominated for testing under national Basmati trials for further release as commercial varieties. A total of 967 breeding lines from F4/BC1F4/BC2F3 to F9 generation are being phenotyped for blast, bacterial blight, drought, cold, submergence, brown plant, gall midge with QTLs/genes of two to ten in targeted recurrent parents. In the project "Marker assisted improvement of rice variety Pusa 44 for phosphorous use efficiency"being implemented at IARI, New Delhi. Pusa 44 –Pup1 NILs with recurrent parent genome recovery of more than 93% were developed. These lines show promise in terms of agronomic performance and P response and are currently under AVT trials.

List of Rice improved lines under multi-location testing:

S. No.	Recipient Background	QTLs/Trait improved	Status
1.	Improved Swarna-Sub1	*$qDTY_{1.1}$+$qDTY_{3.1}$+Xa4+xa5+xa_{13}+Xa21+Bph3+ Bph17+ Pi9+ Gm4+Gm8*	Mutilations trial
2.	Lalat	*$qDTY_{1.1}$+$qDTY_{3.1}$+ $qDTY_{12.1}$+ Xa4+ Xa21+ Pi9*	
3.	Naveen	*$qDTY_{1.1}$+ $qDTY_{2.2}$ + $qDTY_{4.1}$+Xa21+Pi9+Gm8*	
4.	Sahbhagidhan	*$qDTY_{1.1}$+ $qDTY_{3.1}$+ Xa21+Pi9+qCTS4a+ qCTS11*	
5.	Krishna Hamsa	*xa13 + Xa21 + Pi54 + Pi2+Bph20+ Bph21*	
6.	WGL14	*Xa21+ Pi1+Pi54 + Pi2+Bph3+ Bph17+Gm4 +*	
		Gm8 + $qDTY_{3.1}$+ $qDTY_{1.1}$	
7.	PR 116	*xa13+Xa38+Bph20+Bph21*	
8.	PR121	*$qDTY_{3.1}$ + $qDTY_{1.1}$+Bph20+Bph21*	
9.	CO 43	*$qDTY_{3.1}$+ $qDTY_{12.1}$+ Bph20+ Bph22+Sub1+saltol*	
10.	CR1009-Sub1	*Sub1+qDTY12.1+saltol+Bph20+xa5+xa13+Xa21*	
11.	Safri 17	*xa13 + Xa21+sd1+Pi1+Pi2+Gm8*	
12.	Dubraj	*xa13+Xa21+ Pi1+Pi2+sd1+Gm4*	
13.	IR64-Sub1	*DTY1.1, DTY2.2 and DTY3.1*	AVT/AICRP
14.	Swarna-Sub1	DTY 1.1 and DTY 12.1	AVT/AICRP
15.	RajendraMahsuri	Sub1	AVT
16.	MTU 1010	Saltol	Mini kit testing in saline areas of five coastal districts of Andhra Pradesh
17.	MTU 1075-Sub1	Sub-1	Mini kit testing in flood prone areas of six coastal districts of Andhra Pradesh.

18.	HUR 105	Sub1	SVT
19.	Sarjoo 52	Sub1	AVT 1
20.	ADT45	Saltol	4 lines(AICRP)
21.	ADT46	Sub1	3 lines(AICRP)
22.	PUSA44	*Saltol QTL from* CSR187-11-241, CSR187-11-229 and CSR187-11-252	3 lines(AICRP)
23.	Sarjoo 52	*Saltol QTL from* CSR189-11-123	1 lines(AICRP)



Pusa Basmati 1728 *Samba Mahsuri*

CARI Dhan 6 *Bahadur- sub1 Ranjit -sub1*

Unnat PBW343 *HQPM 1 (improved)*

Varieties developed through molecular breeding

Wheat: In study "Pyramiding of rust resistance genes into high grain quality wheat lines developed through Marker-assisted selection" supported at PAU, Ludhiana, introgression lines with HGPC containing *GpcB1* genes were developed in two elite background of PBW550 and DBW17 along with yellow rust resistance genes (*Yr36* and *Yr5)*. Stable introgression lines with Pre-Harvest Sprouting Tolerance (PHST) were developed in PBW621 background. ILs with High Grain Weight (HGW) from Rye Sel III were developed in PBW550, DBW17 and PBW621 background. In HGW introgression lines (PBW550 background) gene for yellow rust resistance *Yr15* was introgressed by crossing the HGWILs with stripe rust resistant version PBW550+*Yr15.*

B. Oilseeds

Brassica: In the project entitled "DBT-UDSC Partnership Centre on Genetic Manipulation of Brassicas", two loci of white rust resistance have been pyramided in the genetic backgrounds of four popular Indian mustard varieties Varuna, Pusa bold, Pusa Jai Kisan and Rohini through marker-assisted breeding and varities are currently under AICRP trials. Eight seed companies have obtained two-loci pyramided white rust resistant lines of Varuna, Pusa bold and Pusa Jai Kisan through signing a tripartite Technology Transfer Agreement (TTA) involving Delhi University-DBT (BIRAC) – Seed Companies. Under the project, several canola quality '00' mustard lines in the genetic background of Varuna have been developed by pyramiding low glucosinolates (6 loci) and zero erucic acid (7 loci) alleles through marker-assisted backcross breeding and doubled haploid methods. These lines are being evaluated for their yield potential during the year 2019-20. Several single copy transgenics for increasing the oil content and for glyphosate resistance are being evaluated in the field in the current growing season (2019 – 20) under event selection trials.

Groundnut: Under project entitled "Improving oil quality and productivity through molecular breeding in groundnut" supported at UAS, Dharwad, a variety DBG 4 of groundnut was developed and has completed two years of multi-location trials. This variety is better than TMV 2 for foliar disease resistance and yield, while retaining the other desirable traits of TMV 2.

C. Pulses

In multi-institutional network project "Genetic Enhancement of Minor Pulses: Characterization, Evaluation, Genetic Enhancement and Generation of Genomic Resources for Accelerated Utilization and Improvement of Minor Pulses"

initiated under mission programme on minor pulses (mung bean, moth bean, horse gram, cowpea, rice bean & urdbean), fourteen institutions (NIPGR-New Delhi, NBPGR-New Delhi, CSKHPKV-Palampur, NIN-Hyderabad, PAU-Ludhiana, UAS-Bangalore, ARS-Bandhanpur, CAZRI-Jodhpur, WVC-Hyderabad, IARI-New Delhi, ABF-Hyderabad, IIPR-Kanpur, IASRI-New Delhi and ILS-Bhubaneswar) have been involved in phenotyping. A total of 14,963 germplasm accessions of five minor pulses (Mungbean: 4100, Urdbean: 2266, Mothbean: 1750, Cowpea: 3720, and Horsegram: 3127) have been evaluated at multiple locations for agronomic traits. Germplasm Field Days were organized at New Delhi, Jodhpur, Bangalore and Ranchi for farmers, researchers and government representatives to showcase variability existing in the germplasm. Each event had a participation of more than 200 people. Project will lead to discovery of new traits and genes.

Chickpea: In a project implemented on "Understanding genetic control of cold acclimatization in chickpea (Cicerarietinum L.)anthers and devising strategies to minimize losses due to cold stress"HPKVV, Palampur has identified cold tolerant genotypes, (ICC 17258, ICC 16347, ICC 16348, ICC 16349 and ICC 16350) which set flowers and pods under low temperature. The high yielding genotypes were also identified (ICC 15264, ICC 7184, ICC 6293, ICC 11253 and ICC 16349), which produce significantly higher number of pods than other genotypes, during cold stress period. A simple and cost effective method for evaluation of cold-tolerance in chickpea based on pod development at lower temperatures was developed.

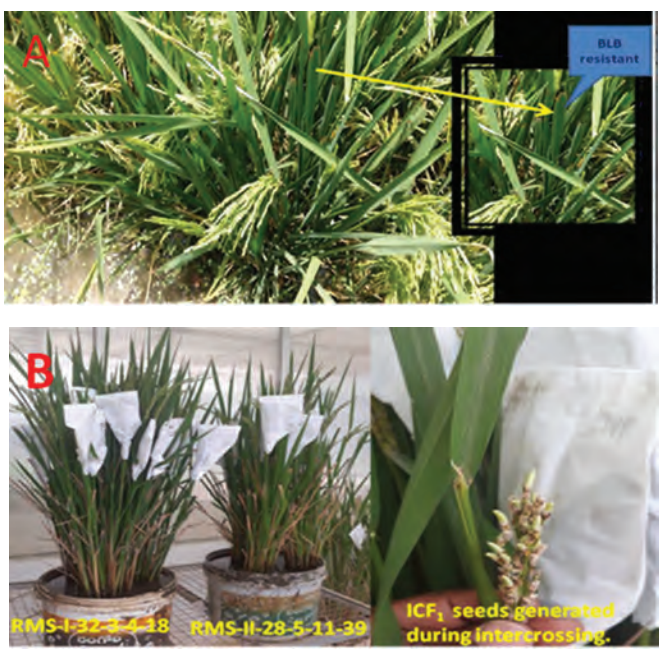
D. Vegetable and Horticultural Crops

In the project "Molecular mapping and transfer of yellow vein mosaic virus resistance in okra [Abelmoschus esculentus (L.) Moench]" being implemented at PAU, Ludhiana, a yellow vein mosaiv virus (YVMV) resistant accession of Okra, IC140986, has been identified and resistance gene has been introgressed into the popular variety Punjab Padmini. In the project "Marker Assisted Introgression of Tomato Spotted Wilt Virus (TSWV) Resistance into Indian Tomatoes" at Sri Konda Laxman Telangana State Horticultural University, Hyderabad, introgression of Tomato Spotted Wilt Virus (TSWV) from resistance source LA3667 into Indian varieties Arka Vikas and Pusa Ruby has been done.The developed Indian cultivars with TSWV resistance can be released for the farmer cultivation after multi-location trials and also used for further gene pyramiding programs to develop multiple resistance. Whole genome sequence based SSR markers development and their utilization in mapping of Bittergourd Yellow Mosaic Virus resistance in bittergourd (*Momordica charantia* L.) was supported at PAU, Ludhiana Screening of bittergourd germplasm has led to the identification of PAUBG-6 as a source of resistance to BGYMV. The selected genotype was crossed to susceptible bittergourd cultivar Punjab-14. BGYMV resistance was transferred from PAUBG-6 into Punjab-14. Under the project "Creating a Genomics platform for Apple research in India_Phase-II" >500 new primer pairs/SSR were standardized/validated and 100 polymorphic markers were identified in the Parental Polymorphisn survey. A working web-portal (Apple Germplasm) using new advance web-compatible tools/architecture has been designed.

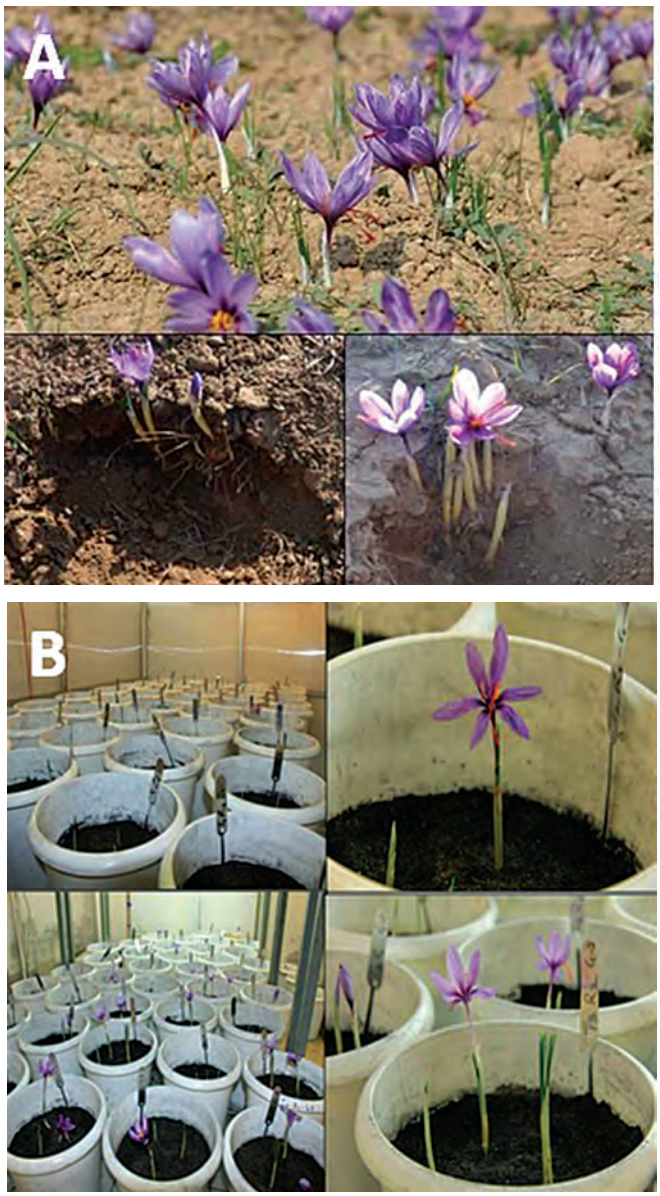
E. Spices

In the project "Characerisation of microflora of rhizosphere associated with saffron with a target to develop consortia of beneficial microbes", CSIR-IHBT, Palampur, evaluated 10 PGPRs isolated from Rhizobacteria/Rhizospheric Soils of Saffron from different Locations in J&K and Himachal Pradesh for growth promotion in saffron. Two efficient PGPR isolates of Pseudomonas azoto formans and Bacillus siamensis were selectedbased on their growth performance under controlled environmental conditions for optimization and up-scaling. Up-scaling was optimized in semi-synthetic medium for these isolates in a laboratory-scale bioreactor (10 L). These PGPRs can be used for saffron growth and farming. In the project "Tissue culture based network program on saffron (Crocus sativus L.)" at CSIR-IHBT, Palampur, an efficient protocol for in vitro production of saffron corms was developed. The protocol has the efficiency to generate 40,000 planting material (corms) within one year. The developed agrotechnology proved successful when trials were laid in farmers' field located at five different locations around Palampur. The EMS in vitro mutagenesis protocol in saffron has also been successfully standardized at University of Jammu, J&K. For the first time, protocol for suspension cell culture followed by mass multiplication of callus has been standardized. Success has been achieved in standardizing induction of hexaploidy in saffron. Development of stigma and stigma like structures from another culture of saffron

has also been achieved. In the project "Characterization of endogenous and episomalpararetroviruses in black pepper" at ICAR-Indian Institute of Spices Research, Kerala, a combination technology of PCR and RT-PCR assay for differentiation of black pepper plants infected with endogenous (integrated) and episomal form of Pepper Yellow Mosaic Virus (PYMoV) has been developed. A purification protocol for production of polyclonal antiserum against the PYMoV was developed. This can be used to develop diagnostics. In the project "Transcriptome analysis and characterization of key metabolic and hormone signaling pathway genes in Piper nigrum in response to defense elicitors" at RGCB, Kerala, the transcriptome data specific to Phytophthora infection generated previously in *Piper nigrum* was analysed and functionally annotated. A number of effect or molecules have been identified in *Phytophthora capsici* which show differential expression in response to disease. This is the first attempt to identify and functionally characterize pathogen specific effectors from the oomycete pathogen *P.capsici*, which is specific for *Piper nigrum*. The work opens up future possibility of identifying potential priming components from the pathogen which can prime defense responses in the host plant prior to infection thus and holds promise as a crop protection strategy.



***A.** BC2F2 lines of Improved Samba Mashuri possessing* Gn1a+OsSPL14 *showing High yield and excellent resistance against bacterial blight. **B.** Intercrossing between two BC2F2 plants having different gene combinations*



***A.** Soil sampling from saffron growing (9 locations) areas was done to explore associated rhizobacteria **B.** Effect of PGPRs from rhizobacteria on flowering of saffron corms.*

Animal Biotechnology

The Department continued its support towards enhancing livestock production and productivity through its R&D programmes. Animal Biotechnology programme of the department is focused towards improving animal health by developing newer vaccines and diagnostics, development of newer reproductive technologies genomics and genetic characterization, production of bio-pharmaceuticals through

transgenesis, animal products etc. Some of the major achievements are as follows:

Livestock Genetics & Genomics: Cattle genomics programme has been initiated at National Institute of Animal Biotechnology (NIAB), Hyderabad with an aim to develop high density single-nucleotide polymorphism (SNP) chip for identification of pure indigenous cattle breed as well as elite animal. Whole genome sequencing all 43 indigenous cattle breeds has been carried out and the data generated is being analyzed to identify SNPs that would be placed on the chip for further use to delineate the admixture in cattle available in field and organized farms. One male each from major five dairy cattle breed (Gir, Tharparkar, Kankrej, Red Sindhi and Sahiwal) has also been selected for sequencing (10X genomics) based on its history/pedigree records with an aim to assemble the whole genome.

Livestock Reproduction: A multi-institutional program on development of early pregnancy diagnostic for cattle and buffalo has been initiated. During the course of study, changes in various proteins of urine, saliva and serum of buffalo and cattle were recorded in pregnant *vis a vis* non pregnant samples using high throughput proteomics study and differentially expressed proteins are being validated. Neutrophil analysis of pregnant and non-pregnant animals also showed changes in shape, number and abundance of various proteins. Two multiple antigenic peptides (MAP) specific antibodies have been raised which have the potential to detect pregnancy at an early stage. Surface Plasmon Resonance (SPR) biosensors array was also standardized to provide significant difference in pregnant *vis a vis* non pregnant samples.

Estrus/silent estrus detection: Estrus/silent estrus detection in buffaloes is a major problem and therefore a multicentric project was initiated targeting various aspects of female reproductive system. The study indicated that poor follicular growth, less number of medium size follicles and smaller size dominant follicle are major contributory factors for occurrence of silent estrus in buffalo. Six major differentially expressed proteins have been identified exclusively in the urine samples of buffaloes having silent estrus which can be used for developing a diagnostic. Few pheromenal compounds have also been identified in urine samples and based on these pheromone calorimetric assays to differentiate between estrus *vis a vis* non estrus animals has been developed. Estrus specific proteins from saliva and cervical mucus have also been identified.

Production of therapeutics: Production of human/animal proteins in milk of large animals for therapeutic use is being studied at NIAB, Hyderabad. In this connection, Goat mammary epithelial cell (gMECs) culture (both primary and secondary) was standardized and transfected in-vivo for expressing targeted proteins. The cDNA of therapeutic protein gene, human blood coagulation factor 8 (hF8) and human tissue plasminogen activator (hTPA) have been validated in gMECs culture. In another project, production of cattle gonadotropins in milk of rabbit by *in vivo* gene transfection has also been carried out. The immune-histochemical analysis of the testicular electroporation in rabbit testis was done and expression of GFP in germ cells was confirmed. A protocol for isolation and culture of mammary luminal epithelial cells has been standardized and a Buffalo beta-casein promoter driven GFP construct has been transformed for its functional validation exhibited strong expression. Further, cDNA of alpha subunit of FSH/LH protein was also validated.

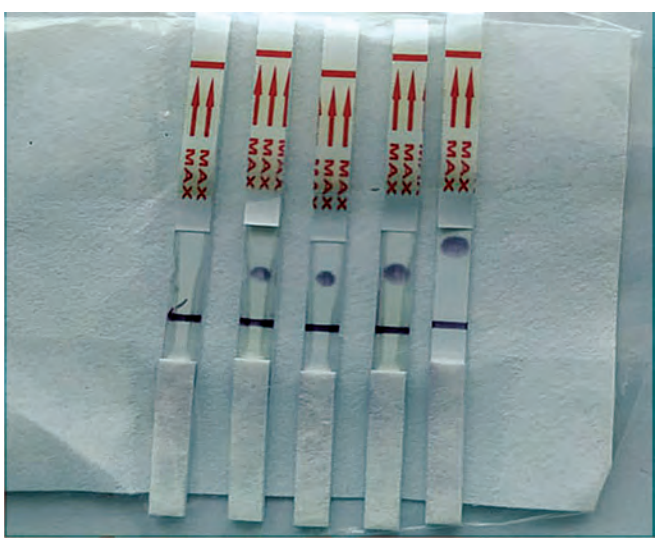
Transgenesis: Development of transgenic chicken for the production of human interferon alpha 2b has been under taken at PDP, Hyderabad. Primary culture of chicken magnum cells has been standardized and their purity was validated by the gene expression study. DPREGG1 vector has been constructed by incorporating ovalbumin promoter, which was detected under in vitro cell culture model. The functional efficiency of DPREGG1 vector was analyzed using GFP marker. This vector will be used to express interferon alpha gene of human, chicken, cattle and other species.

***In vitro* meat production:** Standardization of *in vitro* meat production process using cell culture / stem cell technology has been initiated at Centre for Cellular and Molecular Biology (CCMB), Hyderabad and National Research Centre on meat (NRCM), Hyderabad to outline various aspects of its production and challenges associated with the process. Various factors responsible for cell growth have been investigated and efforts are on to standardize technology. Beside, work on developing alternatives of fetal calf serum would be taken up to reduce the cost.

Animal Health

Canine Health Research: PAN India program on Canine Health research is being implemented at Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) Chennai, Tamil Nadu and Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab. The focus of the program is to address major problems of canine upkeep in terms of health, nutrition and therapy to prevent zoonotic infection through segregation of human and veterinary medicine interface for addressing One Health Concept in canine. At TANUVAS following diagnostics have been developed during the course of study:

1. A multiplex PCR based assay to differentiate Canine Parvovirus (CPV) 2a & 2b.
2. PCR for Antigen Receptor Rearrangements (PARR) assay to differentiate the B and T cell lymphoma.
3. Concanavalin-A based ELISA test for differentiation dog erythrocyte antigen (DEA) 1.1 positive and negative RBCs.
4. Evan Syndrome Flow cytometry Staining Kit.
5. Lateral Flow Assay (LFA) kit for diagnosis of Immune mediated haemolytic anaemia.
6. A PCR based diagnostic technology for the detection of Haemoprotozoan parasites is ready for commercialization.

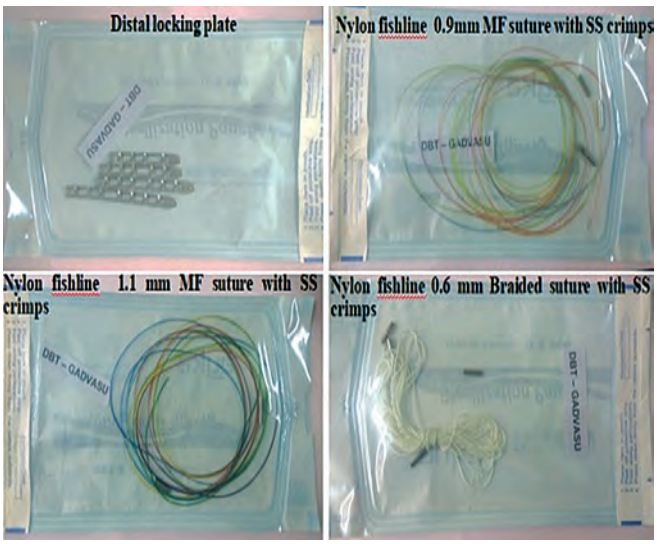


Evan syndrome Flowcytometry staining kit

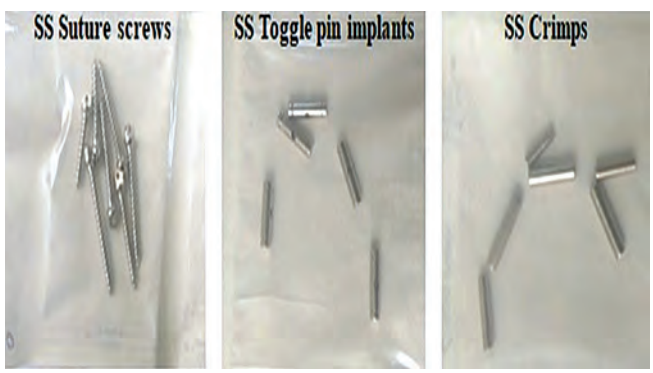
Lateral flow assay kit

Blood 4 Pet Mobile App: To create awareness on blood donation among pet parents and to connect interested pet parents as donor a Mobile App "**Blood 4 Pet**" has been developed and launched on Sept, 19, 2019. So far a total of 150 blood donors and the pet parent's details have been registered. Further, a canine blood bank unit has been established and a total of 195 dog blood samples of different dog breeds have been screened with canine blood typing kit (KABB) which revealed 65.1% samples to be DEA 1.1 positive, 1.0 % DEA 1.2 positive and 33.9% DEA 1 negative. Fresh whole blood transfusion has been performed in 36 anaemic canine patients, most of them responded well after transfusion.

A veterinary hospital database management system has been established at GADVASU and analysis of major health problems in dogs analyzed. A canine dental laboratory has also been set up and procedures for undertaking root canal and crown therapy using different biomaterials carried out. A portable acoustic sensor based system capable of analyzing fetal heart beats, litter size & gestation has been developed to detect pregnancy in dogs. Indigenous suture materials using nylon fishline (0.9 mm, 1.1 mm & 0.56 mm) with SS crimps of MF & braided sutures types and the implants for stabilization of hip & stifle joints (suture screw toggle pin, suture crimp) were developed which will help in arthroscopy in canine.



Indigenous suture



Implants for stabilization of hip & stifle joints

The field virus isolates of Canine Distemper Virus (CDV) were serially passaged, scaled-up and whole genome sequencing was carried out to explore suitable vaccine candidate(s). Recombinant haemagglutinin (H) & matrix structural (M) proteins of CDV have been expressed to develop virus like particle for use as vaccine candidate. *Nucleoprotein* and *phosphoprotein* genes of CDV have been cloned into T7 promoter plasmid to develop a multivalent vaccine delivery system for dogs. For sero-monitoring of anti-rabies vaccinal antibodies in dogs, a rec-G protein based quantitative ELISA has been developed. Also, a novel rec-Locked Nucleic Acid (LNA) protein has been expressed to evaluate *in-vivo* use as a replacement to rabies immunoglobin.

Translational Research Platform for Veterinary Biologicals (TRPVB): The department has established TRPVB at Tamil Nadu Veterinary and Animal Sciences University, Chennai for the production of novel veterinary biological, diagnostics and also to develop quality human resource. The ultimate aim of this platform is to convert science into commercializable technologies in animal science by creating a inclusive ecosystem involving academia, industry and regulatory agencies. TRPVB has developed a large number of veterinary biological/ technologies, some of them have been commercialized and few of them are ready for transfer/ commercialization. Beside, few are at different stages of development. During the year, two technologies have been commercialized *viz* virus like particle (VLP) based vaccine for Canine Parvo Virus using baculovirus expression System (BEVS), was transferred to M/s Palamur Biosciences, Hyderabad and technology of PCR based diagnosis of canine haemoprotozan diseases was transferred to M/s. Illume Gene Private Limited. A large number of veterinary biologicals were also produced for State Veterinary department of Tamil Nadu for their distribution among farmers. TRPVB has also conducted training programmes to develop quality human resource in the area of veterinary biological production.

Mycobacterial diseases in animals network (MyDAN): A major network program on the mycobacterial diseases in animals has been initiated to establish a dynamic research and development consortium focused on providing knowledge-based real-world solutions to accelerate the control of mycobacterial diseases in livestock. This programme has been designed to evaluate Define Skin Test (DST) antigen peptides to differentiate infected from vaccinated animals (DIVA) capability for cattle and buffaloes for skin testing and to evaluate the usefulness of BCG in cattle and buffaloes along with survey across the states. The preliminary survey suggested that bTB incidence is increasing in animals with varied incidence rate of 1.29% to 22% at different center. The synthetic peptides have been evaluated for their specificity, sensitivity and found at par with OIE peptides. DIVA potential studies of these peptides after the dose optimization studies in cattle and buffaloes have also been completed. BCG immunogenicity study has been completed in calves at TANUVAS and is being carried out at LUVAS in buffaloes.

Newcastle Disease Vaccine (NDV): Development and evaluation of genetically engineered vaccine against Newcastle disease and Chicken Infectious Anaemia infection

of chicken was supported at IVRI, Izatnagar. Transcription cassette consisting of VP1 and VP2 genes of chicken anemia virus (CAV) along with the regulatory signals of NDV has been constructed and introduced within the P and M genes of NDV strain R2B. Recombinant NDV containing the VP1 and VP2 genes of CAV has been rescued from vero cells, and grown in 9-11 days old embryonated chicken eggs. Molecular characterization of the virus indicated that the virus harboured the foreign immunogenic genes within itself.

Recombinant vaccine: A novel broad spectrum recombinant subunit Blue tongue virus (BTV) vaccine has been developed and found to be effective against BTV serotype. Administration of conserved epitope of VP2 protein as a part of subunit vaccine conferred broad-spectrum immunity against most of the available serotype of BTV. Initial evaluation of the immunogenicity of the proteins has been done in BALB/c mice. Immune response and neutralizing ability of the antibodies developed have been detected by I-ELISA and serum neutralization test, respectively, which revealed that the proteins were immunogenic.

Molecular characterization of *Dichelobacter nodosus* and development of recombinant vaccine against ovine footrot is being implemented at Sher-e-Kashmir University of Agricultural Sciences & Technology, Jammu. A total of 42 positive samples of *Dichelobacter nodosus* were evaluated and out of them 34 carried serogroup B and 6 serogroup E. Locally isolated serogroup B isolate is being assessed as an effective killed vaccine. The expression of the fimbrial protein in *E. coli* is a lead towards development of a potent vaccine against *Dichelobacter nodosus.*

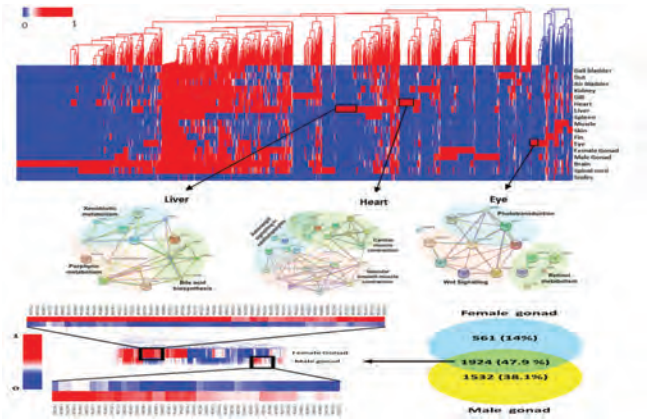
Mastitis: Study on molecular epidemiology and genomics of mastitis-associated Staphylococci has been carried out at NIAB, Hyderabad. A total of 27.5% of the *Staphylococcus aureus* isolates were identified as methicillin-resistant by phenotypic assay and their genomic analyses showed potential for multi-drug resistance. Analyses suggested the carriage of several toxin genes as well as AMR genes with the potential for multi-drug resistance. The study suggested the presence of diversity and yet preponderance of certain clones, with pathogenic potential, among *S. aureus* associated with bovine mastitis in India.

Aquaculture and Marine Biotechnology

Fisheries and aquaculture is an important sector of food production providing nutritional security, besides livelihood support, gainful employment and its contribution towards agricultural exports. There have been continuous and sustained increments in fish production in the past few decades. Fish and fish products have presently emerged as the largest group in agricultural exports from India. The department has made concerted efforts towards developing newer diagnostics and therapeutics, improvement in aqua feed, developing novel cell lines etc. through the adoption of molecular tools and techniques. The broad areas of research of programme are fish genomics, transcriptomics, diagnostics, therapeutics, marine ornamental aquaculture, marine bioprospecting etc. Two national repositories, one each for fish cell lines and viral cell lines have been established. First Diatom collection centre has been established for bioprospecting. Several training programs and workshops have been conducted to disseminate improved aquaculture techniques and to produce trained manpower on various aspects of Aquaculture and Marine biotechnology. Important leads obtained in 2019-20 have been delineated below.

Fish Genomics/Functional Genomics

Whole genome sequencing of Rohu and Magur was completed and submitted to NCBI genome database. Reference proteome map for Rohu has also been developed by proteomic profiling of 19 histologically normal fish samples; 17 tissue samples, one embryo sample (4-day post fertilization) and plasma of female fish. Proteomic profiling resulted in the identification of more than 10,000 unique proteins. The expression profile was analyzed for unique and shared proteins. Differential protein expression was also analyzed between gonads as well as other organs. The resulting reference proteome map can be used as a baseline for further omics research in rohu.



Landscape of Rohu proteome expression across all organs

To enhance productivity of Rainbow trout, triploidy induction was standardised using heat shock and pressure shock techniques for its mass scale production. Rainbow trout brood stock is being maintained at ICAR-DCFR Experimental Trout Farm, Champawat (Uttarakhand) and state trout farm, Uttarey, Sikkim for production of triploid rainbow trout eyed ova. It is expected that 40, 000 triploid rainbow trout ova will be produced by January, 2020 and will be released in natural water bodies.

The complete genome sequencing and de novo assembly of *Halomonas malpeensis* PRIM 29T, a novel marine bacteria isolated from west coast of India, was carried out at Yenepoya University, Mangalore. Gene annotation studies confirmed the presence of genes involved in ABC transporter dependent pathway of EPS biosynthesis. *H. malpeensis* possesses genes for the synthesis of phytoene, lycopene, â-carotene and zeaxanthin involved in the carotenoid biosynthesis pathway. The bacterial genome also showed the presence of genes coding for other industrially important metabolites such as ectoine and betalins.

Fish Feed:

Various diet forms for larval rearing of giant fresh water prawn, *Macrobrachium rosenbergii* were evaluated to develop alternate nutritious and cheap larval feed. Ribbonfish powder at 25-30 % or Pink perch fish powder at 30-35% as major feed ingredient was found to have a direct bearing on larval rearing of giant freshwater prawn, there by bringing down the total feed cost. The optimum inclusion of these ingredients accelerates the optimum larval metamorphosis by reducing larval rearing time.

Immunostimulatory and disease resistance properties of seeds and leaves of medicinal plant, *Achyranthes aspera* enriched diets were evaluated in Rohu (*Labeo rohita*) and Magur (*Clarias batrachus*) rearing. Seeds supplemented diet was found to be more effective as higher growth rate of fishes with better feed conversion ratio (FCR) were recorded. Immunological parameters and expression of immune related genes showed positive effects of diet enrichment in terms of overall health, productivity and disease resistance.

Herbal extract (Herbal immunostimulant feed, HIM) against white spot syndrome virus (WSSV) was developed and supplied to investigators, shrimp farmers and companies to assess its efficacy. It was noted that herbal extract have strong antiviral activity against WSSV. The pure herbal immunostimulant isolated and found to have activity at the concentration ranging from 10 to 25 µg per shrimp. Field evaluation of HIM formulated feed has been carried out in shrimp ponds located at Mungamur, Nellore, AP to protect the shrimp from WSSV infection and encouraging results have been obtained.

Diagnostics and Therapeutics: A simple method to isolate broad host range coliphages using multiple host enrichment has been developed. The protocol was optimized using 24 strains of antimicrobial resistant *E. coli* and a universal host *E. coli* 2089. Phages produced by multiple host enrichment showed lytic activity against higher number of *E. coli* isolates and found to be more efficient.

A highly sensitive, cost effective and specific loop-mediated isothermal amplification (LAMP) assay has been developed for diagnosis of Vibrio pathogens by targeting its tlh, tdh and trh genes. Additionally, a hydroxynapthol blue (HNB) dye based simple visual detection for the amplified LAMP products was also standardized. LAMP assay with HNB dye has also been

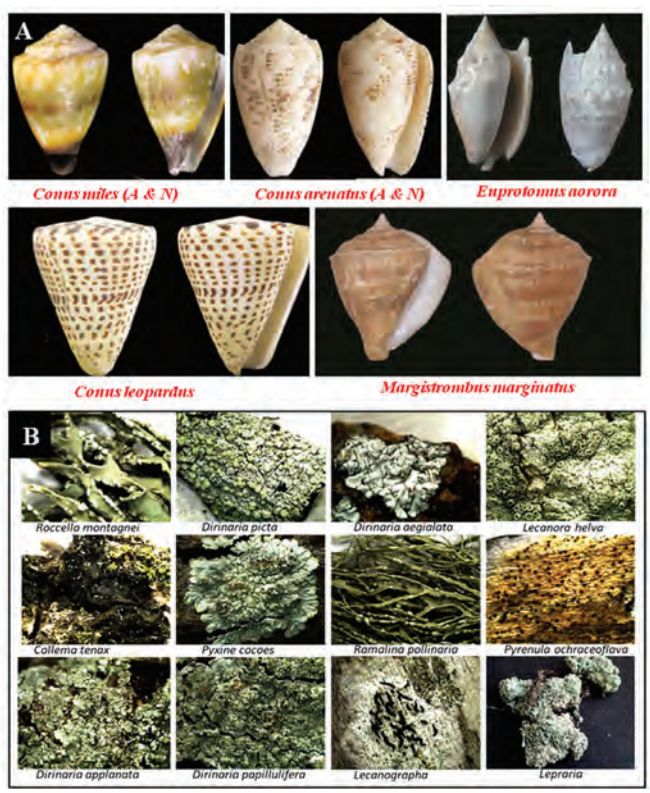
developed for detection of acute hepatopancreatic necrosis disease (AHPND) caused by *V. parahaemolyticus* targeting Pir A and Pir B regions.

An anti-virulence molecule targeting Vibrio pathogens (*V. alginolyticus* and *V. campbelli*) was identified. The compound was named as 'V8' found to have effectively inhibited phenotypic expression of biofilm, luminescence, motility, haemolysin, and cell surface hydrophobicity in Vibrio. The effect of lipopeptide on the control of Vibrio infection and modulation of gut microbiome in *Litopenaeus vannamei* was demonstrated. A shift in microbial diversity was noted with the shift to the lipopeptide feed indicating that the diet of the shrimp is altering the microbial community. The presence of probiotic strains revealed the role of microbiome in enhancing the effect of the antimicrobial compounds in improving shrimp survival and disease resistance.

A surgery based viable alternative method to harvest the spermatozoa for artificial fertilization and seed production, without sacrificing *Clarias magur* was developed. Harvested spermatozoa can be used immediately for fertilization of *C. magur* eggs and can also be stored at ultra low temperature for future use. Fertilization and hatching percentage of eggs fertilized with partially harvested *C. magur* spermatozoa was similar to that of results obtained from usual sacrificing method. Surrogate brood stock development for *C. magur* was standardized in germ cell-depleted gonads of host *Pangasius hypophthalmus*.

Marine Diversity and Bioprospecting: Inventorization of cone snails and strombs including identification of new species available along Indian Coast has been initiated. A total of 20 species of Conidae and Strombidae families were collected from nine sampling sites identified along both the coasts of India and Andaman and Nicobar Islands. Species specific molecular signatures through DNA barcoding and phylogenic analysis of collected cone snails and strombs species were carried out. Fragments of the mitochondrial genes 12S rRNA, 16S rRNA, Cytochrome oxidase subunit I (COI) and nuclear H3 gene were amplified for phylogenentic analysis of the collected species. All genes were sequenced in both directions for increased accuracy.

Anti-cancer potential of venom proteins of jelly fish species and their structural characterization is being studied at Sathyabhama University, Chennai. Preliminary screening of jelly fish nematocyst and their venom proteins indicated that two species viz. *Chrysaora chinesis* and *Chrysaora fuscescens* displayed potent anticancer activity against MCF-7 and MDA-MB 231 cancer cell lines. Cell viability assay were conducted using normal African Green Monkey kidney cell line (Vero) and IC50 of 117.35 and 110.25 ìg/mL was observed for *Chrysaora chinesis* and *Chrysaora fuscescens*, respectively.



Exploration and characterization of marine biodiversity of A. Cones, B. Lichens

Protein protease inhibitor (PPI) was isolated and purified from a marine bacterium viz. *Oceanimonas* BPMS22. The purified PPI showed promising anti-promastigotes activity and anti-amastigotes activity against *Leishmania donovani* AG83. Anti-amastigotes proficiency of PPI and concurrent NO generation in infected macrophages indicated its possible prospect in the treatment of visceral leishmaniasis and macrophage repolarization.

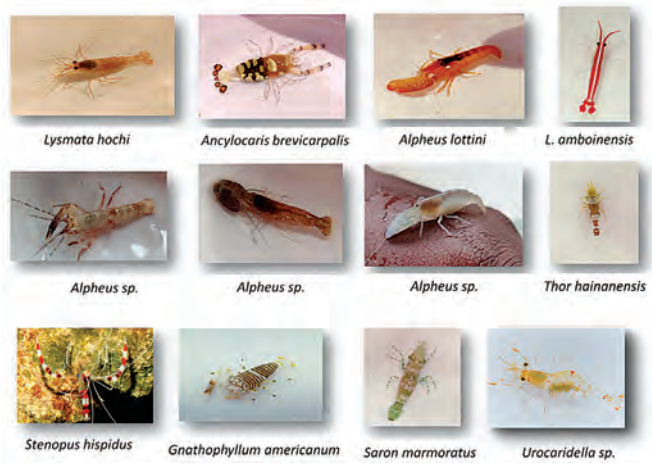
Marine Algal Liquid Fertilizer (MALF) was extracted from marine algal species viz. *Turbinaria ornata*, *Portieria*

hornemannii and *Enteromorpha intestinalis* having various plant growth promoting substances including benzoic acid, tetradecane, eicosane, succinamic acid etc. These marine algae possess macro and micro nutrients (N, P, K, Zn, Cu) and fungicidal compounds. Field study confirmed that MALF is effective against phytopathogens such as *Rhizoctonia solani*, *Sclerotium rolfsii*, *Macrophomina phaseolina*, and *Alternaria solani* resulting in substantial increase in yield of various crops.

A novel marine bacterial species viz. *Halomonas malpeensis* PRIM 29T was collected from the southwest coast of India. Two exopolysaccharides (EPS-A21 and EPS-H29) were isolated from these bacteria. EPS-A21 was found to have potent wound healing properties by modulating cellular proliferation, cell migration and expression of Ki-67, a fibroblast proliferation marker protein. Preclinical evaluation of the EPS-A21 was carried out on animal models. The results showed accelerated healing in animal model with EPS treatment group. Validation of EPS-H29 is being taken up.

Three new protoypes of bioreactors were developed at CIFE, Mumbai for biomass production of a commercially important cyanobaterium viz. *Spirulina* (*Arthrospira*) *platensis* and efforts are on to standardize the technology. A low-cost medium for biomass production was formulated to reduce the cost of its production. With these bioreactors, biomass production can be continued throughout the year without any interruption which is not possible in open raceway ponds during the rainy season. A single step process using a multilayered column bed was also designed and fabricated for purification of a valuable pigment phycocyanin (colorant grade).

Repository of Ornamental Shrimps, Fish Cell Lines, Diatoms, Fish Viruses: The department has established a "Germplasm resource centre for marine ornamental invertebrates" in the premises of CMLRE field station at Agatti Island, Lakshadweep. So far, more than 280 individuals of ornamental shrimps were collected and stocked in the centre. Among the shrimps, *Thitarodes hainanensis* was reported for the first time from Indian waters. In addition, 70 tentacle sea anemone were also collected and work on their asexual reproduction is being carried out. Broodstock development was successfully achieved for five species of shrimps. Ornamental invertebrates other than target organisms were also collected during exploration and are also being maintained at centre for further investigations.



Ornamental Shrimps

The department has continued its support for fish cell line repository at CAHC, Vellore and NBFGR, Lucknow. At present, 50 and 63 fish cell lines are being maintained at CAHC and NBFGR respectively. Three new cell lines (eye, spleen and kidney) from *Oncorhynchus mykiss* and another three new cell lines (eye, heart and gill cell lines) were developed from *Oreochromis mossambicus.* Tilapia lake virus (TiLV) is being propagated in these cell lines at CAHC, Vellore. Seven new cell lines were also developed, characterized and cryopreserved at NBFGR, Lucknow. Both institutes are providing cell lines to different research organizations across country for R&D purpose. Training programmes are also being conducted to develop manpower to handle fish cell lines and their possible utilization in applied research.

Diatom culture collection was established with an aim to exploit their possible utilization as neutraceuticals and other applications. Ten strains of marine diatom species and two fresh water diatom species were isolated and their mass cultivation is being attempted. Fatty acid profiling of marine diatom species was studied for the isolation of bioactive compounds such as EPA & DHA and fucoxanthin.

Repository of Finfish, crustacean and molluscan viral pathogens was also established and PCR based diagnostics were standardied for identification of pathogens. Primers of these viruses were synthesized for disease diagnostics. A draft manual of finfish and shell fish viruses was prepared.

Bioenargy, Bioresources and Environment

As per National Policy on Biofuels, an indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel is proposed by 2030. Department has initiated major R&D effort toward development of alternative fuel. A major focus is on development of 2nd generation biofuels. A platform has been created to connect more than 200 Scientists working in Biofuel area via its five Centres of Excellence set up across the country, extramural projects, fellowship schemes and International co-operation. R&D in advanced biofuels has been promoted through various schemes/ programmes which includes 2nd Generation ethanol production (pretreatment of biomass, indigenous enzyme development scale-up and fermentation of xylose & glucose), algal biorefinery, advance biofuels, bio-diesel, bio-butanol, biohydrogen, biogas, methanol) etc.

Besides above, R&D support is continued on development of clean technologies for treatment of municipal solid and liquid waste. During 2019-20, a total of 65 ongoing R&D projects have been supported and 25 new projects sanctioned. More than 150 publications have published in journals of repute, 3 patents granted and 2 technologies developed. Department has proposed to demonstrate the potential clean technologies at small units level in collaboration with suitable stakeholder/ ULBs, setting up of Translational Centre, scale up, licensing and commercialization of technologies proven at pilot scale.

1. Conversion of Agriculture residue into energy /value added products

Agricultural waste especially rice straw is not only creating air pollution due to its burning but also increasing human health issues in urban as well as rural areas. An indigenous 2G ethanol technology has been developed which is an advanced technology that is feedstock agnostic and converts any biomass including rice straw to sugars and ethanol. Efforts are being made to develop cost effective 2G ethanol by improved pretreatment, enzyme development and lignin valorization. DBT-ICT has been successfully demonstrated 2G ethanol production technology with rice straw and cotton stalk. Initial trials have been completed at 5 tons/ day of rice straw and cotton stalk to yield 185L/ ton and 213L/ ton of ethanol respectively.

Lignocellulosic ethanol production using indigenous microbial strains: An alternative cost effective 2G ethanol technology has been developed by Centre for Advance Bioenergy Research, DBT-IOC, Faridabad at the level of 10 TPD scale pilot plant. The Cellulytic enzyme activity successfully improved in the formulation and the improved enzyme scaled up at 5 KL scale and successfully evaluated at 1 TPD pilot plant at Pune Centre showing comparable hydrolysis efficiency to the commercial enzyme. Next trials at 12 TPD 2G ethanol demo plant are under progress.

Pretreatment of Biomass: A simple and effective process for pre-treatment of lignocellulosic biomass and recovery of value-added products from biomass such as cellulose, lignin, xylan, silica has been developed at SPRERI Gujarat. The green solvents, NADES developed are recyclable and reusable which makes the process not only economically sustainable but also environment friendly. In another project the plant cell wall deconstruction of crop residue & biotransformation to value added products is being studied at NCL Pune with special emphasis on ultra structure of cell wall and inhibitor generation during multiple pretreatment. New catalyst has been developed to convert the sugar into value added products.

Enzyme Development: Cellulolytic enzyme is the critical component in 2G Ethanol production and therefore major initiative to develop indigenous low cost Cellulolytic enzyme has been taken up. ICGEB has developed DIC_{3yme}-1 a fungal enzyme preparation and found potent for hydrolysis of pretreated biomass. The enzyme was tested for hydrolysis of pre-treated biomass. This in-house developed cellulase enzyme preparation process and product has got US Patent. A process for the production of chimeric enzymes has been developed at DBT-Pan IIT Center for Bioenergy. This engineered chimeric enzyme preparation showed better conversion of lignocellulosic waste to ethanol than commercial formulations. Based on the available data on 2G ethanol production, a detailed model has been developed to perform techno-economic optimization for an integrated lignocellulosic biorefinery in Maharashtra.

2. **Algal Biofuel/ Biodiesel:** Algae fuel is an alternative to liquid fossil fuels that uses algae as its source of raw material for biofuel production. In order to address the various challenges such as low lipid content, lower growth rate and higher cost of production, R&D projects supported for algal improvement, cultivation and higher lipid production. Some of the achievements are:

- Strains improvement of marine algae like *Parachlorellakessleri*-I, *Tetraselmissubcordiformis*, and *Nannochloropsis oceanic* was carried out.
- Genetically modified algal species developed and successfully cultivated in a vertical photo bioreactors (PBR) of 100 L capacity.
- Identified and optimized oleaginous yeast isolates producing lipids more than 20% of dry cell weight.
- Process optimization for low-cost microbial biofuel production
- Efficient and low-cost algal harvesting
- Scaled up Microbial fuel cell (MFC)
- Cost effective Proton Exchange Membrane (PEM) for MFCs
- Novel cost-effective clay-based catalysts for conversion of algal/non-edible oils to biofuels that perform better than commercial formulations
- Cost effective mass production of robust thermotolerent, halophilic microalgal strains and utilization of biomass for biofuel production has been optimized.

Under a DBT-TERI Bioenergy Centre, a facility of 100,000 L algal growth system is being installed at coastal site and a low cost commercial fertilizer has been successfully tested as suitable replacements for conventional algal media. Micro-algae produced in the growth system will be used for extraction of lipid for bio-diesel production and the delipidified biomass have various applications such as aqua feed, bio-fertilizer and proteins etc.

3. **Waste to Value Technologies:** Department has taken a major initiative to demonstrate the technologies for the treatment of Municipal Solid/ Liquid Waste. The focus includes Modern and scientific conversion of MSW/ MLW as improper management emerged a major environmental concern in India.

Biowaste to Energy/ Value Products

A demonstration plant has been commissioned at Murmugoa, Vasco-Da-Gama, Goa for converting 5 tons Organic Waste/ day and 10 tons Septage/ day into 500 - 600cu.m Biogas which is equivalent to 1000–1200kwh of electricity production/ day using Anaerobic Digester Technology. Second demonstration plant is being commissioned at Dr. Ambedkar Bowenpally Market Yard, Secunderabad for converting 10 Tons Organic Solid Waste/ day and 2.5 m3 Leachate/ day into 825 kWh Power per day and 10,000 litres Bio-Manure per day using High rate Bio-methanation process based on Anaerobic Gas Lift Reactor (AGR) Technology.

Municipal Liquid Waste to Clean Water: Department initiated a novel holistic waste water management approach in collaboration with Netherland that aims for the Local Treatment of Urban Sewage streams for Healthy Reuse. The project objective is to covert 10,000 litres Sewage/ day (Municipal Liquid Waste into 10,000 litres Clean Water/ day using Photo Bio-Reactor (PBR) Technology at Sundial Park, Barapullah, New Delhi. A demonstration plant is being commissioned at Barapullah Site for conversion of Municipal Liquid Waste into Clean Water at a capacity of 1 Million Litres Sewage per day. The technology has been developed using Microalgae using tubular Photo Bioreactor (PBR). The sewage would be converted into Clean Water and other useful value added products like Bio-CNG. At present 1000 litres/ day clean water is being produced from Municipal Liquid Waste which is being used for secondary agricultural purpose.

Wealth from Sewage: DESMI EnviRo-Clean-up project supported by DBT in collaboration with DESMI RO-CLEAN A/S, Denmark at Sun Dial Park, Sarai Kaale Khan, Delhi for research with mixed waste feedstock using DESMI Trash Traps. The aim of the project is to test the gasification technology for mixed waste feedstock at a capacity of 1.5 tons and clean Barapullah drain from floating debris and the collected mixed waste can be used to generate resources i.e. gas or electricity. Since February 2019, about 5 tons/day floating debris is being collected from the Barapullah drain.

Way Forward: To make the overall process cost economically feasible the efforts are continued to establish

various bio-refinery platform systems for production of value added bio-commodities such as high value pigments, bio-plastic, aqua feed and animal feed etc , from the co-products generated during biofuel production,. Major goal is to achieve the zero waste discharge by effectively utilizing the co-products of different processes as feed to produce value-added bio-products that would aid in closing the loop. The potential clean technologies are taken forward by implementing in small units in collaboration with suitable stakeholders or urban local bodies.

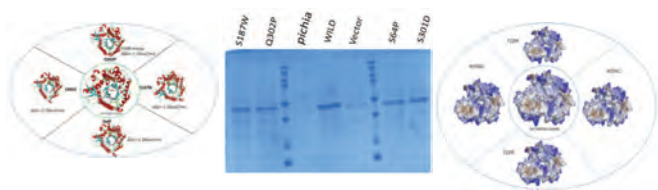
Biotoilet awareness programme in Tripura

Demonstration of Ignition test of Biogas collected from biotoilet in Kadamtala Girls Hostel, Tripura

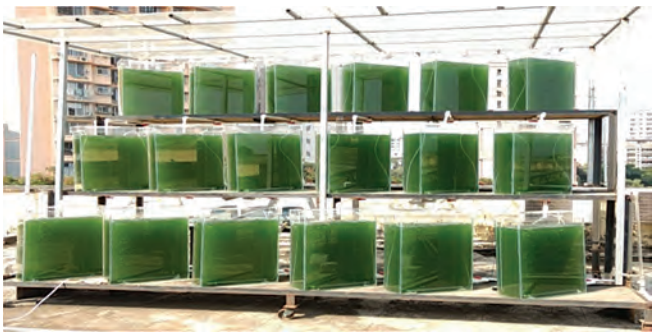
DBT Bioenergy Centre's Team Meet during Oversight Committee Meeting at TERI

MSW Treatment Demonstration Plantcommissioned at Dr. B.R. Ambedkar Bowenpally Market Yard, Secunderabad

Installation of 100,000 L algal growth system at Mumbai coastal site



Three enzymes isolated from A. fumigatus NITDGPKA3



Algal photo bioreactor Facility at KETVGV Mumbai

Waste Flower collected from Kalkaji Temple, Digestion of Flower

BIORESOURCES & SECONDARY AGRICULTURE

The aim of the programme is to support R&D projects in the related areas of Bioresources and Secondary Agriculture biomass biotransformations, bioresource systems analysis, and technologies associated with conversion or production of value added products and processes from natural resources. Specific objectives of the programme are:

1) Inventorisation and characterization on bioresources.

2) Prospecting of bioresources for novel genes and genes products, biomolecules and compounds.

3) Improvement of economically important bioresources.

4) Technology development of value added products from Natural Resources.

5) Capacity building including strengthening of infrastructure and other biomolecules components of R&D.

During this year, efforts are being continued to support the research for bioprospecting, inventorization and characterization, value addition and sustainable utilization of bioresouces along with relevant training, capacity building and awareness generation. Various Brainstorming-cum-Consultation meeting swere organized for prioritization of R&D areas based on available research leads. The Department has taken an initiative to develop a Marine Bioresource and Biotechnology Network Programme involving identified institutions of CSIR, Ministry of Earth Sciences and other institutions and universities dealing with marine biological research in India for strengthening of marine biotechnology and biology research in the country. This will be a virtual centre in a "Hub and Spoke Model". The virtual centre network will actively network and collaborate with leading national institutes and universities dealing with marine biological research in India for strengthening of marine biotechnology and biology research in the country and international agencies with complementary expertise.

A "Brainstorming-cum-Consultation Meeting was organized to discuss India's participation in the important Global Mission on Earth Bio Genome project, a global effort to sequence the genetic code, or genomes, of nearly 1.5 million known animals, plant, protozoan and fungal species on Earth. It is a grand challenge for the global scientific community. A detailed project proposal entitled "Indian Initiative on Earth Biogenome Sequencing (IIEBS)" has been developed with the aim to sequence about 1000 plants and animals (100 Reference Genome and 900 Draft Genome) in the next five years. A detailed evaluation process has been done and based on overall comments, a memorandum for Standing Finance Committee has been prepared which is now under process.

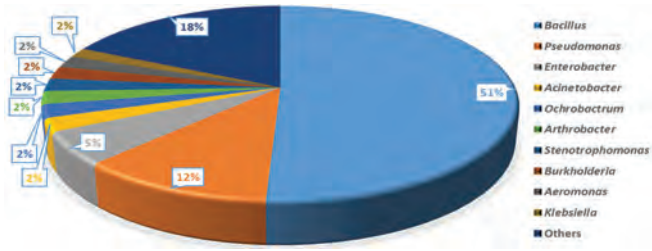
The salient achievements of the programme during the year are as follows:

National Centre for Microbial Resource (NCMR)": DBT created a central facility, the National Centre for Microbial Resource (NCMR) as a Centre of Excellence in 2017, originally established as the Microbial Culture Collection in 2009 to cater the need of authenticated, reliable biological materials and associated information for the research fraternity and biotech industry. NCMR has a mandate of exploring and conserving the microbial diversity of India and of developing an infrastructure to facilitate services of the highest standard in microbial identification, characterization and preservation. Within a short span of time, NCMR has marked its presence across the globe by offering such services to researchers in industry and academia. This has now extended to include

collection of AMR isolates generated across the country. NCMR has trained young manpower in the field of microbial systematics and ecology. A Policy for the supply of the cultures across the country to the researchers has been formulated for access to their cultures by other researchers. New initiative being undertaken towards taking some of the potentially active molecules generated from the DBT's Microbial Mission Program for development of bio-active molecules of socio-economic relevance. With over 180,000 microorganisms in its collection, NCMR is the single largest culture collection in the world, putting India in the top three countries with the largest collections after USA and Japan. NCMR is playing a pivotal role in the NCMR remains committed to enrich and exploit this hidden treasure for its biotechnological benefits. DBT has expanded the mandate of National Centre for Microbial Resource to function as "Bio-repository for resistant microbes/infective agents (Bacteria and Fungi)" and to carry out collection, storage, maintenance, preservation and characterization of these microbes across the country. NCMR has generated 400 AMR isolates under various surveillance projects. NCMR has recently launched a blog site 'Microbe World' for dissemination of scientific information via social media networking (https://ncmrnccs.wordpress.com/).

At the newly established microbial genome sequencing facility at NCMR, it performed whole-genome sequencing of two of the first phytoplasma genomes from India belonging to 'Rice Yellow Dwarf' (RYD) group associated with Sugarcane Grassy Shoot (SCGS) and Bermuda Grass White leaf (BGWL) diseases. These are the first draft genomes of SCGS phytoplasma (strain SCGS) and '*Candidatus phytoplasma cynodontis'* (strain LW01) from the RYD group (also 16SrXI group) which will help to delineate these phytoplasmas at a finer level, taxonomically.

Over the last year, 44 peer-reviewed publications have been published by NCMR. Of these, seven were novel taxa descriptions. While two novel bacteria were named after Dr. Tapan Chakrabarti as *Nitrincolatapanii* MCC 2863^T and *Chakrabartia godavariana* MCC 3406^{T}honouring his contributions to microbial taxonomy research in India, four novel fungi were named as *Naganishia indica* RNF072^T, *Leucosporidium himalayensis* MCC 1733^T, *Coniochaeta dendrobiicola* MCC 1811^T and *Aureobasidium tremulum* MCC 1683^T.



Ten most abundant microbial taxa preserved and available at NCMR for further exploitation. The others pie (18%) comprises of ~240 taxa in NCMR's collection, each with <1.5% relative abundance. Percentage abundance for each of the pies are round off to the nearest integer

Microbial repository established at IBSD, Imphal has got a total collection strength of ~55,000 microbial cultures (including cultures isolated during 1st phase of the project) including bacteria, fungi, yeast and actinobacteria isolated from different unique niches of NE India such as hot spring, cold spring, caves, endophytes from medicinal plants, lakes, fermented food products and other extreme environments. A total of about 34 thousand cultures were deposited by the 8 collaborating institutions during Phase II. Culture characterization using MALDI-TOF analysis of 15000 cultures was carried out.

Bioresource and Sustainable livelihoods: A multi-institutional project, Bioresource and Sustainable livelihoods in North East India comprising six components and 29 teams has been supported. During the current year, two new species of diatoms described and published. Anti-biofilm activity of biochemicals isolated from *Gaultheria fragrantissima* oil published in Nature Scientific Reports. Nine workshops strengthened the capacity of over 260 participants from all over northeast hailing from different strata of the academia, practitioners, government officials as well as the civil society (amateur naturalists). Seven papers already published in high impact international journals, one has been submitted and is undergoing second stage review after first revision while 19 are under various stages of preparation. Two Book Manuscripts are being prepared based on findings from this project. In addition, three Patent applications for bioresource based product developed have been filed. Market surveys in Sikkim indicated high bioresources trade volume with gross annual turnover of Rs 1.5 crores. Bioresource data obtained from six markets of Sikkim indicated a high volume trade of 87 tonnes per annum resulting in a gross economic turnover

of INR 1,46,41,114 and annual gross profit of INR 72,84,042. Two new distribution records and two new species of edible insects and two new species descriptions of diatoms provide leads for the potentiality of new biological resource and unrecorded biodiversity from NE India. Data from the freshwater mollusc help unravel their biogeographic origins and provides lead to understand about the biodiversity evolution in NE region. Data on wild edible insects and mollusc show the magnitude of wild edible resources that play a pivotal role in the regional economy to explore for food security related issues in the NE region.

The team of field researchers deep inside the remote forests of Tripura to conduct a transect survey for quantitative estimation of flowering plant diversity

Musa ornata*, an important wild edible bioresource from Mizoram*

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 importanceIn a network project on search for novel anticancer bioactives from the Kashmir Himalayan Mushrooms, more than 50 mushroom species from Kashmir Himalayan habitats collected, morphotyped, molecularly identified and screened. Extracts of *Armilleriamellea*, *Cortinariousfraudulosus, Inocybegeophyla* significantly decreased the phosphorylation of p70S6 Kinase, thereby influencing mTOR pathway, cell growth and translation. *A. mellea* & *C. fraudulosus* prevented almost 100% DNA damage caused. Antitumor activities of *Fomitopsispinicola, Morchella sp., Lactariusdeliciosus* and *Cantharelluscibarius* were exceptionally strong with reduction in tumor growth as high as 95%. *F. pinicola and Morchella* sp. were found to possess significant anti-angiogenic activity. A total of 23 insects have been screened for Anti-Microbial Peptides from Hymenopteran (ants, bees and wasps) insects and bioassays from solvent extracts of six species have shown biological activity. One species of ant, *Monomoriumindicum* has yielded eight active fractions out of which one fraction showed good antimicrobial activity against both Gram+ve and Gram–ve bacteria. This fraction yielded seven potential AMPs of which five peptides were characterized and sequenced. All the seven antimicrobial peptides identified so far from these two species are novel peptides.

Under the IBSD Flagship programme, Conservation, Propagation and Mass Multiplication of Selected Orchid species from North-East has been initiated and a pilot project has been sanctioned for developing bio-based entrepreneurship in North-East India.

Biodiversity Characterization and Digitized Inventorization:Indian Bioresource Information Network (IBIN) has been launched as a single window system for acquiring and distributing data on India's bioresources and biodiversity; in particular, on the taxonomy, distribution, biology and uses of plants, animals, microbes and marine resources. This is being developed as a globally recognized repository of information on Indian bioresources. The digital data sets being updated and hosted by IBIN shall go a long way in sustainable utilization and conservation of bio-resources of our country. The species data consists of taxonomy, distribution, chemical and biochemical, pharmacological and other use information on plants, animal, marine and microbial assets of the country. Currently such information is available on 28,734 plant species; 1,303

birds; 222 amphibians; 175 lizards; 127 mammals; 203 snakes; 39 turtles; 672 fish; 1,075 mollusc; 72 prawns; 2043 butterflies; 471 lichens; 4350 marine animals; 19,926 microbes; 4,634 pests; 23 lab animals; 7 domestic animals; 232 parasites; 295 predators and 5 silkworms. During current year, an Artificial Intelligence based butterfly identification software has been developed. The software is accessible through www.pathangasuchaka.in and android app through play store can identify 800 butterflies and 500 moths of India. Further, the website provides information on distribution of the butterflies captured by the users which is added to the database in real time. The androiod app was very well received at the 107th Indian Science Congress held in UAS, Bengaluru from 3-7th January 2020. An informative database on pollinators, silkworms, pests, predators, parasites, edible and therapeutic database has been developed for entire India pooled from varied published sources such as books and research publications. The database now has 660 species of pollinators, 68 species of silk worm, approximately 2300 species of insect pests, 1850 species of predators and parasites for India is being developed. The database has 250 edibles and 177 therapeutic insect's details along with taxonomy, use and application details in it. Several workshops have been conducted to promote the use of IBIN in education, research, and conservation. So for, over hundred students, researchers and teachers are trained through these workshops.

A first ever systematic attempt has been made for quantitative assessment of plant resources and its distribution in Madhya Pradesh, Central India. This assessment has been done in a grid based manner and compiled the data in the form of database. A total of 412 transects have been laid in 373 grids of Sagar, Damoh, Panna, Chhatarpur and Hoshangabad, Umaria, Gwalior, Riwa, Alirajpur, Dhar, Mandsour and Neemuch districts of Madhya Pradesh.A total of 352 plant species are recorded so far of which 339 plant are identified, 134 are trees, 25 shrubs and 186 herbs and liana 1 and climber 6.Out of the 339 identified plant species only 134 (39.52% species) are regenerating and only 25 (7.37 %) species are found in all the three different growth forms (seedlings sapling and adults).Out of the 339 recorded plants 40 species (11.79 %) are IUCN Red listed viz. *Dalbergialatifolia* Roxb., *Pterocarpus marsupium* Roxb., *Santalum album* L., *Ziziphusjujuba Mill.*, *Alternantherasessilis*(L.) R.Br. ex DC. *Cyperusrotundus*L., *(Sw.)* DC., *Justiciaquinqueangularis* J. König ex Roxb. *Saccharumspontaneum* L., *Albiziaprocera (Roxb.)* Willd., *Brachiariaramosa* (L.), *Ixorajavanica (Blume)* DC, and *Hardwickiabinata* (Roxb.).

In order to document the diversity of Indian honey bees and stingless bees, multi-institutional network project has been implemented with UAS, Dharwad as lead centre. Total of 120 grids from ten biogeographical regions have been identified. Three species of honey bees *viz*. Apiscerana, A. florea and A. dorsata and five species of stingless bee *viz*., *Tetragonulairridipennis, Tetragonulalaeviceps, Lophotrigonacanifrons, Lepidotrigonaarcifera* and *Tetragonulagressitti* have been identified from three physiographic zones of north east India. For the first time, information about the true taxonomic diversity of Indian stingless bees and their phylogenetic relationships among them has been explored.Building of National Bee Repository is completed and all honey bees and stingless bees of entire India are pinned and preserved here in UAS, Dharwad.

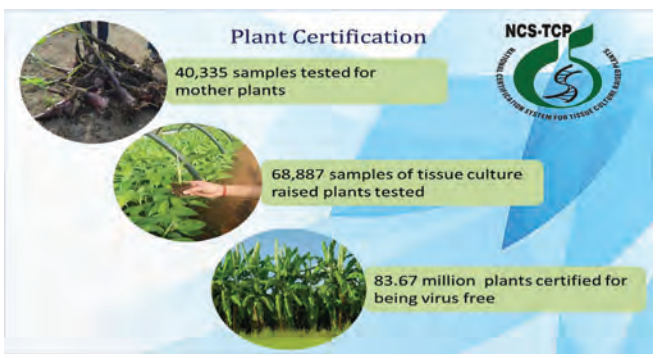
DBT- Department of Space Mission on Biodiversity characterization: The Department of Biotechnology (DBT) had under an earlier Mission mode programme with Department of Space (DoS) over 10 years back taken up "Biodiversity Characterization at landscape level". This was the first such network on Spatial and Non-Spatial data. Under this project, a national level assessment of biodiversity richness was undertaken for the first time in India using spatial data to identify and to map potential biodiversity-rich areas in the country. So far 84% of the Country's forest cover has been characterized. The study has brought out a Spatial Database, first of its kind, adding spatial explicitness to understanding of vegetation formation; it provides a wall to wall mapping of natural habitats.

Under the Mission in collaboration with Department of Space, a new initiative has been undertaken recently towards Intensive mapping of Hot-spots and mapping of Coral Reefs. The Mission activities will include the creation of new geospatial inventory of Indian coral reefs covering 172 grids of Indian coral reef regions at 1:25000 scale. The project is going to deliver a new status report on Indian coral reefs and carry out change detection vis-à-vis 2004-08 coral reef inventory based on Indian Remote Sensing satellite. The

project also aims to study change hotspots for each of the coral reef region and develop coral health indicator based on field spectroscopy methods. The project on Biodiversity Characterization at community level is targeted at developing an Earth Observation based strategy for monitoring biodiversity at the vegetation community level in India. The project outcomes will lead to the development of earth observation-based biodiversity monitoring system that will benefit both national imperatives and reporting to international commitments on biodiversity goals.

National Certification System for Tissue Culture Raised Plants (NCS- TCP): Production of quality planting material: National Certification System for Tissue Culture Raised Plants (NCS-TCP) has been established by the Department of Biotechnology (DBT), Govt. of India as per the Gazette of India Notification under the Seeds Act 1966 with the objective of certifying the production and distribution of disease free and quality tissue culture plants. The major objective of NCS-TCP is to facilitate production and distribution of quality tissue culture planting material. To achieve the above objectives, tissue culture companies are recognized under system on the basis of infrastructure and implementation of quality management system. Apart from recognition of tissue culture companies, test laboratories have also been accredited under system. After Recognition, the tissue culture companies become eligible to get their tissue culture raised plants tested and certified by the Accredited Test Laboratories (ATLs). Two Referral Centers have also been identified for testing of disputed samples, training etc. So far, more than 350 million plants have been certified under NCS-TCP. During the current year, efforts have been continued to provide quality planting material to farmers. With recognition of 84 companies under the system, it is mandatory to achieve 100 % batch certification to ensures that every tissue culture plant reaching out the farmer is disease free and of the best quality.A robust online system has been developed to make the process of NCS-TCP expeditious and transparent. This enables various stakeholders and Tissue Culture Production Facility (TCPF) to maintain centralized information database. Moreover, software for label printing and QR code generation is being developed to ensure traceability of each plant produced.

This year, NCS-TCP has made significant progress in terms of recognition tissue culture companies, testing, certification, capacity building, updating of guidelines, creating awareness among stakeholders etc.. Total of 1, 09, 222 samples were tested by ATLs. Out of this, 40,335 samples are of mother plants and the remaining 68,887 samples are of tissue culture raised plants, certifying 83.67 million plants, which largely include tissue culture banana. 691 samples of tissue culture raised plant were found virus positive and subsequently their batches were disapproved for certification which is significant in terms of preventing distribution of any virus infected/sub-standard tissue culture plants in the field. Total 45 site visits were organized which include 17 site visits for recognition and 24 site visits for Renewal of Recognition, 2 random visit, 1 verification visit and 1 visit for redressal of grievance. Certificate of Quality (CoQ) and labels with barcode for certified batches of TC plants are being provided to companies. Total 41,790 labels were issued against the certified plants in 2019. NCS-TCP web-portal has been operationalized. ATLs and TCPFs are using online web portal for testing & certification, recognition and renewal of recognition etc.

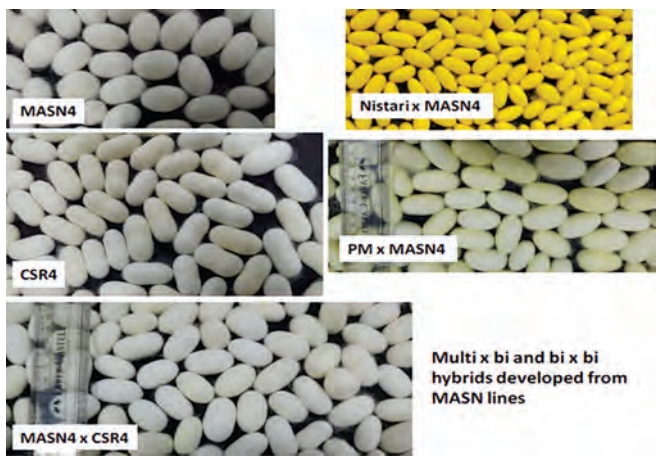


SILK BIOTECHNOLOGY

The programme on application of biotechnology towards developing newer and emerging technologies in silk and its applications in biomaterials continued during the year. Programme has been reoriented during the year 2014-15 with focus on addressing newer and emerging technologies for improving the productivity and enhancing the quality of silk and its applications in biomaterials. The major Priority R&D areas of this programmes are- technology development both in silkworm and host-plants by employing tools and techniques of biotechnology towards improving the productivity, enhancing the quality and utilization of by-products in both mulberry sericulture as well as non-mulberry (Vanya silk) sectors; developing novel applications of silk

proteins (both fibroin and sericin) in biomedical, pharmaceutical and cosmeceutical areas; developing network programme on biotechnology applications for developing improved varieties of mulberry and; developing network programmes on Vanya silk (tasar, muga and eri) on biotech applications towards improving the productivity of silk as well as improvement of host plants.

Salient achievements: Under a network project on biodiversity assessment of wild silk moths and rearing potentialities of Muga (*Antheraeaassamensis* Helfer) and Eri Silkworm (*Samiaricini* Donovan) for sustainable development in Nagaland being implemented jointly at Nagaland University, CMERTI, Jorhat. About 14 species of wild silk moths belonging to 8 genera were reported from Nagaland. Morphological characterizations of all species were done. 22 species of naturally available host plants were also identified along with their distribution in different area and feeding preference of wild silk moth species. One wild stock of muga silkworms have been extracted and isolated. Mass rearing of muga and eri silkworm conducted during different seasons at adopted rearers level was successful and farmers were economically benefitted. Larval duration and cocoon harvest varied seasonally and depended on location. Validation of the DNA markers in silkworm:Large scale rearing of the pure lines of MASN 4, 6 & 7 were conducted under CSRTI, Mysore and NSSO (CSB) and used for hybrid synthesis by crossing MASN4 with CSR4 (bivoltine F1 hybrids) and MASN4 with Nistari and Pure Mysore (multivoltine cross breeds). The hybrids developed from MASN lines (Nistari x MASN4 and MASN4 x CSR4) are potential and suitable for east zone and can be exploited commercially. The performance of Bivoltine MASN hybrids in respect of yield and cocoon quality is better than ruling hybrids (SK6 x SK7). Likewise performance of Multi x Bi hybrids developed from MASN line in respect of yield and cocoon quality is better than ruling hybrids [Nistari x (SK6 x SK7)]. MASN4 x CSR4 hybrids showed better survival, higher Silk content (shell ratio %) and better yield in Himachal Pradesh however these observations are based on single spring crop and to be confirmed.In Jammu, Himachal Pradesh and Dehradun region, 31500 DFLs of MASN4 x CSR4 were distributed to different farmers and it showed >90% survival rate. In Dehradun (Uttarakhand) and Jammu (J & K) and associated sericulture areas, two major crops, viz Spring (March – April) is the commercial crops. In Jammu, and Himachal Pradesh the crops were successful In HP, the yield was 51.41 kg / 100 DFLs which is equivalent to ruling hybrid FC1 x FC2. However MASN 4xCSR4 had high silk content (SR %) of 21% against 18.9% for FC1 x2. At Jammu and other sericulture belt, the yield was higher to 75.40 kg/ 100 DFLs and SR was ~21.5%. Under Dehradun region, Spring rearing was successful and survival rate was up to 85-90%. Fecundity was 450-500 and hatching was up to 95%. The shell ratio ranged 17 – 20%.



Hybrids and cross breeds developed from MASN line of the silkworm B. mori *for NPV tolerance and high yield*

Development of disease and pest control measures: A PCR based technique has been developed to detect the tiger band virus AnprNPVin silkworms, moths at early stages as well as a major source of infection is identified from the contaminated egg surface. A protocol has been developed to remove the virus present on the egg surface and the preliminary findings indicate that leads to the significant improvement in oak tasar cocoon production besides prevention of the disease.

Design and development of silk fibroin coatings for biomedical applications: Work on development of silk fibroin blend coatings with recombinantly produced elastin polymer has been carried out at CSIR-National Chemical Laboratory, Pune to prevent premature failure of implant due to bacterial biofilm formation and foreign body reaction. These coatings have been demonstrated to show reduced protein adsorption demonstrating in in vitro studies.

A project has been carried out on analysis of DNA and RNA

components of nuclear matrix in *Bombyxmori* embryos*at GITAM University, Visakhapatnam*.Double hybrid, bivoltineKrishnaraja strain of *Bombyxmori* was selected for the project. Nuclei and Nuclear matrix isolation protocol from embryos and silk glands of the above strain was successfully established in the lab. Results showed that 13.61% of the total nuclear DNA, 11.67% of the total nuclear RNA and 12.3% of the total nuclear protein were retained in the NuMat of embryos while, 14.93% of the total nuclear DNA, 5.09% of the total nuclear RNA and 15.97% of the total nuclear protein was retained in the NuMat of silk glands. Sequencing results showed several silk gland protein genes, transposable elements and different kinds of repeats associated with nuclear matrix.

Assessment of SNP Variation in Silkworm (Bombyxmori by RAD Sequencing and Genome-wide Association Mapping of Important Commercial Traits*has been continued at CSRTI, Mysore and R. V. College of Engineering, Bangalore*100 diverse silkworm genotypes *(*60 bivoltine& 40 multivoltine*)*, were collected from different sericulture R&D Institutes of India and phenotyped for five qualitative traits and nine quantitative traits. Analysis of variance indicated significant differences among the genotypes for all the parameters studied. Principle Component Analysis and hierarchical clustering revealed genetic diversity among the genotypes as witnessed by 8 distinct groups justifying rational of selection of genotypes which is most important for association mapping.

Work on Genetic enhancement of Mulberry by Genomics Approaches: A multi-component Network Projectbeing coordinated by CSRTI, Mysore.Isolation of DNA from 311 mulberry accessions were completed and SSR profiling was employed to assess genetic relatedness among the diverse mulberry accessions and a common workflow language protocol for SNP analysis and annotation has been developed. Ninety-six germplasm accessions were screened using 4 polymorphic SSR markers and these SSRs are informative for estimating the extent of genetic diversity as well as to determine the pattern of genetic relationships between the 96 diverse germplasm lines. Four different constructs expressing the AtSHN1 and AtDREB2A were generated, confirmed, mobilized to Agrobacterium and are being transferred to CSR&TI, Mysore for mulberry transformation as per IBSC guidelines. The transgenic mulberry plants already generated at UAS, GKVK were screened for confirmation of transgene integration, and positive plants have been identified and confirmed by sequencing. The drought transcriptome was analyzed and five candidate stress responsive TFs were identified, cloned from mulberry, over expression cassettes were prepared and mobilized to Agrobacterium. The required numbers of saplings for establishing experimental plantation for the sub programme NW4a were raised at CSRTI-Mysuru and fresh leaves of five mulberry varieties *(*Mysore Local, K2, G2, G4& V1*)* were collected and sent to CSIR-NCL, Pune for characterization of secondary metabolites.

TRANSLATIONAL RESEARCH ON MEDICINAL AND AROMATIC PLANTS

The DBT is providing research support across the country towards developing products and processes from medicinal and aromatic plants following multi-disciplinary approach. The DBT is also providing research support for conducting R&D utilizing rich traditional knowledge disciplines on the basis of conventional traditional knowledge in the country following any of the two available regulatory frameworks: (a) DCGI-Phytopharmaceutical Drugs, and (b) AYUSH mode. The aim is to develop a herbal drug pipeline.

During this year, the DBT has taken initiative on developing Phyto pharmaceuticals Mission Programme in North East Region using modern scientific tools following DCGI- CDSCO protocols. The DBT has signed a tripartite agreement with CSIR and ICMR with the aim for mutual collaboration to develop phyto pharmaceutical products for therapeutic use following DCGI- CDSCO protocols. The effort would be to take forward the leads already existing with CSIR, DBT and ICMR and develop specific collaborative projects in the domain aiming at rigorous modern scientific testing and development of standard products to maintain global competitiveness. Under this tripartite agreement, Phyto pharmaceutical development of three plant species –"Development of *Boswellia serrata* based phyto pharmaceutical drug for rheumatoid arthritis"; Development of *Cannabis* based CBD-Enriched Phyto pharmaceutical Drug for the treatment of Epilepsy" and Development of *Cannabis* based "CBD-THC

Enriched Phyto pharmaceutical Drug for Pain management" will be taken up during 2019-20. DBT has also taken initiative on developing Phyto pharmaceuticals Mission Programme in North East Region and two projects for developing phyto pharmaceutical drug from *Ficus semicordata* for the treatment of Diabetes and establishment of State of the art Quality Control (QC) and Quality Assurance (QA) Laboratory Facility at IASST, Guwahati have been supported. A proposal for establishment of pilot scale extraction facility for standardized botanical extracts is being developed.

A MoU with NMPB, Ministry of AYUSH has been signed for Inter-Ministerial Cooperation for Promotion and Facilitation to have a biotechnological intervention in AYUSH sector. DBT has taken initiative to launch a focused programme on Turmeric with an aim to generate high-quality raw material for developing nutraceutical products / dietary supplements from turmeric for global market and develop curcumin and curcuminoids-based therapeutic drugs.

The salient achievements of the programme during the year are as follows:

A project has been supported to study the Gene transfer and expression system studies of key *Santalol* pathway genes in Sandalwood cell culture system to induce constitutive biosynthesis of santalol in sandalwood cell suspension cultures. The outcome of the study revealed that expression of genes namely SaFDS, SaSS and AtP450 hydroxylase leads to accumulation of santalenes in mature heartwood of the tree. Further hydroxylation of santalenes to santalols is catalyzed by cytochrome P450 hydroxylase. Thus, in the present project, constitutive overexpression of these three genes will be attempted in cell suspension cultures to achieve santalol production.

Work has been continued to develop Phytopharmaceutical product for Bovine Mastitis.Three topical formulation were prepared based on *in vitro* anti-infective (MIC 8-128 µg, against mastitis causing bacteria eg. *Staphylococcus aureus, Streptococcus agalactiae, Streptococcus disgalactiae* etc) and *in vitro* anti-inflammatory (40-64% inhibition of pro-inflammatory cytokines IL1â, IL2, IL6, TNFá in LPS induced RAW264.7 cells) activity of 24 extracts (alcoholic, hydro alcoholic, aqueous extract). Six best enriched extracts were selected from four medicinal plants (*Terminalia bellerica*, *Piper betle*, *Boswelliaserrata and Bergeniaciliata)* for the development of three topical gel formulations as anti-infective and anti-inflammatory for bovine Mastitis. Standardized topical gel formulation was evaluated for proof of concept in standard animal model (Carrageenan induced Paw edema model) of inflammation. Topical gel showing promising activity and comparable with marketed product Diclofenac gel (overan gel; Novartis) as control.

A project has been supported to develop a standardized, efficacious and safe herbal &herbo mineral formulation in Ayush made for psoriasis, a chronic, noncommunicable, painful, disfiguring and disabling disease for which there is no cure and with great negative impact on patients' quality of life.

Work has been initiated on Manipulation of Rumen Microbes Using Medicinal Plants Extract to Enhance the Nutraceutical Value of Milk as a Functional Food.Study on *Bacopa monnieri* and *Withania somnifera* is in progress. Based on animal studies, the anti-dermetophytic herbal formulation using essential oil of *Trachyspermum ammi* (Ajwain) has been further improved jointly at Dolphin Institute of Biomedical and Natural Sciences, Dehradun and Centre for Aromatic Plants (CAP), Dehradun. Significant results obtained against Microsporumcanis and Trichophyton mentagrophytes suggests its utility in treating animal dermatophytes, common in pets. Genomics and biosynthetic pathways. Based on research leads generated under this project, a follow up proposal has been formulated towards Phytopharmaceutical Development of *Trachyspermum ammi* for Post Kala-azar Dermal Leishmaniasis.

In the project on investigation on high value sesquiterpene(s) biosynthesis and its overproduction in heterologous systems at CSIR-CIMAP, Lucknow, comparative transcriptome sequencing was carried out for the basic understanding of the genes involved in various biological pathways. Overexpression of *MPTPS4* gene in *M. piperita*has been done. Four transgenic lines were obtained, overexpression of this gene has been validated by real time analysis and GC-MS. All lines showed significant increase of viridiflorol content in essential oils compared to vector control plants. Other metabolites like menthone, menthofuran, and menthol decreased as flux diverted towards the increased content of viridiflorol further as one sesquiterpene alloaromadendrene

has the same biosynthetic origin like viridiflorol, also increased compared to vector control plants. A patent on high viridiflorol producing transgenic *M. piperita* plant has been filed.

In the project on product development based on thymol-rich Jammu monarda *being jointly implemented at CSIR- IIIM, Jammu and FFDC, Kannauj* various field experimental trials have been conducted on *Monardacitriodora* on experimental field of FFDC, Kannauj (U.P.) and MSME TC project Imphal (Manipur). The overall performance of the crop was good having excellent oil recovery (0.6%). The oil of *Monarda citrodora* is the good source of Thymol content which is used in various flavour and fragrance industry. The Thymol fraction of oil will convert into solid crystal though standardization of process and become easy export. It has better self-life than other essential oil due to its antibacterial property. Waste product is also useful in manufacturing of incense stick. The laboratory scale work on monarda oil has been done and found 98% purity of production of Thymol crystal.

A project has been supported at Amrita Institute of Medical Sciences and Research Centre, Kochi to develop Plumbagin ointment as topical anti-microbial agent for the treatment of *S. aureus* skin and wound infections. The study revealed that the developed Plumbagin ointment formulation showed antibacterial activity against *S. aureus* strain SA113 (ATCC35556) and multi drug resistant clinical isolates. Plumbagin ointment was found to be stable for 10 months without preservatives.

A multi-component Network Project on Field Demonstration of Cultivation and Development of Processed Technologies of Aromatic Plants – Patchouli, Citronella and Sugandh Mantri in Assam has been continued at Kelkars Education Trust's Scientific Research Centre, Mumbai in collaboration with Institute of Horticulture Technology, Mandira, Assam for demonstration on cultivation of selected Aromatic Crops in 100 acres area (Patchauli: 60 acres; Citronella: 35 acres and Sugandh Mantri: 5 acres) in farmers' fields in Assam. For the establishment of the Demo Plantation at IHT, soil testing was carried out. Nursery with elite verities Patchouli and Citronella has been established at IHT. About 40,000 Citronella saplings were planted in two-acre demo plot at IHT. The nursery of patchouli plants has been established at IHT with 6,500 patchouli plants. The demo plots for Patchouli, Citronella and experimental cultivation of Sugandh mantri has been established at IHT. Training of farmers for distillation and value-addition is scheduled at IHT in next month. Demo plantation in two acres each for Patchouli, Citronella and Sugandh mantri is established at IHT. The process for installation for FDUs at IHT has been initiated. Periodic testing of oil is carried out at Scientific Research Centre to check the market feasibility of oil. The oil obtained from farmers fields will also be tested. Marketing tie-up and MoUs will be established with farmers for buy-back of the Aromatic Oils.

A multi-component Network Projecton demonstration of Cultivation, Processing and Value Addition of Selected Aromatic Crops in Bundelkhand Region jointly implemented at CSIR-Central Institute of Medicinal and Aromatic Plants CIMAP, Lucknow, Fragrance and Flavour Development Centre, Kannauj; CSIR-Indian Institute of Integrative Medicine (IIIM), Jammu and, Bundelkhand University, Jhansi. During current year, 47 awareness programmes have been conducted in the 14 districts of Bundelkhand region and trained 3812 farmers (males and females) about economic benefits of adopting cultivation and processing of aromatic crops.Currently 492 acres area are under cultivation of Lemongrass (166), Palmarosa (87.5), Rosa grass (144), Vetiver (3.5), Basil (55), Mints (31) and Jammu monarda (5) across 14 districts of Bundelkhand region. 11 distillation units in different clusters in Bundelkhand region have been installed to facilitate the processing of the aromatic crops. During this period, total essential oil produced was 3903 kg i.e. Lemongrass (457), Basil (450), Mints (1400), Rosa grass (457), and *Jammu monarda* (6). The total worth of this produce was Rs. 41.02 lakhs and the employment generated through this cultivation was about 40,000 mandays of worth Rs. 80.00 lakhs. Complete produce was marketed through tie-ups with 20 buyers/exporters/manufacturers.

Releasing of Training Booklet for Bundelkhand

A collaborative project including Siksha-O-Anusandhan University, Bhubaneshwar and Fragrance and Flavour Development Centre, Kannauj has been supported to study the Chemical and molecular profiling of kewra (*Pandanus fascicularis*) from various eco regions of Odisha for selection of elites with high essential oil yield and quality. A total of 205 kewda flower samples were collected for GC MS analysis from different eco regions of Odisha. The essential oil yield varied from 0.019% - 0.028% among all the zones. A total of 34 components constituting 84.1% to 97.96% of the total essential oil were identified. Four elite germplasm were selected basing on their oil yield and quality (PEME content more than 75%). Genetic diversity was studied in 84 local cultivars of Kewda collected from 12 different zones of Ganjam district of Odisha by using ISSR and SSR markers. Both ISSR and SSR markers showed moderate level of polymorphism i.e. 68.63% and 74.36% respectively. The selected elites of kewda germplasm from four zones were supplied to 12 local farmers of Berhampur district for plantation. Selected elite plants from four zones according to their uniqueness of essential oil yield and quality analysis have been propagated and maintained at FFDC Extension Unit, Berhampur as well as at farmers' fields.

A multi-component Network Project on Identification of Elite Planting Material of Selected Temperate Medicinal Herbs, Mass Multiplication, Field Demonstration and Post-Harvest Processing jointly implemented at Bennett University, Greater Noida, G.B. Pant National Institute of Himalayan Environment & Sustainable Himachal Unit, Mohal-Kullu and, Zandu Foundation for Health Care, Gujarat. The project aims at developing rural enterprises among high altitude farmers of Himachal Pradesh and Uttarakhand through mass multiplication and production of quality plant material of four medicinal plant species, *Swertia chirayita*, *Picrorhiza kurroa*, *Nardostachysjatamansi grandiflora* and *Rubiacordifolia*. Elite plant material has been identified as per industry API standards for all 4 species and 50 farmers have been provided with planting material of *P. kurroa*(accession Ramni, UK) to cultivate in 6 acres of farmers' fields. *S. chirata* sample from Nepal; *Rubia* samples from Uttarakhand and Guwahati; and Two samples UK 2 and UK 3 of *Nardostachys jatamansi grandiflora* have complied with the herbal industry API specifications in all quality parameters. RAPD-based DNA fingerprinting has been optimized for *Nardostachys jatamansi grandiflora* and *Rubia cordifolia* to develop diagnostic fingerprints for quality plant material for their IPR protection and ensuring genetic purity.

N. jatamansi populations collected from different locations of Uttarakhand

Distribution of plants of a critically endangered medicinal plant species, S. Chirata to farmers for cultivation in Uttarakhand

Environmental Biotechnology

The Environmental Biotechnology Programme aims to harness the rejuvenative properties of nature to address the major challenges such as anthropogenic pollution and climate change. To this effect this programme funds R&D efforts towards development of technologies for efficient monitoring of environmental health, treatment of solid & liquid wastes, bioremediation of polluted sites, and development of novel technologies using insights from environmental processes. Seven new projects have been sanctioned in the calendar year 2019-20, including a major networking project spread across 9 institutes for engineering approaches for bioremediation of crude oil contaminated soil. Apart from the 7 new projects, 34 projects were ongoing at the end of 2019. The major highlights of the programme are given below.

Environmental Monitoring & Bioremediation

- A project has been implemented at Bharatidasan University, Tiruchirapalli, to monitor rivers for the concentration of emerging pollutants such as parabens, biphenyl S, tetra bromo biphenol A etc. Gas chromatography Mass Spectroscopy methods have been developed for 16 phthalates and 7 phenolic compounds. Microalgal bioremediation techniques for these emerging pollutants are also under development.
- Safe cultivation practices for reducing arsenic contamination of paddy crop have been developed at CSIR-NBRI. This use of arsenic accumulating fungi isolated from soil using easy to apply techniques such seed-soak, root-soak and soil treatment. These techniques have resulted in 24-54% reduction in arsenic content of rice grain as compared to untreated control. Additionally, the arsenic sequestering fungi have been shown to successfully remove arsenic from contaminated water. DBT is now focused on translation of these findings into a technology package and widespread dissemination to tackle the problem of arsenic contamination of rice.
- Microcosm models have been designed at NCCS, Pune based on sampling data from major landfill sites in Delhi, Pune, Bhandwari and Jaipur. These models have given a comparative picture of gas emissions from different sites. Methanogenic consortia isolated from these sites have been enriched and have potential for application in biomethanation and landfill gas production systems.
- A new wastewater treatment model in which naturally occurring organisms are used as "biofilters" is being developed at Central University of Bihar. This technique utilizes filter feeding organisms, aquatic plants, snails, microorganisms etc at various levels to progressively treat the wastewater at much reduced cost.
- A major network project involving 9 institutes coordinated by NEERI has been initiated for engineered approaches for on-site bioremediation of petroleum contaminated soils.
- Constructed wetlands technology for wastewater treatment has been developed at various institutes with DBT funding. DBT is considering funding of large scale demonstration projects for these technologies and attempt to bridge the gap between R&D and field application.

Waste Treatment

- A bentonite clay coated ceramic ultrafiltration membrane (avg. pore size 4.85 nm) has been developed at Central Glass and Ceramics Research Institute. This membrane can be produced indigenously and addition of this high throughput ultrafiltration module to conventional activated sludge treatment followed by microalgal treatment of permeate resulted in recovery of high quality recycled water. This can find application in treatment of highly problematic wastewater containing high COD and toxic heavy metals, such as tannery waste.
- Wet air oxidation (WAO) technology for pretreatment of petroleum leachates containing emulsified and solubilised recalcitrant crude oil pollutants has been developed at CSIR-NEERI, Nagpur as a promising pretreatment for breaking down recalcitrant hydrocarbons into easily biodegradable compounds. The pretreated leachate has been demonstrated to be rapidly degraded by microbial consortia and Typha grass. DBT intends to develop these outcomes into a technology package for bioremediation of crude oil leachates at source.
- A sequential anaerobic solar photo-Fenton process, a hybrid system for decolorization and complete mineralization of dye compounds from textile industry effluents is being developed at Anna Institute of Technology, Tiruchirapalli. This technology combines microbial reduction of azo-dyes with a photochemical process utilizing iron filing scrap and microbially generated hydrogen peroxide for mineralizing the toxic amine products.
- Nitrogen removal is an essential part of wastewater treatment and is performed mainly by denitrifying bacteria. Researchers at M S University of Baroda have identified and developed consortia of amyloid forming denitrifying bacteria for use in moving bed biofilm reactors. These bacteria are highly efficient at biofilm formation and improved the efficiency of nitrogen removal in the reactor.

- Biodegradation of plastics is a major area of investigation around the world. The bacterium *Ideonella sakaensis* is known to degrade poly (ethylene terephthalate) or PET. Through research carried out at Indian Institute of Technology (BHU), the gene responsible for PET degradation has been identified. This can be a major step for understanding the biological mechanism of PET degradation and engineering microorganisms to efficiently degrade PET.

- A *Paracoccus* sp. isolate with multiple capabilities has been isolated in a joint project carried out by Madurai Kamraj University and Gandhigram Rural University (Deemed). This isolate can be used for removal of organic recalcitrant pollutants such as N-methylformamide and chloroaromatic compounds, as well as heavy metals such as chromium, mercury etc.

- Coke oven wastewater generated from iron and steel industry contains a large number of toxic pollutants including cyanide, phenols and ammonia. Researchers at Siksha O Anusandhan University have isolated *Pseudomonas citronellosis* and *Rhodococcus pyridinivorans* strains capable of degrading these recalcitrant pollutants and developed a photocatalytic nanocomposite system which can reduce toxicity upto 90%, and has potential for use in treating coke oven wastewater.

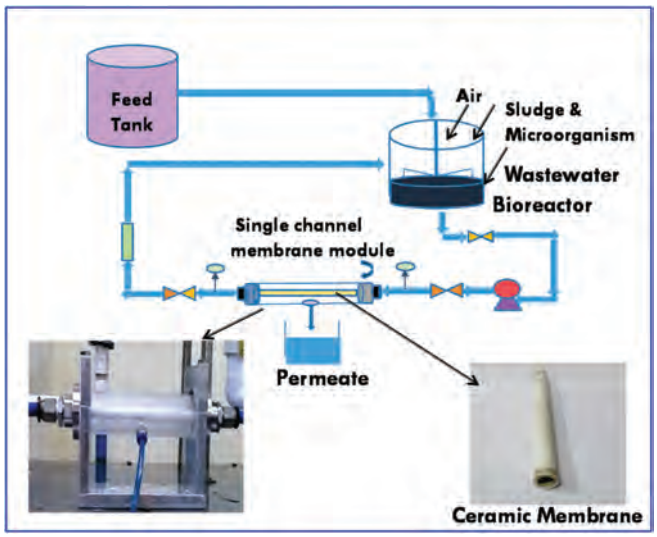
- Enzymes such as endoglucanase, lipase and xylanase with application in recycling of newspapers and waste office paper have been developed through a joint project involving Maharshi Dayanand University and Avantha Centre for Industrial Research and Development.

- An eco-electrogenic model utilizing plants, rhizosphere microbes and electrodes for efficient treatment of textile industry effluents is under final stages of testing at CSIR-IICT, Hyderabad. An eco-electrogenic constructed wetland system has been designed and submitted for construction and demonstration.

Potential leads to take forward

- A unique method for repairing surface cracks in concrete using photoautotrophic bacteria has been developed with DBT support at Thapar Institute of Engineering and Technology, Patiala. A significant increase in compressive strength of cement mortar and decrease in water permeability achieved through this treatment could lead to development of cost-effective technology for repairing of surface cracks and waterproofing of concrete surfaces.

- The catechol 1,2 oxygenase gene from *Paracoccus* has been cloned into *E. coli* and used for production of cis,cis-muconic acid, an important industrial raw material, from catechol.



Ultra filtration module for effective treatment of tannery waste water

Root soak, seed soak and land application of arsenic sequestering fungi for reducing arsenic load in rice.

Forest Biotechnology: Forests are the world's greatest repository of terrestrial biomass, soil carbon and biodiversity. Forests provide a variety of provisioning, supporting, regulatory

and cultural ecosystem services, which are so crucial for the survival of humans. Forests also contribute immensely towards maintaining local hydrological balance. With this background, this new program on Forest Biotechnology has been started in the financial year of 2018-2019 with the overall aim to support R&D projects on Forest and Conservation Biotechnology with focus on mapping and technological intervention for forest conservation, resource utilization and climate change mitigation. This programme addresses research gaps in forest genetics and genomics, and subsequent molecular breeding approach to improve the growth and quality of forest trees for improved productivity of forest areas. So far 22 R&D projects have been implemented. Some of the major projects are biotechnological approach to elucidate adaptation mechanism, migration pattern and reproductive biology of indicator temperate-alpine plants in Himalayas in response to changing climate, assessment of adaptive genetic diversity in teak and sandalwood to guide conservation and genetic improvement efforts, Co-management and sustainable use of non-timber forest products in three protected areas of Western Ghats, efficacious management of wood borers in protected areas of forest by pheromone loaded organo gel, genome wide and geospatial approaches for enhancing the adaptive potential of threatened rattan resources in India etc. Following are the salient achievements of the projects supported under the program:

Project on conservation of salt-sensitive back-mangroves *Heritiera fomes* and *H. littoralis* through re-introduction in protected area at RPRC, Bhubaneswar focused on standardization of vegetative macro-propagation techniques using micro-cuttings in *Heritiera fomes* and *H. littoralis*. In the project on regeneration and molecular characterization of Andaman Padauk (*Pterocarpus dalbergioides* Roxb.) at ICAR- CIARI, Andaman & Nicobar, investigators have identified candidate plus trees. Seedlings were produced from all the accessions and kept for further growth, nutrient and rooting media experiment. A new padauk block of seedlings was developed at Institute farm for its long term evaluation. Project on biotechnological interventions for forest conservation and climate resilient livelihood in eco fragile hills of J&K has been initiated at Sher-E-Kashmir University of Agricultural Sciences &Technology of Jammu. the floral resources for A. mellifera in J&K have been recorded. During the survey, it was also ascertained that little respite in temperature (±2.5) is not only crucial for lac survival but it also affects the phenology of lac host. Training programmes were conducted in which farmers were briefed about the climate smart techniques of lac cultivation and bee keeping.

Diversity and bioactivity of Fungi from Achanakmar-Amarkantak Biosphere Reserve is being explored by NCCS, Pune and Raipur University with emphasis on conservation. Collected culture isolates have been sequenced and phylogenetically analyzed. Further studies are in progress. In the network project on conservation of efficacious management of wood borers in protected areas of forest by pheromone loaded organo gel, pheromone guided organo gel loaded traps were deployed in protected areas of plantation to determine the efficacy of the slow and controlled release formulations towards pest control. Further studies are underway.

During the year a brainstorming meeting has been organized through which following thrust areas have been identified for supporting R&D projects:

- Development of biotechnological mitigation and adaptation strategies in forestry sector to meet the challenges of climate change.
- Cutting edge research using newer technologies like tree genomics for understanding of forest tree biology, development of tree diagnostics and planting material improvement for improved productivity and biodiversity of forested ecosystems.
- Development of seed handling and molecular marker-based seed testing/ certification technologies for development of good quality seeds and planting materials for industrial forests
- Development of site specific technological packages for restoration and rehabilitation of degraded and fragile forest eco-systems.
- Development of technologies for measuring and maintaining ecosystem services from forests.
- Modelling and control of invasive species in protected areas using biotechnological approaches.

Efforts are also being made to develop network projects on modelling and control of invasive species in forest, terrestrial carbon sequestration, technologies for measuring and maintaining ecosystem services, and use of biotechnological approaches on afforestation and regeneration of degraded forest area.

Healthcare And Medical Biotechnology

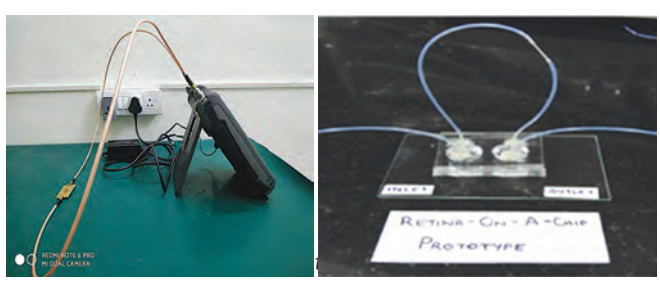
With a focus on affordable healthcare for all, the Department's impetus has been towards understanding the cause of human diseases at genetic and molecular level that enables the development of innovative therapies or preventive measures and early detection in fields of enormous importance for public health. Numerous projects in areas like infectious diseases, chronic diseases, human genetics and genome analysis, maternal and child health, public health and nutrition, vaccine research, bioengineering and bio design, stem cells and regenerative medicine have been supported by the Department for developing new affordable health care interventions for prevention and treatment of diseases, creating healthcare delivery systems and developing important products of high medicinal value. Different areas supported under Medical Biotechnology are detailed below:

BIOMEDICAL ENGINEERING

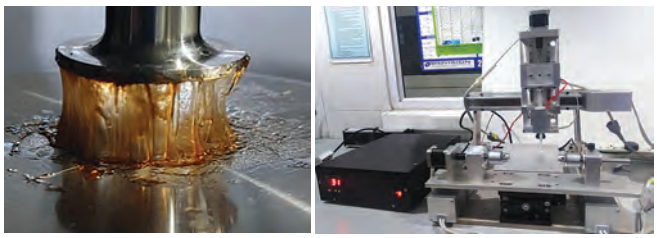
The multidisciplinary domain of biomedical engineering fosters and supports innovative ideas in the field of bio-medical devices and bioinstrumentation. Major achievements of the projects in the current year are highlighted below.

The feasibility of performing Radio Frequency (RF) based characterization of biosamples was explored in a study conducted at IIIT Hyderabad. Interdigitated Capacitor based sensor was chosen for performing the primary analysis which utilized specific binding as the basis of identification of proteins. The sensor required minute volumes of samples for testing, involved simple and label-free procedures for sample preparation besides being portable and reusable in nature. The results provide an excellent insight into the feasibility of using RF based characterization for performing bio sample identification. This has immense practical implications towards development of a portable kit that can be readily utilized for antigen detection. A microfluidic device is being developed for good quality sperm selection for assisted reproductive technologies jointly by National Institute for Research in Reproductive Health and IIT Mumbai. Using the microfluidic device, the group has demonstrated increased directionality and higher velocities of sperm to an increasing gradient of ovulatory oviductal fluid (OF) as compared to pre-ovulatory OF.

A prototype of a microfluidic platform for bio-artificial retina was developed by poly-dimethyl siloxane (PDMS) polymer at ICT, Mumbai. Retina-on-a-chip devices were tested for their ability to support phase separated co-culture of retinal cells and 99% cell viability was seen. Retina-on-a-chip microfluidic based perfusion platform will create a significant impact on understanding the biology of retinal degenerative diseases and in high throughput screening of drugs. An in-house duplex PCR targeting the *opa* and *porA* pseudo gene for detection of *Neisseria gonorrhoeae* was developed jointly by AIIMS, New Delhi and DTU, Delhi. The results suggested that duplex PCR offers a sensitive, specific and reliable assay suitable for the detection of *N. gonorrhoeae* in clinical specimens. Considering the current drawbacks with commercially available sealants during massive trauma or blood loss, a project at Amrita Institute of Medical Sciences and Research Centre, Kochi has developed injectable *in situ* bio adhesive hydro gel using phosphorylated chitosan or phosphorylated HA, tannic acid with glyoxal or poly(ethylene glycol) crosslinkers. Also, at the Amrita Institute of Medical Sciences and Research Centre, Kochi a multi-axis 3D bio printer was built and viable bio-printed vascular grafts were obtained using this bio printer. This work for the first time led to development of a 3D bio printer with four degrees of freedom that can be used for printing a variety of complicated structures with rotational symmetry. Further this group reports for the first time, detailed confocal investigations of cells at different printing conditions and ink compositions. A novel mechanical nitinol-based clot retriever has been developed at Sree Chitra Tirunal Institute for Medical Sciences & Technology Trivandrum. So far 20 prototypes have been fabricated with a 4mm diameter & 20mm length and patent has also been filed. The device is expected to be used in the treatment of acute cerebral ischemic stroke.



Retina on a Chip Prototype (right)



A A. Bio- adhesive hydro gel B. 3D Bio-printer B

Significant strides were made at DBT's Translational Centre of Excellence on Biomaterials for Orthopaedic and Dental Applications at IISC, Bangalore. A new generation of polymer-ceramic hybrid acetabular socket/liner was fabricated using a compression moulding approach. Results indicate that the bonding between reinforcements and matrix can strengthen the UHMWPE (Wear of Ultra High Molecular Weight Polyethylene) and the combined properties such as hardness and lubricity of Alumina (Al2O3), Hydroxyapatite (HAp) and Carbon nanotube (CNT) in UHMWPE matrix can substantially improve its mechanical and tribological properties. CAD based 3D designs of a complete 3 piece-dental implant system comprising of implant screw, straight and angulated abutments, locking screw, healing abutment and cover screw were updated, with designs of 6 implant screw variants being made. An implant screw length of 11 mm with the Channel 2 configuration was found to provide the best biomechanical response. This study also revealed that the implant supported dental bridge approach which requires lower bone invasion results in favourable biomechanical response. A novel acrylic-based ink system assisted with a hybrid processing methodology was innovated for drop-on-demand printing of metallic and ceramic powders. The mechano-physical behaviour of the ink in terms of 'printability' was tuned using rheological assessments and high speed shadowgraphy.

R&D Collaboration through International Partnership- SWEDEN

Till date 16 joint projects have been funded by DBT and VINNOVA and the major achievements during the year are listed below:

- Children will be undergoing approved clinical trial protocol at CMC, Vellore using a GMP manufactured drug product consisting of fetal mesenchymal cells for treatment of osteogenesis imperfecta.
- Research efforts on developing Strategies/tools for secondary prevention and treatment of osteoporotic fragility fractures were taken up by Lund University, Sweden and IIT Kanpur. A hip fracture model in osteoporotic rats was developed and using NC/Cerament as a carrier of bone active molecules enhanced trabecular bone formation was demonstrated.
- Structure of all of the enzymes involved in the catabolic pathway of N-acetyl neuraminic acid (Neu5Ac) in several gram- positive bacteria were determined. Drug discovery approaches using inhibitors synthesised against the periplasmic binding protein, the transporter, the lyase (first enzyme involved in catabolism) and the synthase (the first enzyme in the incorporation pathway) are underway.

CHRONIC DISEASE BIOLOGY

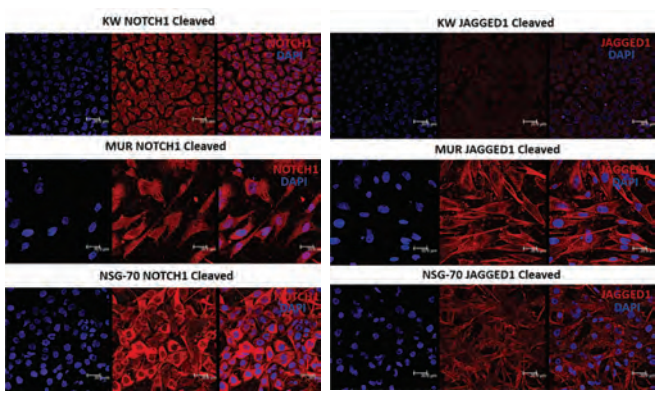
Chronic diseases represent long-term non communicable medical conditions that are generally progressive. The contribution of most of the major non-communicable disease groups to the total disease burden has increased all over India since 1990, including cardiovascular diseases, hypertension, asthma, diabetes, chronic respiratory diseases, mental health and neurological disorders, cancers, musculoskeletal disorders, and chronic kidney disease. As per recent reports three of the five leading individual causes of disease burden in India were non-communicable, with ischemic heart disease and chronic obstructive pulmonary disease as the top two causes. Overall 61.8 % of all deaths in India are due to non- communicable diseases.

Cancer Disease Biology

Cancer Biology Research (CBR) is one of the thrust areas of the Department of Biotechnology. Individual investigators and institutions are being supported to carry out basic, applied and clinical research to develop new methods for prevention and treatment disease in the area of Breast Cancer, Cervical Cancer, Lung Cancer, Prostate Cancer, Oral Cancer, Retinoblastoma, Multiple Myeloma, Head & Neck Cancer, Myeloid Leukaemia, Chronic Myeloid Leukaemia and Ovarian Cancer etc. DBT has funded projects under Basic, Diagnostic/Biomarkers, Nanotechnology & Therapeutics, Animal model systems for the development of chemotherapeutic agents,

target identification, synthetic chemistry for target inhibition, genetics & epigenetics of nationally relevant cancers, cancer stem cells and its use in diagnosis & therapeutics.

Researchers at IIT Jodhpur have identified NLRP12 belonging to the cytoplasmic family of Pattern Recognition Receptors as a prognostic marker for glioblastoma. Research group at NCCS, Pune has shown the presence of Notch signalling pathway components in the cells as well as exosomes of glioma stem cells and further established a reciprocal relationship between Notch and Wnt5a pathway in Glioma progression and pathogenesis (Figure). Research group from NIT Rourkela has identified a new and fundamental mechanism to establish autophagic alteration in oral cancer stem cells. They also observed that the CSC/progenitor phenotype displays higher autophagic flux than the non-CSC/progenitor phenotype at the basal level. Researchers at ACTREC, Mumbai (Basak *et al*.) are working on a relatively new liquid biopsy approach, the BEAMing (Beads, Emulsion, Amplification and Magnetics) methodology to detect the presence of the EGFR mutations in circulating tumor DNA of Non-Small Cell Lung Carcinoma (NSCLC) patients and monitor the tumor burden during the course of the disease.



Expression of the Key Components of the Notch1 (A) and Wnt5a (A) in Established Glioma Stem Cell-lines.

Under the Glue Grant Scheme of DBT for establishing research partnerships between medical colleges and research institutions, the project awarded to IISc, Bangalore, Narayana Hospital (NH) and Mazumdar Shaw Medical Foundation (MSMF) to test the efficacy of a small molecule Bcl-2 inhibitor made by IISc on patient samples of haematological malignancy from the NH hospital, the team has been able to collect bone marrow samples from over 250 patient and have demonstrated the efficacy of the novel molecule in primary cultures spanning 9 different haematological malignancies. Enthused by success of the collaborative project, many of the clinicians have shown interest in research and three of them have registered for PhD program.

Virtual National Oral Cancer Institute (VNOCI)

The VNOCI is a multi-institutional endeavour which aims to understand the disease biology of oral cancer in the epigenetic perspectives, and to develop modalities for oral cancer prevention and therapeutics. The participating institutions in this project are Jawaharlal Nehru Centre for Advanced Scientific Research (Bengaluru, Karnataka), Indian Institute of Science (Bengaluru, Karnataka), National Centre for Biological Sciences (Bengaluru, Karnataka), Kalinga Institute of Industrial Technology (Bhubaneswar, Orissa), Rajiv Gandhi Centre for Biotechnology (Thiruvananthapuram, Kerala), North-Eastern Hill University (Shillong, Meghalaya), and Kidwai Memorial Institute of Oncology (Bengaluru, Karnataka) and National Institute of Biomedical Genomics (Kalyani, West Bengal). VNOCI has identified the protein Nucleophosmin (NPM1) as an important contributor to oral cancer pathogenesis and also found that a gain-of-function mutant of a well-known tumor suppressor p53 i.e. P152L is prevalent in tumors Indian oral cancer patients and this significantly contributes to cancer manifestation.

Virtual National Cancer Institute – Breast Cancer

Under the aegis of the Virtual National Cancer Institute (VNCI) collaboration, the participating institutions seek to characterize hormone therapy sensitive and resistant breast cancer using multi-omics big data generation approaches (genomic, transcriptomic, epigenetic and phosphoprotemic approaches). The Tata Memorial Centre's Tata Memorial Hospital (Mumbai) and the Advanced Centre for Treatment, Research and Education in Cancer (Navi Mumbai) are the host clinical institutes where patients are being recruited. TMH and ACTREC have generated and are analyzing Whole exome sequencing (WES) and Whole Transcriptome Sequencing (RNA-Seq) data. The National Institute of Biomedical Genomics (NIBMG, West Bengal) has generated and is analyzing whole genome sequencing (WGS) data from resistant and sensitive patient tumours. The National Centre for Cell Science (NCCS Pune), has generated patient derived xenografts (PDX), and these will be tested for various cancer

drugs to understand tumour response to these compounds.

Centres of Excellence

- Programme support on Translational Research on Triple Negative Breast Cancer (TNBC) (RGCB, Thiruvananthapuram and Regional Cancer Centre, Thiruvananthapuram): The group has successfully developed PDX model in NSG mice from Indian TNBC patients. Optical imaging ready TNBC cell line has been developed from one TNBC patient that can be used for drug screening and in vivo drug efficacy study using optical imaging. The group has also identified a key role for autophagy / mitophagy in cell state transitions and cancer cell persistence after neo adjuvant chemotherapy that could play a role in tumor recurrence in TNBC.

- Multi-institutional Network Programme on Molecular Neuro-Oncology (IISc, Bangalore; NIMHANS, Bangalore; SSSIHMS, Bangalore and AIIMS, N. Delhi): The group has shown that secreted target of Wnt pathway is important for tumor angiogenesis induced by Glioma stem-like cells (GSCs). They further reported that METTL3 is essential for the expression of actively transcribed genes and sustenance of the oncogenic signalling.

- Centre of Excellence on Evaluation of Biology and Mechanisms of Resistance in Leukemia (CMC, Vellore): Results obtained by the group suggest that there is a significant bone marrow micro-environment mediated drug resistance in acute myeloid leukaemia. The group has also shown that Arsenic Trioxide enhances the NK cell cytotoxicity against acute promyelocytic leukaemia. They have established low cost- effective care using arsenic trioxide (ATO) in acute promyelocytic leukaemia (APL) and were instrumental in moving this therapy to front line therapy in the management of APL globally. The research work has been published in high impact factor journals like *Leukaemia* and *Blood*.

Units of Excellence

Study by researchers at NBRC, Manesar linking metabolism-inflammation axis with molecular clock suggests the importance of treatment timings to endogenous circadian rhythms for effective design of chronotherapies (targeting metabolism and inflammation) in cancers characterized by dysfunctional circadian rhythm. Researchers from MKU, Madurai and Cancer Institute, Adyar have developed a sub-classification scheme to classify and clearly distinguish gastric tumors into 8 sub-classes. Researchers at NII, New Delhi investigating the role of BLM helicase as a global tumor suppressor have shown that BLM acts like a clamp or adaptor molecule, thereby enhancing the degradation of oncogenic transcription factor, c-Jun. The work has been published in high impact factor journals, *Nature Communications* and *Cell Reports*. Research group working at AIIMS, N. Delhi (Gupta *et al.*) has established a panel based NGS test for Multiple Myeloma that is useful in clinical practice. They have also published a nucleic acid-based algorithm using qRT-PCR and MLPA for Revised -International Staging system which is resource-effective in terms of small quantities of sample requirement; feasibility of batch processing and reduced overall cost for the total number of regions evaluated.

Researchers at ILS, Bhubaneswar who are developing the CML mice model were able to observe the expression of BCR-ABL oncogene after 12 days in some of the mice that were transplanted with the oncogene. Researchers at ACTREC, Mumbai have identified the ligands recognised by ãä T cells on tumor cells, and provided in depth investigations into the anti-tumor cytotoxic mechanisms of ãä T cells and their epigenetic regulation.

DBT-DAE Partnership for Cancer Research

The Department of Biotechnology and the Department of Atomic Energy signed a MoU on 22nd May, 2019 for supporting joint activities in the area of cancer. Joint collaborative research and clinical trials are envisaged under the already implemented Cancer Network Program (CNP). The MoU shall help in strengthening various initiatives specifically development of new and affordable technologies, conducting clinical trials, and training of manpower and infrastructure development.

DBT-CRUK Bilateral Research Initiative for Affordable Approaches to Cancer

Department of Biotechnology (DBT) and Cancer Research UK (CRUK) has signed a Memorandum of Understanding (MoU) for a Cancer Research Initiative, "Affordable Approaches to Cancer". This was signed during the Inaugural Researchers Summit that was held in New Delhi during 14th

-16th November, 2018. DBT and CRUK has partnered to launch a £ 10 million, 5- year research initiative focussed on finding affordable cure to cancer. DBT, CRUK and DBT/ Wellcome Trust India Alliance have signed a tripartite agreement that sets out the terms and conditions by which the India Alliance will undertake grant funded activities for the second and the third phase of India-UK Cancer Research Initiative.

DBT and CRUK Bilateral Research Initiative for Affordable Approaches to Cancer will be implemented in three phases; Phase I: Identifying Core Challenges; Phase II: Establishing New Research Partnerships, and Phase III: Program Awards. The Bilateral Initiative has successfully completed Phase I with identification of seven thematic areas/core challenges - (1) Prevention, (2) Early Detection, (3) Early Diagnosis, (4) Computational Approaches, (5) Small Molecule Treatment, (6) Affordable Treatment, and (7) Children's and Young People's Cancer. Phase II: A total of 106 applications were received against the joint call inviting seed grant applications for establishing new research partnerships between India and UK. The second meeting of the Advisory Panel to evaluate the shortlisted applications was held during Jan. 20th -21st, 2020 at Mumbai. The successful applicants will be awarded the seed grant funding by March 2020.

Second Meeting of the DBT CRUK Advisory Panel held on 20th& 21st January 2020 in Mumbai

International Cancer Genome Consortium (ICGC) DBT-India Project

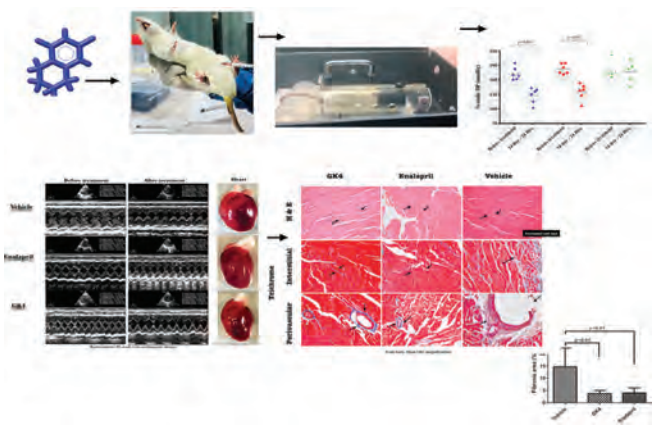
India is one of the 7 founding members of ICGC. Now, 40 countries are participating in this consortium. There are two participating institutions including Advanced Centre for Treatment, Research & Education in Cancer (ACTREC), Mumbai and National Institute of Biomedical Genomics (NIBMG), Kalyani. At ACTREC, Mumbai, patient recruitment, treatment & follow up; sample collection, bio-banking, functional characterization of novel genes & clinical correlation is being carried out. At NIBMG, Kalyani, Whole Exome / Genome sequencing and its bio-informatics analysis is being done. ICGC-India project has established a dedicated bio-repository with best international practices at ACTREC, Mumbai and State-of-the-art high throughput Genome sequencing centre at NIBMG. The research has led to the identification of certain signatures in oral cancer as biomarkers for early detection. 435 cases have been recruited so far with biobanking, standard treatment and follow up. Comprehensive genomic studies have been completed on tumor and normal pairs; SNP Array (350 cases); Whole Exome (200 cases); Whole Genome (200 cases); Mythylome (100 cases); Transcriptome (44 cases).

Metabolic Disorder/Diseases

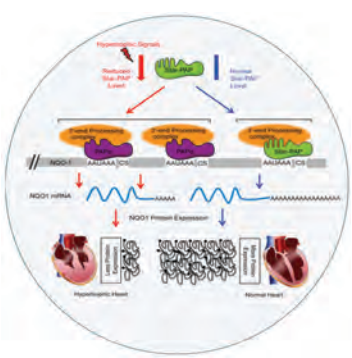
The impact of chronic diseases such as diabetes, cardiovascular diseases, chronic obstructive respiratory diseases, and hypertension are increasingly dominating the disease pattern with 55 per cent morbidity and premature mortality attributable to these conditions. In order to address basic, applied and clinical questions related to metabolic disorders and other chronic conditions, DBT has supported projects in the areas of Gene environment interactions; Inflammation, Innate immunity and adaptive immune response; toxicity of energy (glucose and lipids) fuels; micro- and macro-vascular complications of diabetes; host-microbiome interactions; Bone Disease Biology etc. DBT has also supported long-term cohort development programs in Indian Chronic Kidney Diseases (ICKD) and Systemic Lupus Erythematosus (SLE) with clinicians at the tertiary care hospitals.

Research group from PGIMER, Chandigarh has found a significant increase in protein levels of APOE, B3GALTL, HTRA1, LIPC, TIMP-3, IER-3 in serum of age-related Macular Degeneration (AMD) patients as compared to controls. Through SNP analysis they observed that genetic polymorphism exists in ADAMTS9, B3GALTL, HTRA1, TIMP-3, and IER-3 between AMD patients and healthy controls. Another research group from PGIMER, Chandigarh has provided insights into the role of butyrate induced cTregs in the suppression of Type 1

Diabetes. Research group working at IIT, Madras has demonstrated that thrombin induced the gene-expression of Ang-2 in primary endothelial cells and the release of this protein into the culture supernatant. siRNA mediated down-regulation of endogenous Ang-2 in endothelial cells blocked both thrombin induced inflammation as well as loss of endothelial permeability. Researchers at UDSC, New Delhi have screened libraries of small molecules to identify inhibitors of Dopamine â-hydroxylase (DBH), and human Cytochrome b reductase 3 (hCyb5R3), which caused significant lowering of blood pressure in spontaneously hypertensive rats (SHRs) (Figure). A research group at RGCB, Thiruvananthapuram has revealed that young adults overweight, but not yet obese, are at risk for Type 2 Diabetes Mellitus, and the risk is more in men compared to women. Another research group at the same institute has shown that Star-PAP controlled alternative polyadenylation coupled poly (A) tail length regulates expression in hypertrophic heart .



The drug discovery flowchart: New Drug Candidates to Treat Hypertension, Hypertrophy and other Cardiovascular Diseases – from Structure-Based Identification to Animal Model.



Model of Star-PAP mediated APA regulates protein expressions in hypertrophy and heart failure

Indian Chronic Kidney Disease (ICKD) Study

The Indian Chronic Kidney Disease (ICKD) project has established one of the first prospective cohorts of patients with CKD in a developing country. A total of 3927 patients have been enrolled in this study till date, 2018 subjects have completed 1st follow-up, 906 have completed 2nd follow up and 240 have completed 3rd follow up. A total of 811 events have been recorded including death (154 subjects) and ESRD (102 subjects). A central biobank with archived blood and urine samples of all the enrolled patients has been created at PGIMER, Chandigarh. A local biobank has also been created at every centre. Diabetes mellitus, glomerular diseases, chronic interstitial nephritis, hypertensive nephrosclerosis and ADPKD constitute majority of CKD cases in the study participants. The ICKD study data will become a national resource to define and identify risk factors for progression CKD in our country. It will provide a platform for future research in CKD, an important non-communicable disease in national context.

Systemic Lupus Erythematosus (SLE) Study

SLE is an autoimmune disease mainly affecting women in the reproductive age group with a global prevalence varying from 5-10 per 10,000 population. Given the fact that there is no known data on SLE from India, DBT has recently implemented a multi-centric Network Program on SLE comprising of basic researchers and clinicians. The overarching goals are to develop and establish a clinical cohort of SLE from different geographical regions in India to study differences in clinical phenotype, relationship between phenotype and autoantibody response, biochemical predictors of long-term outcome, major causes of mortality and establishment of a bio-repository. Under the multi-centric Network Program on SLE, 767 patients with SLE have been enrolled with a majority of females. Nearly 1/3rd had nephritis and 13% had CNS involvement. The CRF has been updated to include newer criteria such as anti-nuclear antibody. Samples of 81 patients have been collected (serum, plasma, DNA, EDTA blood, urine, cells) for storage in the bio-repository.

Translational Research Studies on some Disorders of the Eye- L.V. Prasad Eye Institute, Hyderabad

Eight focal themes are being supported under this program

which covers public health studies and eye care delivery across populations; innovation of devices; microbiology; genomics of eye diseases and associated proteins; childhood eyecare; neurophysics of vision; cancers of the eye and application of stem cell- based treatment possibility of eye disorders. These eight focal themes will be studied under the following three broad objectives: Biology of eye diseases for biomarker identification and personalized medicine; Stem cell based ocular regeneration in eye diseases and neurophysics of vision.

National Alliance for Translational Research in Autoimmune Diseases (NATRAD)

The Department is formulating a national consortium for research on autoimmune diseases, which is an unmet need in the country. A pre-conception meeting for this consortium was convened in June in CSIR-IICB and was attended by representatives from almost all major clinical and basic immunology departments in the nation, viz. IICB, SGPGI, NCCS, NII, IGIB, CDRI, PGIMER, CMC Vellore, IPGMER, AFMC, ISI, IIT-KGP, IISER-Kol, BHU etc. The intended direction of NATRAD will be to undertake basic research on disease mechanisms, cohort development for prospective studies, clinico-pathological stratification for heterogeneity of clinical presentation and therapeutic responses, clinical trials for new therapies, preclinical validation of novel technologies and disease awareness programs. NATRAD proposes to focus on five major autoimmune diseases in the country including Systemic Lupus, Psoriasis, Rheumatoid Arthritis, Inflammatory Bowel Disease and Type 1 Diabetes.

R&D Collaboration through International Partnership

A Joint Centre for Cancer Biology & Therapeutics (CCBT) supported by Medical Research Council (MRC) at National Centre for Biological Sciences (NCBS) has created several first-in-class lead compounds that modulate targets originally considered undruggable. The work provided a proof-of-concept for a new strategy to interrupt intracellular signaling by inhibiting the recognition of site- specific protein phosphorylation for cancer treatment.

The Department has funded a Cancer Research Programme at National Institute of Immunology (NII), New Delhi which was initially launched with Queen's University of Belfast, UK. The programme identified the combinatorial effect of SPAG9 ablation and paclitaxel treatment which showed that ablation of SPAG9 resulted in increased paclitaxel sensitivity and caused enhanced cell death. Under the programme a Phase II, double blind, randomized, three-arm study to evaluate the efficacy of dendritic cell vaccine in stage IIIb cervical cancer employing therapeutic grade recombinant SPAG9 in collaboration with Cancer Institute (WIA), Chennai was initiated. Under the project, 54 patients are enrolled for a three-arm study which is likely to be concluded in 2022.

Loyola College, Chennai in collaboration with University of Valencia Science Park, Spain have developed a sugar-free and non-alcoholic sweet lime, watermelon, orange, and apple fruit juices for diabetic patients without affecting their nutritional constituents using immobilized *Saccharomyces cerevisiae* cells and a patent has been filed. Under joint collaborative research with the German counterpart Charite-Universtatmediz in Berlin, DBT has funded researchers of the Kasturba Medical College, Manipal. This project has provided avenues for the researchers to develop a NGS based gene panel for the bone mineral density diseases. This panel gives a minimum coverage of 99% with at least 20 sequencing reads. Under this study 50 patients affected with osteogenesis imperfecta were recruited and mutations were identified in 49 cases giving a 98% sensitivity for the NGS based methods.

Neurosciences

Department has supported a cohort study to unravel the cause of Stroke and Cognitive Decline: A cross-cultural perspective under the Indo-Netherland joint collaboration. Till December 2019, at the urban site i.e. AIIMS, New Delhi 8892 patients have been enrolled in the study and DNA of 84% of the recruited patients has been isolated and Brain MRI has been carried out for 43% of the recruited patients. Six monthly follow up has detected a total of 73 outcome events, of which 41 were myocardial infarction, 9 stroke, and 23 deaths. At the rural site i.e. CRHSP, Ballabgarh, 1826 patients have been enrolled and DNA of 92% of the recruited patients has been isolated. Six monthly follow up has detected a total of 15 outcome events, of which 2 were myocardial infarction and 13 deaths.

DBT has also supported a 'Dementia Science Programme' that is aimed at collecting reliable data regarding prevalence,

incidence, biomarkers and risk and protective factors. The programme aims to establish long-term population-based cohorts besides hospital-based cohorts who will be followed up. The Standard operating Procedures (SOP) have been finalized and pilot studies were conducted by NIMHANS-Prevalence site and by INCLEN at Palwal (prevalence site).

An interesting study at UDSC, Delhi has demonstrated for the first time that dmyc (a Drosophila homologue of human cmyc proto-oncogene) could be utilized as an efficient drug target to restrict the pathogenesis of human neurodegenerative disorders such as Huntington's, Alzheimer's, and Parkinson's disease etc. Another group at UDSC, N. Delhi has shown that co-up regulation of the dMyc/*cmyc* and insulin pathway causes complete rescue against the poly (Q) mediated neuro degeneration. These findings could potentially help in designing novel treatment strategies to combat the devastating human poly (Q) disorders. Researchers at Centre for Cellular and Molecular Biology, Hyderabad have shown that the binge alcohol drinking pattern induced transcriptional changes in glial cells for some chromatin remodelers like PRMT5, a novel demethylase Rik and REST, as well as in neuronal populations.

Human Genetics, Genome Analysis and Precision Medicine

With a large population, high birth rate, and consanguineous marriage favoured in many communities, there is a high prevalence of genetic disorders in India. In this context, the Department's R&D program on Human Genetics, Genome Analysis and Precision Medicine seeks to address the burden of such diseases via developing cost-effective diagnostic methods for genetic diseases, implementing prenatal and newborn screening programs, developing personalized medicine regimens, development of affordable therapies for these diseases and building capacity by promoting training on technology platforms and methodologies for genome analysis in relation to human health and disease.

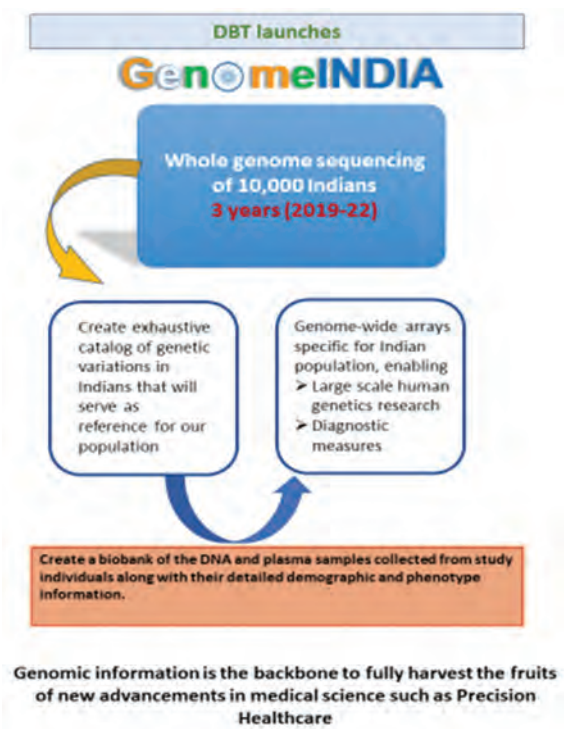
During the year, Unique Methods of Management of Inherited Disorders (UMMID) program and Genome India project for cataloguing the genetic variation in Indians have been launched. About 20 research publications and 2 patent applications have emanated out from the R&D activities supported under this program. Genetic diseases which have been studied under the ongoing and new projects include various lysosomal storage disorders, multiple myeloma, Wiskott-Aldrich Syndrome, Systemic Lupus Erythematosus, Sickle Cell Disease, Thalassemia and other hemoglobinopathies, and acute lymphoblastic leukaemia. Some of the major research projects are - consortium project on celiac diseases, tumour genome profiling and minimal residual disease estimation in acute haematological malignancies using single-platform next generation sequencing strategies, deciphering idiopathic intellectual disability (DIID) through next generation sequencing (DIID-NGS study), multi-centric effort towards understanding a high-resolution, genomic architecture of congenital non syndromic deafness in India.

Unique Methods of Management of Inherited Disorders (UMMID) Initiative : Department launched 'UMMID' initiative to tackle inherited genetic diseases of new born babies. UMMID plans to work at three levels of medical care with a close link between training and establishment of diagnostic services. Under the pilot phase of the UMMID initiative, Department has supported establishment of five genetic laboratories, seven training centres for training clinicians in diagnosis and management of genetic diseases and screening of pregnant women and neonates in seven aspirational districts. The Genetics Labs-NIDAN Kendras (National Inherited Disorders AdministratioN Kendras) would provide comprehensive clinical care including diagnosis, management, multidisciplinary care, counseling, prenatal testing at five government hospitals spread across four states. The training centres are providing training in Biochemical Genetics, Cytogenetics, Molecular Genetics, Clinical Genetics and Comprehensive clinical care to the clinicians working in government hospitals. Seven aspirational districts namely Mewat, Haryana; Yadgir, Karnataka; Haridwar, Uttarakhand; Washim & Nandurbar, Maharashtra; Ranchi, Jharkhand; Shrawasti, Uttar Pradesh have been identified for screening of 10,000 pregnant women and 5000 new born babies per year in each district for diagnosis of inherited genetic diseases and to provide comprehensive clinical care. This initiative was officially launched by the Honorable Minister Dr Harsh Vardhan on 23rd October 2019 in New Delhi.

Launch of UMMID Initiative

Expansion of UMMID program is planned in the coming year. In this direction, mission program on Rare and Genetic disorders is being worked out with an objective of developing novel affordable diagnostic methods and therapies for rare genetic diseases; to elucidate the disease biology of poorly understood rare genetic diseases so that targets for diagnostic and therapeutic interventions could be identified; and to improve counselling, screening and diagnosis of rare genetic diseases.

Genome India : Department has recently initiated pan India network Genome India project for cataloguing the genetic variation in Indian population. The goal is to start with and execute whole genome sequencing and subsequent data analysis of 10,000 individuals representing the country's diverse population. 20 national institutions in the country are collaborating in this project. This will help build an exhaustive catalogue of genetic variations in the Indian population and aid in the designing of a genome wide association chip for Indian population which will facilitate further large-scale genetic studies in a cost-effective manner. The results from this project would be a valuable national resource for the country. This project has initiated national level capacity building in sequencing and computation for high throughput human genomics and several dovetailed efforts of additional whole genome sequencing would happen that will greatly facilitate our understanding of diseases in the Indian population and open up avenues for precision medicine in the country.



Genomic information is the backbone to fully harvest the fruits of new advancements in medical science such as Precision Healthcare

Department has also started working towards new initiative on Human Microbiome of select endogamous populations of India for comprehensive characterization of human associated microbes and diverse dietary habits from carefully selected endogamous groups including key tribal populations which are not much influenced by modern lifestyle. 'National Mission on Bio-Science for Precision Health' is being planned with an aim to extend the existing commitments of the government to promote wellness using a fusion of modern and traditional concepts in harmony through Ayushman Bharat's Health & Wellness Centres and NIDAN Kendras for genetic disorders. The initial focus will be on genetic and rare diseases, maternal and child health, cancer and life style disorders like cardio and brain disorder, through inter-ministerial efforts. Project on 'National Genomics Core' has recently been initiated to facilitate pursuit of biomedical genomics at the national level by opening up its core facilities of genome sequencing and analysis to universities and other national labs.

Some of the salient scientific and technical outcomes emanating from the R&D projects supported under the programme are highlighted as follows:

The fungal microbiome of the ocular surface of healthy individuals was analyzed by Next Generation Sequencing (NGS), at LVPEI, Hyderabad. The results indicated that genera like *Aspergillus*, *Setosphaeria*, *Malassezia*, and *Haematonectria* constitute the core genera in the healthy eyes. Further the fungal Alpha diversity in the two eyes was similar and sex had no effect, but Chao 1 and Simpson indices

were altered by age. The investigators further demonstrated dysbiosis in the fungal microbiome in the ocular surface fungal microbiome in fungal keratitis patients both at the phylum and genera level and implicate the dysbiotic fungi in fungal Keratitis. This is the first report on the observed dysbiosis (alterations in the diversity and abundance) in the fungal microbiome of conjunctival swabs and corneal scrapings in individuals with fungal keratitis compared to healthy control eyes. Study on immunogenetics of severe pandemic influenza A/H1N1pdm09 infections is being carried out at NIV, Pune. The results suggest that *TNFA* -308 A allele and G/A genotype and *TLR3* rs5743313 T/T genotype were associated with susceptibility to severe influenza A (H1N1) pdm09 virus disease while mutant allele of 54th codon of *MBL2* gene was associated with protection to severe disease.

Identification of rare variants and copy number variations in schizophrenia by affected sib pair analysis using next generation sequencing tools has been carried out at UDSC and RMLH, New Delhi. In this project investigators have carried out exome sequencing on a large number of families to demonstrate the contribution of rare variants in genes of prominent pathways that contribute to the complex etiology of common disorders. This was an excellent demonstration in a reasonable large-scale study to emphasize efforts on creating oligogenic risk scores from rare and common genes for identification of pathways that might be actionable in an individualized manner. The clinical, enzymological and molecular study of children with Gaucher disease (GD) for identification of demographical loci on GD phenotype at FRIGE, Ahmedabad has revealed that exon 10/11 are the hot spot for GBA gene mutation and 65% of patients with Gaucher disease have L444P mutation which seems to have founder effect in Indian population. Results of the study on molecular characterization of organic acidurias using targeted next generation sequencing at SGRH, New Delhi, showed that all patients with different disorders can be diagnosed with reasonable certainty using 15 genes of the possible 55 genes. Thus, a future panel of 15 genes can be made which would be cost effective in the resource poor patients.

In the project on tumor genome profiling and minimal residual disease estimation in acute hematological malignancies at TMC, Kolkata investigators report that high density SNP array analysis shows a distinct and heterogeneous pattern of copy number alterations in high hyper diploid BCP-ALL compared to reports in western patients. Based on the results of a study at NEERI, Kolkata biomarkers like serum calcium, magnesium and osteocalcin could be reliable indicators for monitoring the health status of individuals living in a fluorosis endemic region. The present study is the first of its kind from India to have shown involvement of genetic factors and provide evidence of association between polymorphisms in the *ESR1* gene with dental fluorosis in affected population from an endemic region. In a study on Genome-Wide Association Study of phenotypic extremes in Primary Angle Closure Glaucoma at NIBMG, Kalyani and AIIMS, New Delhi, investigators have completed analyses for the identification of copy number variation (CNV) throughout the genome associated with PACG with the hypothesis that germ line CNVs may play a role in the development of PACG. In network project on Genome Sciences and Predictive Medicine (GESPREM) being implemented at UDSC, New Delhi and AIIMS, New Delhi three potential drug targets for rheumatoid arthritis namely ARL15, BTK and MAP3K8 have been taken forward for lead molecule development.

Infectious Disease Biology

Under the aegis of Infectious Disease Biology program, the Department is supporting basic and applied research to better understand and ultimately provide solutions in terms of therapeutics, diagnostics and preventive measures against infectious diseases of global concern such as HIV/AIDS, tuberculosis, vector borne diseases; emerging or re-emerging threats such as influenza, Japanese Encephalitis and antibiotic-resistant microbes. The Department provides funding opportunities and a comprehensive set of resources for researchers that support discovery and interdisciplinary research, pre-clinical development, and clinical evaluation in the area of infectious diseases. With the vision to foster R&D in terms of cost-effective and indigenous therapeutics, the Department has initiated major programs on New Drug Development, Monoclonal Antibodies as immune-therapeutics and Snake-bite Envenoming. During the period following approaches have been deployed under this program in order to tap best feasible R&D solutions:

Mission Antimicrobial Resistance (AMR)

Considering Antimicrobial Resistance as a global threat, the Department has launched an ambitious Mission Program on Antimicrobial Resistance with the vision to develop

indigenous and cost-effective therapies against AMR; categorization of AMR-specific pathogen priority list of India; establishment of Bio-repository for AMR-specific pathogens and development of rapid and cost-effective diagnostic kits to identify AMR-specific pathogens.

- DBT has notified the National Centre for Microbial Resource (NCMR), National Centre of Cell Sciences, Pune to function as a Bio-repository for resistant microbes/infective agents (Bacteria and Fungi) and to carry out collection, storage, maintenance, preservation and characterization of these microbes across the country. NCMR has developed uniform SOPs for deposition, storage and transport of AMR samples.
- In consultation with the WHO Country office, New Delhi, the National AMR-specific Pathogen priority list has been prepared by DBT.
- DBT in collaboration with BIRAC is preparing a landscaping report on existing rapid and cost-effective diagnostic kits to identify AMR-specific pathogens which will be useful to focus on supporting R&D efforts in developing AMR specific rapid and cost-effective diagnostic kits.
- DBT in collaboration with BIRAC has announced support for Projects in the area of development of new antibiotics and alternatives to antibiotics to counter AMR. Under this Call, 378 LoIs were received by the Department and after two rounds of screening a total 10 projects have been approved.
- India's One Health Initiative to combat problems associated with AMR was launched on 18th February, 2019 in Delhi.
- India has partnered with Global AMR R&D Hub as a member of Board of Members through the Department of Biotechnology, Ministry of Science & Technology, Government of India. This expands the global partnership working to address challenges and improve coordination and collaboration in global AMR R&D to 17 countries, the European Commission, two philanthropic foundations and four international organisations (WHO, FAO, OIE and OECD) as observers. By partnering, with the Global AMR R&D Hub, the Department will work with all the partners to leverage their existing capabilities, resources and collectively focus on new R&D intervention to address drug resistant infections.

Board Meeting of Global AMR R&D Hub, Paris

National Facilities Supported

a. National Liver Disease Biobank (NLDB), ILBS, New Delhi: This is a first of its kind national biobank, executed as a joint initiative of the Department and Institute of Liver & Biliary Sciences for translational research in Liver and allied Diseases.

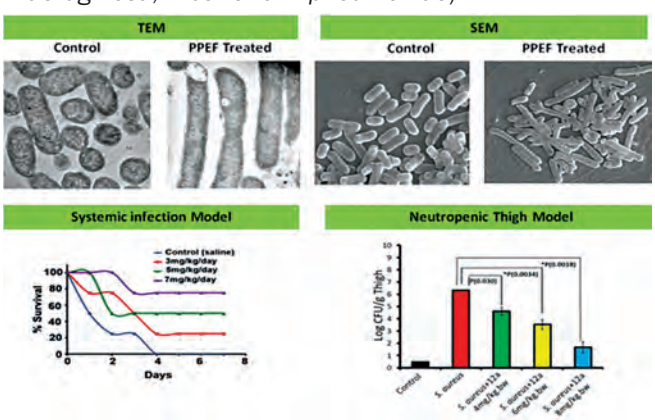
b. Advanced Technology Platform Centre (ATPC), RCB, Faridabad: ATPC has six operational platform facilities- Flow Cytometry Facility, Mass Spectrometry Facility, Protein Purification and Molecular Interactions Facility, Genomics Facility, Optical Microscopy Facility and Electron Microscopy Facility equipped with the various high-end technologies for aiding biotechnology start-ups and researchers.

R&D Support

Therapeutic solutions to address Antimicrobial Resistance

Group of scientists from JNU, New Delhi have established PPEF as a non-cytotoxic and non-mutagenic molecule that acts as a potent antibacterial agent targeting topoisomerase IA (Figure). Scientists from IISc, Bengaluru have identified 2,4-D, NAA, Dicamba and Gallic acid to be potent inducers of

antibiotic resistance in *Escherichia coli* against antibiotics like ciprofloxacin and ceftriaxone. This has a significant relevance for public health since there are a wide variety of compounds present in the environment that induce phenotypic antibiotic resistance. They have developed genetic mutants of *E. coli* that can be used for understanding the mechanisms related to the development of antibiotic resistance.Scientists from JNCASR, Bengaluru synthesized two series cyclam-based antibacterial molecules (CAM-1 to CAM-8) and characterized them using NMR and HR-MS. Based on the MIC octyl-conjugated leucine derivative of cyclam, CAM-8 was selected as the best and most active compound. It displayed excellent activity (2 to 8 µg/mL) against various critical Gram-negative bacteria (*A. baumannii*, *P. aeruginosa*, *E. coli* and *K. pneumoniae*).



TEM and SEM in comparison with control and Treated PPEF (top panel), Efficacy of compound PPEF in mouse systemic infection model (bottom left panel) and Graphical representation of percentage survival versus drug dose (mg/kg body weight) (bottom right panel).

HIV

Cohorts for HIV Resistance and Progression in Indian Children and Adults (CoHRPICA).

Under DBT-ICMR collaborative effort on HIV/AIDS, a consortia based cohorts for HIV Resistance and Progression in Indian Children and Adults (CoHRPICA) Program was initiated in 2017-18 with the aim to create uniform standardized cohorts across stages of HIV-infection, the first centralized state-of-the-art bio-repository at National AIDS Research Institute (NARI), Pune for access to biological samples and a National Database at National Institute of Epidemiology (NIE), Chennai to aid in identification of critical research questions and promoting multidisciplinary research collaborations to address the national HIV epidemic. While all sites have been engaged in community engagement activities in alignment with their respective community engagement plans, NARI developed a preliminary set of experiential learning tools working with community leaders. These tools bring together ideas from behavioural sciences, social psychology, gamification, participatory theatre and the creative arts and are currently focused on educating the communities about HIV and need for biomedical research to help the communities make an informed decision on participation.

- **Indo-SA Collaborative Program**

  Scientists from THSTI, Faridabad have developed a new soluble native-like Env trimer, isolated from an elite neutralizer in India, for single B cell sorting and isolation of broadly neutralizing antibodies. A patent "Engineered HIV-1 Envelope Immunogen" has been filed. In the same project, AIIMS has isolated 2 broadly neutralizing antibodies from a paediatric elite neutralizer in India which are being characterized for their breadth and potency at THSTI. In a parallel effort, THSTI is also evaluating cross-neutralization potential of CAP256.VRC26 antibody, isolated in South Africa, to assess its suitability against Indian subtype C.

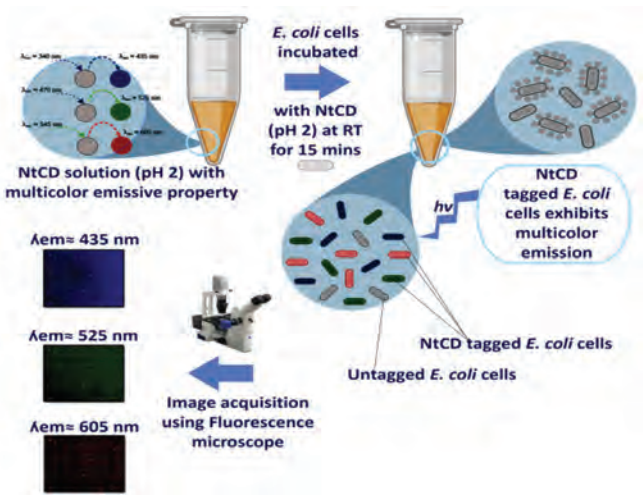
- **Indo-Dutch collaborative effort**

  Department is supporting design of effective disease management strategies to address the global epidemic and enabling multitude of cross-learning prospects by harmonizing capacity by bringing together isolated centres of excellence in the regions. The definite scientific priorities include biomarker studies for understanding HIV latency towards applied research.

  Dengue : Scientists from University of Hyderabad have developed a novel anti- NS2BNS3pro antibody based indirect ELISA test for the diagnosis of dengue virus infections.

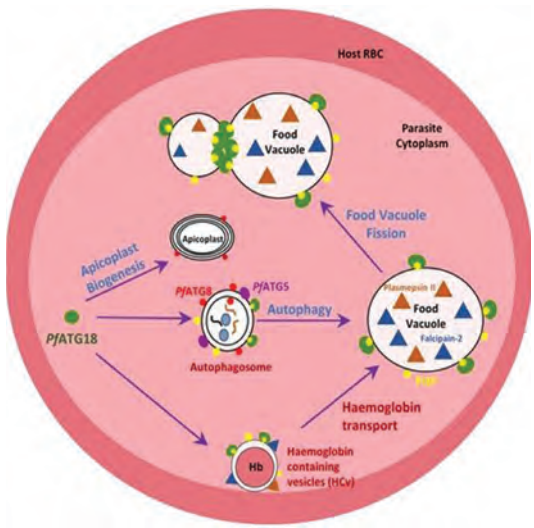
  Tuberculosis : Scientists from CSIR-IMTECH, Chandigarh, NIPER, Mohali and NII, New Delhi working on establishing a genome editing approach

in mycobacteria using CRISPR/Cas9 and creating a repository of single and multi-gene knockdown strains to assist the TB researchers in India have created 35 CRISPRi based knockdown mutant strains of Mtb targeting individual genes and a strain targeting 2 genes together (rimI and rimJ) in *M. smegmatis*. They have also attempted to express the wild-type Cas9 in *M. smegmatis* and analyzed its effect on editing. Scientists from CDGD, Hyderabad observed that PPE17 induces strong B-cell and T-cell responses in active TB patients and could distinguish TB patients from the BCG-vaccinated healthy controls. They suggested that PPE17 may be used as a novel serodiagnostic marker to screen the latently infected subjects. Scientists from Amrita Vishwa Vidyapeetham, Coimbatore have developed Screen Printed Carbon Electrodes (SPCE) for analyzing the highly sensitive impedimetric response towards pathogenic bacteria. They have reported a pH-responsive detection of the pathogenic bacteria using multicolour emissive Nitrogen-doped Carbon Dots (NtCD) synthesized by one step hydrothermal method.



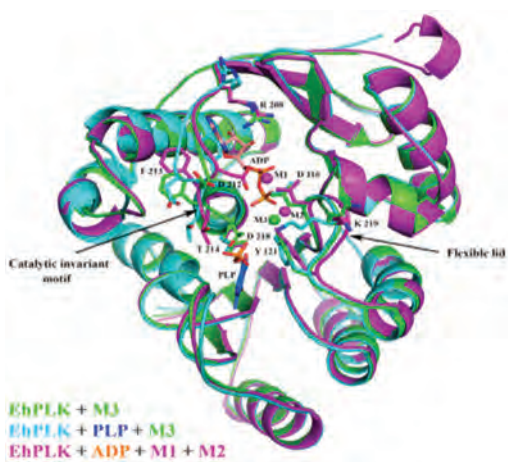
pH-responsive detection of the pathogenic bacteria using multicolour emissive Nitrogen-doped Carbon Dots (NtCD).

Malaria : Group of scientists from JNU, New Delhi, ICGEB, New Delhi and CCMB, Hyderabad have shown that the *P. falciparum* GCN5 protein promotes its localization to the nucleus and it's binding to the target genes enhances their transcription to mediate successful infection of the host cell. Scientists from JNCASR, Bengaluru have established that the *Plasmodium falciparum* autophagy protein; the PfATG18 participates in noncanonical (apicoplast biogenesis) as well as in the canonical functions of this family; i.e. in vacuolar dynamics and autophagy.



PfATG18 mediated functions in P. falciparum.

Amoebiasis : Scientists from JNU, New Delhi have reported high-resolution crystal structures of dimeric pyridoxine kinase from *E. histolytica* in unligated, ADP-bound, and PLP-bound states at about 1.6 Å resolution. These structures provided both a snapshot of the transition state and help in understanding the reaction mechanism in great detail.



Crystal structure of E. histolytica *PLK*

Fungal Diseases : In a across-sectional observational study scientists from IGIB, N. Delhi have studied more than 200 cases of dermatophytosis with a significant number of reinfected or recalcitrant cases. *T. Interdigitale* was identified as the predominant species in the clinical isolates.

Snake Bite Envenomation : Considering snakebites as one of the well-known medical emergencies in many parts of the world, especially in rural setup, World Health Organization (WHO) has included snakebite into Category A of neglected tropical diseases. Since, India accounts for around 50% of mortality and morbidity due to snakebite in the world, there is an immense need to support research and innovation for the development of health products for the patients of snakebite. Towards this, the Department has initiated a major mission program, Mission-NGTS (Next Generation Treatment for Snakebite) with a vision to develop an indigenous, cost-effective and globally accessible technology and products with the aim to cater the needs of the affected people and facilitate employment generation through training and skill development under Make-in-India and Skill India missions of the Government.

Novel Monoclonal Antibodies as Immuno-therapies : Immuno-therapies are leading a shift in the global paradigm of disease management in recent years, with antibodies currently dominating the field. Considering immuno-therapy an important area for disease management, the Department has taken an initiative to spur discovery and development of novel antibodies against diseases that are particularly relevant in Indian context and would ensure that these products are accessible and affordable to the target population. Based on deliberations, three diseases - Antimicrobial Resistance (AMR), Human Immunodeficiency Virus (HIV) and Snakebite Envenoming (SBE) were prioritized as focus areas for this initiative. The prioritization was done on basis of (i) India's disease burden and potential for public health impact, (ii) use of antibodies to address those diseases and (iii) India's research and product development capabilities for those diseases. In order to tap the huge potential of novel antibody as immuno-therapeutics, DBT announced a Joint call with BIRAC on "Globally Accessible and Cost-Effective Novel Antibodies".

Drug Development : With an aim to bring India to the global map in terms of R&D innovation in the area of drug development, the Department has initiated a new program on "Drug Development" with as vision to develop indigenous and cost-effective new drugs against diseases prevailing in our country with priority to TB, Cardio Vascular Diseases (CVD), Chronic Obstructive Pulmonary Diseases (COPD) and cancer (oral, head & neck, cervical and breast cancer). DBT in collaboration with BIRAC has announced a Joint Call on "Development of Drugs from existing leads with established proof of concept".

R&D Collaboration through International Partnership

A UK-India joint centre funded in partnership with Medical Research Council (MRC), UK for advanced technology to minimize the indiscriminate use of antibiotics was supported at L V Prasad Eye Institute, Hyderabad. The centre developed a novel muco-adhesive formulation for ocular delivery of fluoroquinolones which is ready for commercialization. A drug eluting contact lens technology and anti-biofilm coating of lens to reduce lens related keratitis was also developed.

Along with Medical Research Council (MRC), UK, the Department also supported Cambridge-Chennai Centre partnership on antimicrobial resistance in tuberculosis with a focus on novel diagnosis and therapeutics. The centre identified drug resistance prediction for *M. tuberculosis* using whole genome sequencing which can help individualize the treatment regimen. Three lead compounds (Trimipramine, Carbamazepine, and R848) that enhance autophagy were demonstrated to have anti-mycobacterial activity which could be useful for adjunct therapy.

Investigators from the Birla Institute of Technology and Science, Pilani and Hyderabad in collaboration with a Spanish partner are engaged in finding novel â-carboline anti-leishmanial agents with reduced toxicity and increased

potency which will enter into clinical trials. The antileishmanial screening study has been completed for twenty- five synthesized and characterized compounds. Out of these tested analogues, around 5 compounds showed significant antileishmanial activity.

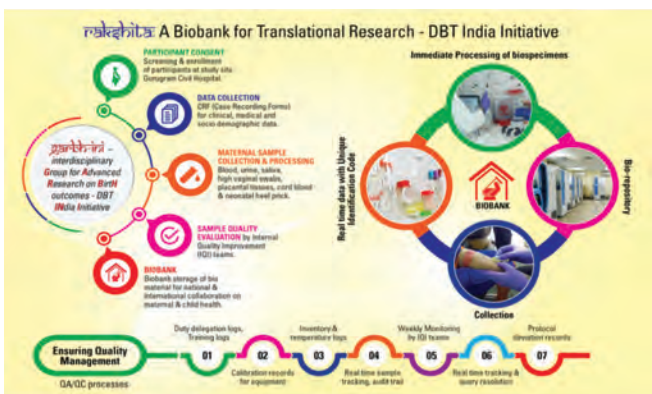
Maternal and Child Health

Maternal and Child Health is an extremely important priority area and in line with the Sustainable Development Goals (SDG) of ensuring good health and well being of people. The spectrum of scientific investigations supported under Maternal and Child Health programme encompasses basic and applied centric discovery emphasizing on research activities related to pregnancy complications, factors of adverse pregnancy outcome, antenatal development, congenital anomalies and problems and diseases of early childhood. The projects supported so far focus on Poly Cystic Ovary Syndrome (PCOS), endometrial dysfunction, recurrent implantation failure, preeclampsia, IUGR, recurrent miscarriages, effect of maternal nutritional status on pregnancy outcome, development of neonatal immune system, neonatal sepsis and aspects of congenital anomalies. Network programmes have also been established with other developing countries.

Grand Challenge Research Programme on Preterm Birth

An inter-institutional and interdisciplinary programme was initiated in 2014 with the objective of acquiring deep fundamental knowledge about preterm birth and to use this knowledge to find efficient and sustainable solutions that would assist in reducing associated mortality, immediate and long-term morbidity. This program coordinated by an interdisciplinary research group christened as GARBH-Ini – (interdisciplinary Group for Advanced Research on BirtH outcomes–a DBT India Initiative) has established a unique pregnancy cohort using an interdisciplinary approach comprising methodologies of clinical, epidemiological, statistical, genetic, proteomic and imaging sciences to study preterm birth. GARBH-Ini has been recognized as one of the five *Atal Jai Anusandhan Biotech Missions* of the Departments.

A total of 22,026 women have been screened so far and around 6,800 women (within 20 weeks of gestation) have been enrolled. The GARBHini platform now comprises of a biorepository (***Rakshita)*** of well characterized clinical phenotypes with 7,50,000 bio-specimens and 4,00,000 ultrasound images. The frequency of preterm birth has been found to be around 13%, which is higher than those reported from economically developed (8.6%) or the low-income countries in Northern (7.3%) or Sub-Saharan Africa (12.3%). It has been shown that pregnant women with either history of prior preterm birth, short interpregnancy interval, short cervix, antenatal vaginal bleeding or multiple gestations had a higher significant risk of PTB. The use of biomass fuel for cooking and exposure to passive smoking appears to be increasing the risk of PTB. Proteomic studies on saliva and vaginal fluid have shown a dynamic alteration of around 60 proteins during the course of pregnancy. Study on vaginal microbiome in Indian pregnant women indicates presence of three distinct microbial community state types (*Lactobacillus iners, Lactobacilus crispatus* & *Lactobacillus gasseri*). This cohort and the biorepository will serve as a global resource to answer critical questions on preterm birth and birth outcomes.

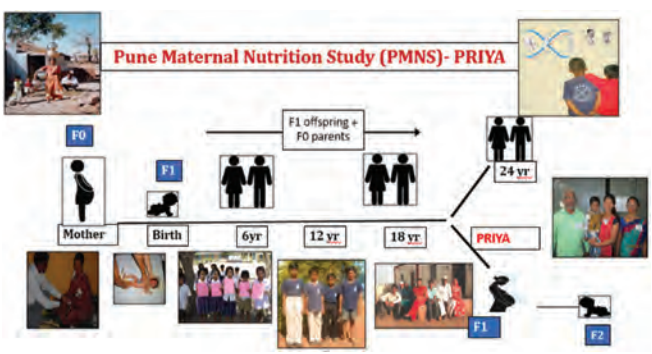


Rakhshita Biorepository

Fetal Programming Research

It is a longitudinal study to understand the reason why prevalence rate of diabetes is so high in India and to investigate preconception micronutrient supplementation towards reducing 'fetal programming' of diabetes. Based on the Pune Maternal Nutrition Study (PMNS) and Pune Rural

Intervention in Young Adolescents (PRIYA), the study highlighted that 'thin-fat' body composition of small Indian babies predisposes them to higher risk of diabetes, and that there is an association of maternal vitamin B12 deficiency and excess folate with child's adiposity and insulin resistance. It was observed that F1 generation had high prevalence of pre-diabetes at young age despite low BMI. An intergenerational landscape of glucose curve for fasting plasma glucose concentrations (F0 mother in pregnancy, F1 girl at 6, 12, 18 years and in pregnancy) showed a remarkable tracking from childhood to young adult age and into pregnancy. The glucose concentration in pregnancy is found to be considerably higher in the daughter compared to the mother, illustrating a rapid rise in 'gestational' glycemia within one generation in modern India. It was predicted by poor linear and liver growth in utero, and was associated more with insulin secretory defect than with insulin resistance. Omics studies are underway to understand the molecular basis of this fetal programming.



PRIYA cohort and PMNS

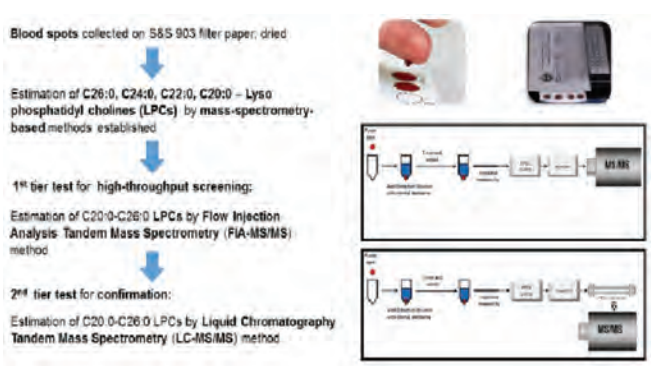
Paediatric Renal Biology Program-Research on Nephrotic Syndrome : Idiopathic nephrotic syndrome is an extremely important chronic kidney disease of childhood, and is associated with significant morbidity related to disease relapses and immunosuppressive therapies. This multicenter collaboration aimed at setting up a registry to understand the disease course, impact of therapies and outcomes in longitudinal cohorts of patients with steroid sensitive and steroid resistant nephrotic syndrome, and form a framework for conduct of collaborative clinical studies. Patient enrolment in the study has been completed and follow up is ongoing at 10 centres. Links among working groups on nephrotic syndrome in India, and with Universities of Bristol (UK), Peradeniya (Sri Lanka), Johannesburg (South Africa) and Michigan (US) have been established. A web-based platform is being set up to provide information to laymen, and enable training of physicians and scientists. Results of whole genome sequencing, available for 92 of 250 patients, indicate a monogenic cause of syndrome in 76% of patients with congenital nephrotic syndrome and 40% of patients with steroid resistant nephrotic syndrome. Specific research questions to understand disease pathogenesis and therapies are being addressed which will enable research on novel and focused treatment options that impact the course of the illness, transforming into better clinical outcomes.

Placental Biology : Investigators at NIRRH, Mumbai have been successful in optimizing in-house developed protocols to differentiate between total and Placental alkaline phosphatase positive (PLAP+) exosomes at the level of the metabolites from maternal serum samples, confirming the feasibility of Omics analysis of PLAP+ exosomes from the clinical samples. In the Phase 2 of the study, comparative analysis of the DNA methylome, miRNA transcriptome and proteome of placental exosomes of women with early onset preeclampsia throughout gestation in a prospective cohort of Indian pregnant women will be pursued. Another group at THSTI has looked at the differential micro RNA profiles of total exosomes and proteomic profiles of the placental specific exosomes derived from longitudinally collected maternal plasma from enrolled participants of the GARBH-Ini cohort. A comparative analysis between the exosomal miRNA profile of term and preterm births reveals a total of 173 miRNAs that significantly change across gestation. The in-silico pathway analysis establishes that the differences in the miRNA profile target the signalling pathways associated with TGF â signalling, p53, and glucocorticoid receptor signalling, respectively.

Diagnostics and Devices : Studies have been supported to develop low cost methods for screening newborns for peroxisomal disorder; NGS based tests for detection of CYP21A2, CYP21A1P, HSD17B3 genes in Indian patients with Congenital Adrenal Hyperplasia and DNA-based diagnostic tool for rapid detection of antibiotic resistant pathogens causing sepsis in neonates. Investigators at

NIBMG, Kalyani and ILS Bhubaneswar have developed a bacterial DNA-based assay for rapid detection of six pathogens causing sepsis in the newborn. Another study is being supported to determine the diagnostic performance of procalcitonin in neonatal sepsis and to evaluate the discriminative ability of novel biomarkers. Interim analysis of nearly 1000 neonates shows a marginal discriminative ability of PCT between culture-positive sepsis and no-sepsis groups.A robust, small wearable wireless, continuous monitoring ear device for continuous and accurate measurement of core body temperature and heart rate has been developed. It is battery operated with wireless transmission and LED alerts, so there is no reliance on electric supply or wires.

X-linked Adrenoleuko dystrophy (X-ALD) is the most common peroxisomal disorder, an inherited neurodegenerative disease. A two-tier testing methodology involving flow injection analysis tandem mass spectrometry and liquid chromatography tandem mass spectrometry methods for estimating a panel of lysophosphatidylcholines (PLCs) in Dried Blood Spots (DBS) has been established. This could be used for mass screening as well as for confirmation of positive cases. Age and gender-specific reference intervals for LPCs in DBS have also been established. For quality control and validation of this method, PIs participated in the Newborn Screening Quality Assessment Programme for X-ALD conducted by Centres for Disease Control and Prevention, Atlanta, USA and the results were 100% satisfactory and accurate for proficiency and precision testing, respectively. This testing methodology can be used for newborn screening for X-ALD in India.



Two-tier mass spectrometry-based methodology developed for low-cost, high-throughput screening for X-linked Adrenoleukodystrophy and other peroxisomal disorders

R&D Collaboration through International Partnership

Healthy Life Trajectories Initiative (HeLTI) is an International Developmental Origins of Health and Disease (DOHaD) research collaboration that seeks to address obesity in children. HeLTI was launched as a joint initiative between India, Canada, South Africa and China in collaboration with the World Health Organisation to address the rising epidemic of Non-Communicable Diseases. It envisions conducting a set of harmonized, coordinated studies that will evaluate whether an integrated complex continuum of care intervention, starting in women pre-conceptionally and continuing through pregnancy, infancy and early childhood will reduce adiposity and NCD risk, and improve neurodevelopment, in the children.

The India study (Early Interventions to Support Trajectories for Healthy Life in India: EINSTEIN) is a community-based, cluster randomised intervention with three arms (pre-conception, pregnancy and control) set in rural Mysore, with individual villages forming the basis for the cluster. Women of reproductive age will receive a longitudinal multi-faceted intervention comprising of: a) multiple micronutrients; b) a group parenting program to address maternal depression and improve child development; c) hygiene and infection prevention measures; and d) reduction of environmental pollution exposure. Interventions will be underpinned by a lifestyle behaviour change intervention. Formative work has been undertaken in representative villages to adapt the interventions specifically to the needs of the local populations; and to ensure that the approach is acceptable and feasible. An extensive engagement process has been undertaken with local communities including community leaders and women, and the local authorities. Basic anthropometric data and information on socio-economic status, screen time, dietary habits, cooking fuel and exposure to pesticides were also collected.

Addressing the issue of Second hand smoke (SHS) during pregnancy, a project led by NIMHANS Bangalore was supported which implemented interventions that reduced smoking in the presence of pregnant women by 50% (intervention) versus 17% (control). The intervention consisted of combining motivational enhancement techniques with cognitive-behavioural strategies, and using

a variety of delivery platforms targeting key family members that helped women in negotiating a smoke free home and men feeling guilty about smoking close to others. Another supported study observed that while the child's own genetic constitution influences the birth parameters, pre- and peri-conceptional maternal nutrition plays an equally important role in birth outcomes. The work suggests that micronutrient supplementation in the peri-conceptional period may alter children's DNA methylation (5-9 years old) in crucial genes and may influence growth, body composition and other health-relevant outcomes.

The department with Ministry of Earth Sciences (MoES), Govt. of India; Natural Environment Research Council (NERC), UK, and Medical Research Council (MRC), UK jointly funded a study on Delhi Air Pollution: Health and Effects. It aims to understand quantitative exposure-response relationship for air pollution, and maternal (birth-weight), child (acute respiratory infections and child growth) as well as adolescent (asthma exacerbations) health outcomes in Delhi-NCR area. The study uses wearable sensors that provide high resolution spatio-temporal data to provide longitudinal exposure estimates which will be utilized for exposure-response modelling.

New Initiatives

The pre-natal, infancy and childhood periods are central for understanding human development. Early childhood developmental trajectories of children at risk can predict adverse developmental outcomes and promote well-being. Hence, a call for concept proposal in the area of Developmental Disorder and Diseases of Infancy and Early Childhood was made. R&D efforts in different aspects of Women's health starting from Menarche to Menopause is being promoted for developing technologies specific to women's health needs and working to enshrine the health of women in the post 2015 United Nations' Sustainable Development Goals. Hence, a call for Letters of Intent (LOIs) in the area of problems associated with Women's Health was made.

Public Health & Nutrition

The Department continued its efforts to promote the research towards Public Health and Nutrition towards addressal of Anemia, Protein Malnutrition, Micronutrient deficiencies, Severe acute malnutrition through food fortification, probiotics for human health and well-being, food safety, molecular detection of GM traits in foods, development of low cost foods/ supplements and utilization of agricultural residues for value added products and capacity building in the field of Public Health and Nutrition Biology. The department has supported the research to tackle Vitamin D deficiency and related aspects like benefits of Vitamin D supplementation, point of care diagnostics, functional significance of Vitamin D deficiency, mechanistic understanding of Vitamin D deficiency. Special efforts for addresal of geriatric health issues through research and development in the area of geriatric nutrition are being made. The department along with DHR is actively engaged to provide technical recommendations to evolve strategies for mitigation of anemia, micronutrient and protein malnutrition to SSC-NTBN constituted by NITI Aayog.

Department has supported the COE "Mutations in GUCY2C and Human Disease: The gut and beyond" at Indian Institute of Science to provide the basic understanding of signalling aspects mediated by GC-C and thus opportunities for interventions in diarrhoea.

New Initiatives and Major Programmes Supported

Food Fortification and Bioavailability

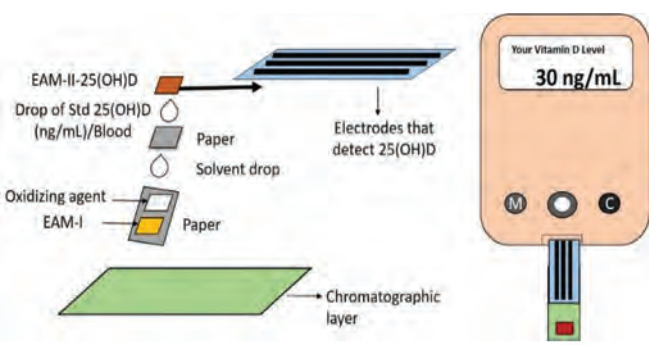
With an aim of making food fortification more efficacious and in help reducing the burden of micronutrient malnutrition in the country, the Department started to support research and development in priorities areas like novel fortificants/ additives, sensory, acceptability and stability studies, methods to overcome negative nutrient-nutrient/food interactions, generating data on bioavailability, micronutrient combinations to impact anemia, among vulnerable population groups, role of other micronutrient nutrients, new insights etc.

Geriatric Nutrition : The elderly population rising rapidly in India is estimated to be over 10% of the total population. With the aim of improving the nutrition and health of the elderly population in the country, DBT decided to support R&D proposals in priority areas like identifying biomarkers for geriatric nutrition, evaluating interventions in geriatric

disorders, estimating recommended dietary allowances, measurement of energy and body composition in elderly, identifying needs to implement food security programs in the elderly from the underprivileged section and others. Special 'call for proposals' as given to seek proposals in above areas. The projects will be supported in the next financial year.

Salient achievements through ongoing projects

With support of DBT significant progress has been made in the development of point of care diagnostics for detection of Vitamin D by synthesizing and characterizing the low-cost Electroactive Molecule (EAM-I), that can detect Vitamin D levels in blood samples electrochemically. The reactants (EAM-I and oxidizing agent) incorporated in the test strip will produce EAM-II that will react with 25(OH)D3 [Vitamin-D marker in serum] of the sample. The product (EAM-II-25(OH)D3) formed will move in the chromatographic layer towards the electrodes that are controlled by the electronic device. The electrodes will be calibrated with standards to detect the amount of 25(OH)D3 in the test samples. Circuit design for the electronic reader that read the Vitamin D test strip signals has been prepared and simulated in Proteus 8 software. Conceptualization of Vitamin D smartphone app is completed. Concept is being converted to a professional Vitamin D app interface.



Point of care diagnostic kit for detection of Vitamin- D

Researchers at Jamia Milia Islamia University, New Delhi have demonstrated the protective role of vitamin-D in both models of lung injury-intratracheal-LPS induced and cecal ligation puncture model. Pulmonary edema a hallmark of acute lung injury was reduced in presence of vitamin-D and also the upregulation of endoplasmic reticulum stress genes was reduced after vitamin D administration. Specific, highly sensitive and reliable conventional and real-time PCR assays have been developed at IARI, New Delhi for diagnosis of the pathogens namely, *Alternaria alternata, Rhizoctonia solani* and *Fusarium oxysporum* f. sp. Ciceris associated with the pulse crops.

Researchers at CIAB, Mohali have established co-encapsulation of dextransucrase and dextranase in the beads of alginate-pectin matrix for higher yield of gluco oligosaccharides from the sucrose biomass. Catalytic biosynthesis of levan and short-chain fructo oligosaccharides (FOS) from sucrose-containing feedstocks, e.g., sweet sorghum stalk extract and cane molasses, has also been established. Characterization of a novel amylo sucrase, and catalytic biosynthesis of a functional sugar, turanose, from sucrose biomass has been established. Kinetic characterization of laccase from Bacillus atrophaeus, and its application in clarification of juices, e.g. sweet sorghum juice, apple juice etc., has been established in free and immobilized forms of the biocatalyst. Characterization of a novel xylanase and its application in bioprocessing of biomass, e.g., sweet sorghum bagasse, for xylo oligosaccharide production has been established. Besides, a process for development of a prebiotic oligosaccharide rich functional juice from sweet sorghum stalk extract has been developed. Another study supported at CFTRI, Mysuru has established the structural diversity and prebiotic potential of short chain â-manno-oligosaccharides generated from guar gum by endo-â-mannanase. Further they have also proved the enhanced survival of *Lactobacillus* sp. in â-manno-oligosaccharides enriched low-fat ice-cream under simulated gastrointestinal stress.

Fortified Rice Pre-mix for Addressal of Anemia in Children : Long term (2 years) efficacy of indigenously developed micronutrient fortified rice (fortified with iron, vitamin B12 and folic acid) in improving iron stores in school children; process standardization to match the physical characteristics of fortified rice kernels (FRK) with commercial rice varieties and storage stability:

Technology has been developed on iron, Vit B_{12}, folate fortified rice premix from broken rice kernels through extrusion process. Sensory studies showed statistical significance in terms of acceptability of the product. A school-based efficacy

study of this indigenous product in improving iron stores in school children is being undertaken. At the present moment, St.Johns Research Institute is recruiting children and their families for the study. In this study, both children and their mothers are included for the intervention.

Inter-Ministerial Activities and Policymaking

The Department is actively engaged in providing technical recommendations to National Technical Board on Nutrition through SSC-NTBN. This department had actively participated in formulation of Operational Guidelines for prevention of Malnutrition and Community – based Management of Severe Acute Malnutrition (C-SAM) developed by the Ministry of Women and Child Development. DBT through a recent series of Brain Storming Sessions identified gap areas and of unmet challenges in Public Health & Nutrition with an intention to formulate the National Level Program on Public Health & Nutrition with participation of all the concerned ministries and other stakeholders.

Stem Cells & Regenerative Medicine

Stem Cells and Regenerative Medicine has been identified as one of the thrust areas under biomedical research of the Department. The objective is to promote basic, early and late translational research, promote capacity building in this emerging area of research through various trainings and workshops and formulation of regulatory framework for stem cell research in India.

In one such study, the effect of changing micro-environment both physical and molecular on neural stem cells, specifically their potential to proliferate and differentiate is being explored. Stiffer substrates activate YAP/TAZ activity and have been shown to play a crucial role in maintaining undifferentiated state of human pluripotent stem cells (hPSCs). In another study, it was observed that among H3K27 demethylases, all members of KDM6 family were significantly over expressed in primary AML blasts. GSKJ4, a small molecule inhibitor of KDM6A and KDM6B selectively inhibited growth of AML cell lines, sparing normal hematopoietic stem and progenitor cells (HSPCs). Another study aimed to investigate whether multidrug resistant proteins (MDRs) are regulated by stem cell-associated factors since these proteins are overly expressed by stem cells, especially cancer stem cells. The *in-silico* analysis suggested a possible interaction of stem cell factors with four major MDR genes, ABCG2, MDR1, MRP1 and MRP2. Further validation by co-expression studies, confirmed that indeed MDRs are regulated by stemness-associated factors at various stages, either to promote or to reduce stemness in cancer cells.

A study using ovarian cancer as a model system demonstrated, both *in vitro* and *in vivo,* that Cancer stem cells can give rise to endothelial cells, pericytes and lymphatic endothelial cells in serous adenocarcinoma of ovary. This provides evidence of the multipotent nature of ovarian CSCs and its role in the pathogenesis of ovarian cancer. A study has been supported to develop novel strategies for expanding genome-edited cells to achieve a sufficient quantity for successful stem cell transplantation. It was observed that combination of SR-1 + UM729+ Resveratrol (RUS) had a high percentage of CD34+CD133+ HSPCs expression. Upon transplantation in the NSG mice, the RUS expanded HSPCs showed a ten-fold increased engraftment in the mouse bone marrow over the control cells.

The findings from a recently supported study showed a phenotypic rescue in gene editing therapy of Hemophilia B using AAV2 or AAV8 vectors containing mFVIIa, gRNA and Cas9 after vector administration. These findings expand the repertoire of gene delivery strategies that can be potentially tested for human applications. Studies have also been supported to improve protocols for reprogramming of somatic cells to induced pluripotent stem cells (iPSCs), their differentiation and trans-differentiation to desired cell types.

Further the Stem Cell Facility at AIIMS is involved in R&D associated with neuronal, cardiac, bone, skin, liver, trachea and their translational implications along with several diseases including myocardial infarct, diabetes, muscular dystrophy, peripheral vascular disease etc. The Centre of Excellence (CoE) had also been involved in isolation, storage and distribution of amniotic membrane grafts (AMG). This AMG has been used by in house clinician and has also been transported to other nearby institutes. The major use of AMG lies in the ocular reconstruction and burn injury cases. The new non-viral/non-integrating method has been standardized for generation of iPSCs from human skin biopsies and human peripheral blood. The Centre also plays an important role in building capacity in this area by organizing workshops and training courses to graduate and postgraduate

students.

The Indo-Japan project -'Accelerating the application of stem cell technology in human disease (ASHD)' was supported by the Department to facilitate research and capacity building in the area of modern stem cell technology for treatment of human diseases. ASHD has two broad research components dealing with human diseases of national importance, namely "Accelerator program for discovery in brain disorders using stem cells (ADBS)" and "Novel approaches to hematological disorders (NAHD)". By leveraging the clinical services at NIMHANS, the ADBS program has assembled a cohort of families with a strong family history of mental illness which will be followed over a twenty-year period to observe the development of clinical disease using a range of clinical investigations including neuropsychological assessments, neuroimaging, and clinical electrophysiology at regular intervals during this period. The cohort is being independently monitored by the Clinical Services Development Agency, New Delhi. In addition, the program is using modern methods of genomic analysis to discover the genetic basis of mental illness. A biorepository of human iPSC lines, neural stem cells, and other related cell lines have been generated from the patients and controls ofthe ADBS cohort. Using biomaterial from human patients, so far 281 lymphoblastoid cell lines (LCLs) and 82 human induced pluripotent stem cells (HiPSCs) have been generated and banked. The biorepository is curated and benchmarked at international standards. A system is in place for the recording and electronic management of ongoing clinical assessments, genomics work and the stem cell repository. The protocol for the differentiation of stem cells into neuronal cultures has been standardized, where development of neuronal activity, neurite outgrowth and synaptic physiology can be studied. An in-house training programs on the generation and maintenance of iPSC cultures was conducted, attended by researchers from across the country. A training program was also organized for a group of Indian researchers at the centre for iPS cell research at Kyoto University, Japan. In addition, ADBS-IBAB has conducted a workshop on the analysis of whole genome sequencing data at NCBS.

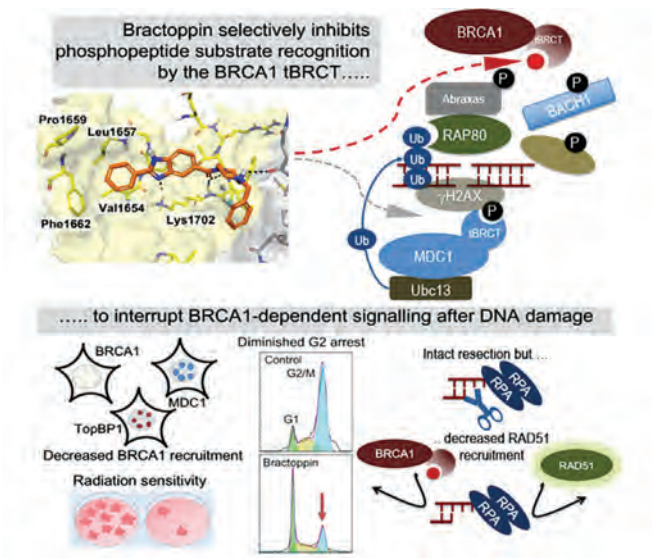
Under the NAHD component, a novel lentiviral vector mediated HSC based gene therapy for haemophilia A is being addressed. For this a hematopoietic stem cell based lentiviral vector mediated gene therapy product for the treatment of haemophilia A has been developed. This is novel approach in the world for gene therapy of haemophilia A (factor VIII deficiency) where the FVIII transgene is packaged in a lentiviral vector to transduce the hematopoietic stem cell (HSC) for stable integration and lifelong transgene activity similar to the principles being applied in the gene therapy for the major haemoglobin disorders. The NAHD team at CSCR, CMC Vellore have also designed and validated CRISPR/Cas9 components for two monogenic disease namely Diamond Blackfan anemia (DBA) and congenital dyserythropoietic anemia (CDA) and have achieved desired cutting efficiencies in iPSC. As a part of establishing a haplobank relevant to Indian population, so far blood samples from 235 HLA donors were collected and PBMNCs were isolated and cryopreserved inside GMP facility. After establishing the protocols for the generation of clinical-grade iPSCs lines, 25 clones were selected from 5 HLA homozygous donors in GMP laboratory. Out of these 25 clones, 10 clones were further expanded for 10 passages under xenofree GMP conditions. These 10 established iPSCs lines showed pluripotent stem cell morphology, proliferation, and pluripotent marker expression. Further detailed molecular characterization for identity, sterility, differentiation and genomic stability is under progress.

The Control Programme for sickle cell anemia and thalassemia has been implemented in a phased manner in six districts of Odisha, including an aspirational district – Koraput. Towards increasing capacity and capability for treatment of major haemoglobin disorders in Odisha State health system, training workshops have been conducted at different levels (State / Regional levels) for doctors / other healthcare workers to train them on different aspects of management and prevention of sickle cell disease and thalassemia in the State. Through this program, training is also provided in chorionic villous sampling for genetic diagnosis.

Centre for Chemical Biology and Therapeutics (CCBT)

The Centre for Chemical Biology & Therapeutics (CCBT) was established at inStem, Bangalore to explore innovative approaches to modulate intracellular signalling pathways disrupted in disease through a unique, integrated and

multidisciplinary programme. The goal is to target the molecular recognition of phosphorylated proteins - a key class of protein modification vital for signalling - by specific domains. The Scientists and the researchers at CCBT have made strong progress towards this major goal and reported (Periasamy et al., Cell Chemical Biology, 2018) the development of Bractoppin, a first drug-like inhibitor of phosphopeptide recognition by the human BRCA1 tBRCT domain, which selectively inhibits substrate binding in vitro, and in cells, selectively blocks BRCA1-dependent signals triggered by DNA damage. Chemical matter surrounding the discovery and SAR of Bractoppin, as well as its potential uses, has been protected in a patent filing (United States Patent Application Publication No.: US2018/0346461 A1).



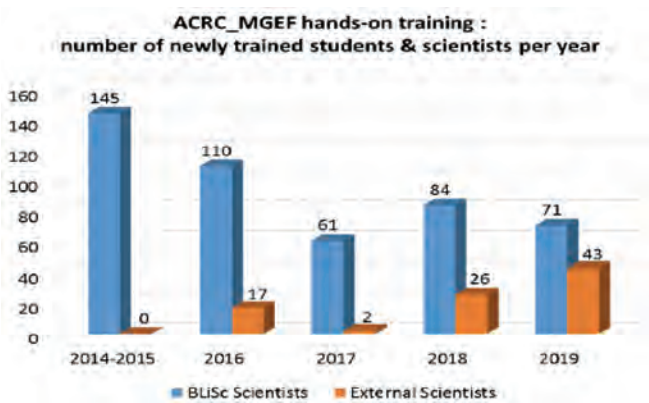
Development of Bractoppin, a first drug-like inhibitor of phosphopeptide recognition by the human BRCA1 tBRCT domain.

The Centre for Neurodevelopmental Synaptopathies (CNS)

The Centre for Neurodevelopmental Synaptopathies at inStem Bangalore is working towards the discovery and delivery of effective therapeutics for these largely untreatable conditions with the initial goal of investigating autism spectrum disorders (ASDs) and intellectual disability (ASD/ID). Over the past five years, 7 new transgenic rat lines have been established, expanded and colonies organized at inStem. An extensive behavioural and electrophysiological characterization of these animals has been carried out at relevant age groups. The focus has been on Fragile X Syndrome (FXS) as well as mutations in key glutamate receptors and their primary signalling pathways as prototypic causes of ASDs. The CNS team have identified a novel mechanism by which non-neuronal glial cells influence network activity in humanized co-culture model system in Fragile X Syndrome patient-derived cells. This "mosaic approach" can be used in future to explore the interactions further between astrocytes and neurons from different genetic background in other neuro developmental conditions.

National Mouse Research Resource (NaMoR)

The National Mouse Research Resource was established at inStem & NCBS, Bangalore by DBT as a 'National facility' to provide cutting edge technology, space and services to scientists using a range of laboratory animal based models in biomedical research. NaMoR has a state-of-the-art facility with two different levels of SPF environments in the high barrier animal facility (SPF1- highest pathogen exclusion level; and SPF2- intermediate pathogen exclusion level). Consistent with its mandate, the animal facility has become a major hub of animal training in the country. The number of external scientists trained in various aspects of animal husbandry, mouse genome engineering techniques, embryo cryopreservation and rederivation, and many other state of the art techniques has been growing substantial year to year. Four major hands-on workshops were conducted in the year 2019.



Recognizing the need for these training sessions and the quality of instruction received at these workshops, these training endeavours received significant support from the

Jackson Laboratory, Tecniplast, Eppendorf, Thermo, and other companies. In addition customized training modules have been conducted on an individual or small group basis to address specific requirements and requests from animal users in new or established mouse facilities.

VACCINE RESEARCH AND DEVELOPMENT

Vaccines are one of the most cost-effective health technologies and their extensive use is key to controlling the burden disease world-wide. Recognizing the importance of the same, over the past three decades, DBT has made concerted efforts towards strengthening vaccine research and development in India. In addition to supporting academic research, DBT has facilitated innovative funding and has recently implemented the National Biopharma Mission (NBM) - an Industry-Academia Collaborative Mission, for accelerating early development of biopharmaceuticals. The Department has actively collaborated with global leaders. Major efforts in this direction have been implemented through the Indo-US Vaccine Action Programme (VAP), a bilateral programme jointly implemented by DBT, the Indian Council for Medical Research (ICMR) and the National Institutes of Health (NIH) since 1987.The VAP has been recognized internationally and is considered as model bilateral programme in biomedical research area. The programme has demonstrated major achievements like the low-cost Rotavirus vaccine which became part of the universal immunization programme & taken major strides towards development of vaccines for diseases like Malaria, Dengue and TB. Various candidate vaccines are currently being supported by DBT through various programmes, as given below:

Malaria Vaccine: JAIVAC -2, a recombinant blood stage vaccine candidate, developed at International Centre for Genetic Engineering and Biotechnology (ICGEB), consisting of a mixture of two antigens (PfMSPFu-24 + PfF2) for falciparum malaria, has completed toxicology assessment. The Phase I clinical trial of JAIVAC2 and is being supported.

Dengue Vaccine: Asub-unit dengue vaccine candidate (DSV4), a recombinant virus like particle-based vaccine expected to protect against all four dengue strains endemic to India, has been developed by ICGEB. The vaccine is being supported for pre-clinical and clinical trials. A live attenuated tetravalent Dengue Vaccine candidate TV003/TV005 licensed from NIH is under development.

TB Vaccine: Phase III trials of VPM 1002, a live recombinant BCG vaccine are going on in India to evaluate the safety and efficacy of the vaccine in preventing TB in household contacts of newly diagnosed sputum positive TB patients and also to prevent recurrence of TB in antibiotic treated adults. RePORT sites are co-enrolling for this trial.

Chikungunya Vaccine: An inactivated CHIKV vaccine has completed phase I development. The phase II study for the vaccine is being planned and will be supported under NBM.

Influenza Vaccines: Immunogenicity study of a live attenuated universal influenza vaccine is under progress and is being supported under NBM. Also, preclinical study is ongoing for a recombinant quadrivalent influenza candidate vaccine under NBM.

Pneumococcal Vaccine: A 15-valent Pneumococcal polysaccharide conjugate vaccine with CRM 197 as the carrier protein, is being supported for phase II-III clinical trials.

Cholera Vaccine: Project is being supported for production of safe and effective oral cholera vaccine of global GMP standards in India through Industry Academia partnership.

Indo-US Vaccine Action Programme

The major Initiatives under the Indo-US VAP and their achievements are described below:

- **Human Immunology Project Consortium (HIPC) Collaboration**

  This programme aims at promoting human immunology research in the context of infectious diseases in India through collaborations of Indian investigators with U.S.-based investigators supported through the Human Immunology Project Consortium (HIPC) of the National Institute of Allergy and Infectious Diseases. The successful implementation of Phase I of HIPC has been followed up by the initiation of Phase II of HIPC wherein, insightful immunological studies are being supported. The study by investigators from Indian Institute of Science

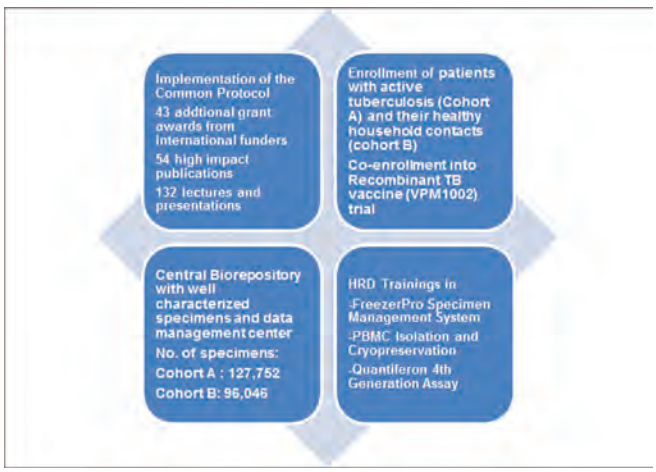
(IISc) Bangalore and Fred Hutchinson Cancer Research Center focused on analysis of innate and adaptive immune responses in blood samples of infants receiving BCG at birth and of IGRA-negative and IGRA positive adolescents receiving BCG revaccination (in Bangalore), using state-of-the-art multiparameter flow cytometry, proteomics, and single-cell RNAseq, including CITE-seq and REAP-seq that allows for combined proteomics with transcriptional profiling at the single cell level; have revealed that revaccination of latent TB subjects with BCG was potentially beneficial. *This result has profound implications on public health and vaccine development strategies for India.*

The team from THSTI and Stanford University is using a systems biology approach to explore immune responses of Indian infants vaccinated with Typbar-TCV (first licensed conjugate vaccine against typhoid that can be used in children less than 2 years of age). State-of-the-art high throughput technologies such as the recently developed CyTOF and EpiTOF are being used for epigenetic landscape profiling analysis. The AIIMS and Emory University group aims to determine the dynamics of B cell responses in dengue patients from India and identify differences in the humoral responses and their receptor repertoire among patients with and without severe disease in primary versus secondary infections.

The effort of scientists from National Institute of Immunology and La Jolla Institute of Allergy and Immunology) are focussed on identifying the ideal Tfh (follicular T helper cell) subset and its positive attributes in long-term protective immunity against Japanese encephalitis virus infection or vaccination. As part of their study, a vaccine cohort has been established at Dibrugarh, Assam for longitudinal analysis after a single dose immunization with SA14-14-2 live attenuated JE vaccine. The team from ILBS and Case Western Reserve University aims to understand the immune mechanisms that characterize HBV vaccine efficacy in neonates/infants born to HBV+ mothers, using a multi-omic strategy. Their initial data suggests that prolonged immaturity early in life may lead to immune responses that are inadequate in fighting bacterial sepsis.

- **Regional Prospective Observational Research in Tuberculosis (RePORT) India Initiative:**

The aim of this initiative is to establish TB consortium with pan India representation involving long term longitudinal cohorts of TB patients in India. These efforts will strengthen TB research capacity and infrastructure, and foster research collaboration within India and with other countries. RePORT India was the first consortium to be established as a part of the six current global RePORT International networks of TB consortia across the world. It is a multi-institutional TB clinical and translational research consortium for India, facilitating high quality human subjects' research and scientific collaborations.



Phase I RePORT India – Key Achievements

Various studies supported under the RePORT Initiative and their major achievements are enumerated below:

1. National Institute for Research in Tuberculosis, Byramjee Jeejeebhoy Government Medical College and Johns Hopkins University - Cohort for TB Research with Indo-US Medical Partnerships (CTRIUMPh): has identified a 71-gene TB diagnostic signature and a 25-gene TB treatment response signature for paediatric TB in India. They have also showed that adult household contacts (HHCs) of TB patients in India have a high prevalence of undiagnosed diabetes, pre-diabetes and latent TB infection, putting them at high risk for developing TB and suggest that routine DM screening should be considered among all adult HHCs of TB and

higher or more frequent dosing required to improve TB treatment outcomes in India.

2. Bhagwan Mahavir Medical Research Center and University of Texas at Tyler: In their efforts to identify immunologic markers of persons at highest risk of progression of latent tuberculosis infection to tuberculosis, investigators have found that young adult HHCs of the TB patients that exhibit decreased production of the thyroid hormones & IL-1á and increased number of the CD16+CD56+ cells and Tregs at baseline are at the highest risk for developing active TB disease.

3. Christian Medical College, Vellore & University of Cambridge: This group has established the largest clinical cohort of TB Meningitis in India which is also one of the largest globally. Latent TB infection among healthy undergraduate medical students has been described in detail for the first time. Thoracoscopic pleural biopsy improved yield of Xpert MTB/RIF for diagnosis of pleural tuberculosis. Pleural tissue Xpert provided a higher yield than culture and substantially improved yield compared with closed pleural biopsy.

4. JIPMER, BU& Rutgers: JIPMER site has successfully completed phase IIb of a multicenter double-blind randomized placebo-controlled study to evaluate the efficacy and safety of recombinant TB vaccine candidate VPM1002.Screening, 2nd week, 2nd month and 6 months follow up for all the participants has been completed and the site is ready for the next phase of the trial.

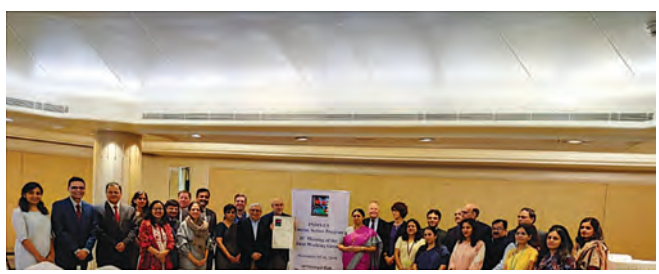
5. Hinduja and Johns Hopkins University Multi-Drug Resistant Tuberculosis (MDR-TB) Free - Monitoring Adverse Effects, Utilizing Resources Optimally, Knowing Resistance Patterns, and Treatment Strategy (MUKT): The group is working towards improving diagnostic assessments of TB and early prediction of drug resistance. In the next few years these activities will be combined to assess the impact of individualized therapy initiated as soon as results are available on clinical outcomes, using comprehensive drug susceptibility testing including MIC testing of the new and repurposed drugs, and mid treatment drug level testing as an early predictor of treatment response.

6. MVDRC & University of Massachusetts Medical School - Effect of Diabetes on Tuberculosis Severity [EDOTS]: This study showed very high (>50%) prevalence of Diabetes Mellitus (DM) in adult pulmonary TB patients in Chennai as well as high prevalence of multiple TB risk factors in TB/DM patients (under nutrition, smoking, alcohol).The investigators observed very poor glycemic control in TB/DM patients and distinct and prolonged pattern of increased inflammatory cytokine protein expression in TB/DM

The remarkable success of Phase I RePORT India has been followed up with implementation of Phase II of RePORT India. The Phase II also would see the addition of two new CRUs from Northern India to achieve pan-India geographic representation.

Meetings in 2019-20

- RePORT India Annual Meeting: 8th Annual RePORT India Joint Leadership Meeting was held from February 4-6, 2019 at National Institute for Research in Tuberculosis (NIRT), Chennai, to review the progress and achievements and discuss the way forward.



- Indo-US: Vaccine Adjuvant Science Collaborative Meeting: The first DBT-NIAID Vaccine Adjuvant Science Collaborative Meeting under Indo-US VAP was organized on 10-11 April, 2019 at National Institute of Immunology, New Delhi. The aim of this meeting was to identify priorities and develop a roadmap to advance Adjuvant Development in India. As was recommended in the meeting, DBT released on its website a Request for Applications (RFA) on India-U.S. Collaborative Research Grants on Vaccine Adjuvant Development.

- Joint Working Group Meeting of Indo-US Vaccine Action Programme: DBT organized the 31st meeting of the Joint Working Group (JWG) of the Indo-US VAP on 15th-16th November, 2019. The two-day meeting was held under the leadership of Dr. Renu Swarup, Secretary DBT from Indian side and Dr Rafi Ahmad, Director Emory Vaccine from the US side. The leadership monitored and endorsed the development of candidate vaccines for Dengue, Tuberculosis, Chikungunya, and Influenza. As per practice "Rama-Robbins Lecture" was organized by the Department in the memory of Late Prof. V. Ramalingaswami and Late Prof. Freddrick Robbins on 15th November, 2019. The lecture was delivered by Prof. K Srinath Reddy, President of Public Health Foundation of India and Dr. Navin Khanna, Group Leader-Recombinant Gene Products, ICGEB.

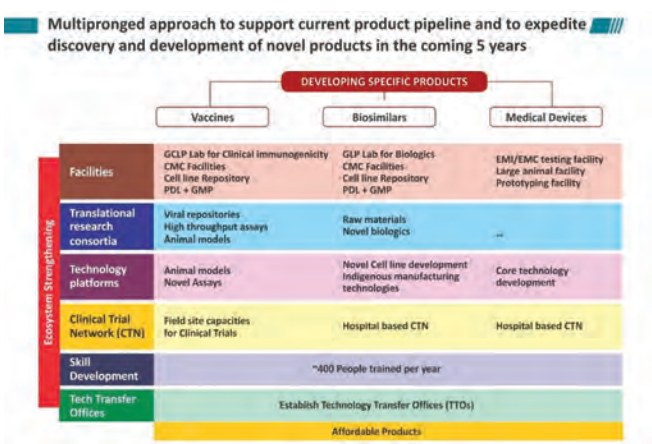
New Initiatives to Support Vaccine Development

The Department is supporting the Ind-CEPI Mission aligned with the global initiative of the Coalition for Epidemic Preparedness Innovations (CEPI). CEPI is an innovative global partnership between public, private, philanthropic, and civil society organizations founded in Davos by the Governments of Norway and India, the Bill & Melinda Gates Foundation, the Wellcome Trust, and the World Economic Forum. CEPI's endeavour is to accelerate development of vaccines against emerging infectious diseases caused by viruses such as Ebola, Zika, Chikungunya, Nipah and SARS viruses, in alignment with the priority list established by the WHO in its *"R&D Blueprint for action to prevent epidemics".*

The Ind-CEPI Mission was approved in 2019, for a period of five years with an aim to support vaccine development for potential outbreak threats up to Phase II testing and enhance inter-ministerial co-ordination for rapid vaccine development. The Mission would also focus on strengthening infrastructure for vaccine development through academia-industry interface, enabling skill development and capacity building activities and supporting development of surveillance frameworks for use of new vaccines. The Mission is being implemented by BIRAC and an infrastructure coordination centre will be set up THSTI. A tripartite strategy engagement document has been signed between CEPI, DBT and BIRAC. Under this mission a Global Chikungunya Vaccine Clinical Development Program (GCCDP) has been recommended for support.

National Biopharma Mission

The Cabinet Committee on Economic Affairs in May 2017 approved the National Biopharma Mission, "Innovate in India (*i3)* – Empowering biotech entrepreneurs & accelerating inclusive innovation". This ambitious Mission of the DBT is being funded by the Government of India at a total project cost of Rs 1500 Crores for five years on a 50% cost sharing via World Bank loan and is being implemented at BIRAC. The Mission is focused to transform the health standards of the country through affordable product development and is currently working to bring 5-7 biopharmaceutical products closer to market in the coming 4 years.The major activities under this Mission are (i) Specific Product Development (ii) Building Shared Infrastructure and (iii) Building and strengthening domain specific knowledge and management skills.



The Mission has identified three major verticals for product development namely Vaccines, Biosimilars and Medical Devices and Diagnostics.

- **Vaccines:** As part of the Vaccine development efforts, support is being provided for Universal Flu Vaccine, Pneumococcal Vaccine and Vaccines for Cholera and Dengue which, are under various stages of development.

- **Biosimilars:** Biosimilars are a cost-effective treatment modality, with a huge market potential. Considering a large number of successful biologics going off patent by 2020, India assumes a great potential to capture this business opportunity. The Mission is focused on providing support for development of biosimilars (therapeutic proteins and monoclonal antibodies) for various communicable and infectious diseases. Some of the biosimilar products supported under the program, currently under development are, Human Serum Albumin, Herceptin, Insulin Glargine, Liraglutide, Ranibizumab, rHU Biosimilar Lispro, Ustekinumab, Palivizumab and Aflibercept. These are currently under different stages of development. The Mission is also supporting development of clones namely Ramucirumab, Golimumab and Factor VIII.

- **Medical Devices & Diagnostics:** The medical device market is dominated by imported products, which comprise of around 75% of total sales. This advocated for a critical need to channelize efforts towards promoting the medical device sector and focus on development of innovative and affordable medical devices and diagnostics relevant to Indian public health needs. The mission is focused on developing core technologies in this segment that offer cost effective indigenous alternatives to existing foreign makes. The mission has funded the following core technologies under this domain: Raw materials for bio-absorbable implants (bone implants), room temperature stable molecular diagnostic reagents, slip ring CT scanners, next generation endoscopes, next generation MRI scanners, medical grade camera for surgeries and laproscopic surgery systems.

Building Shared Infrastructure

The program is supported with an aim create an ecosystem that enables affordable product development in the country viz-a-viz creation of GLP, GMP, GCLP facilities besides cell line repositories and facilities for medical device testing and prototyping. Creation of Translational Research Consortia (TRC) and establishing Clinical Trial Network (CTN) and Technology Transfer Offices (TTOs) are areas of prime importance for the Mission.

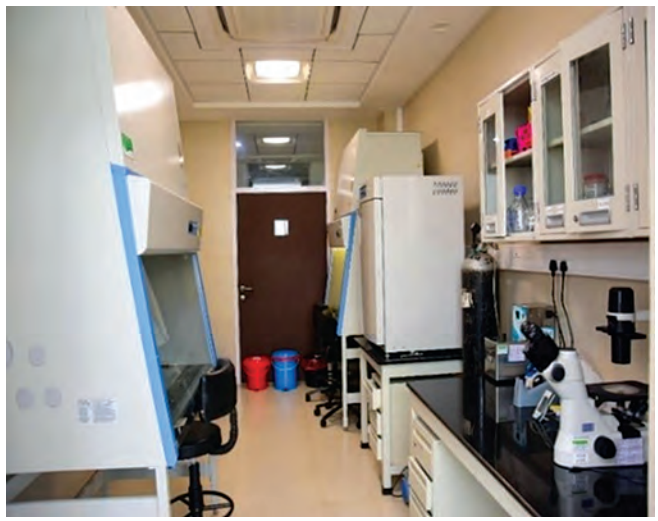
Facilities: One GLP compliant facility for analytical characterization of biotherapeutics supported under the mission is functional while two analytical characterization labs are funded for providing affordable analytical services to start-ups and MSMEs. Two GCLP facilities for clinical immunogenicity (one each for bacterial and viral assays) are being supported under the mission. One cGMP biologics pilot facility catering to clinical grade drug substance and drug product has been supported. Process development lab and GMP manufacturing facilities for biotherapeutics (Microbial and Mammalian) are being funded by the Mission along with Cell-Line Repositories (Microbial & Mammalian).

Four Medical Device and diagnostics rapid prototyping facilities are being supported under NBM. These will cater to prototyping of medical devices using metals and electronics, plastic and electronics, biomaterial and tissue engineering and rapid prototyping for microfluidics based medical devices. One large animal facility being supported under the mission will provide access to swine testing facility for evaluation of implantable medical devices. Two EMI/EMC facilities are being funded under NBM for electrical safety testing of electronic medical devices.

Centre for Advanced Protein Studies (CAPS) at Syngene, Bangalore

cGMP Facility at Shilpa Medicare, Dharwad.

National Centre for Pneumococcal Vaccine Immunogenicity Evaluation at Central Research Laboratory attached to Kempegowda Institute of Medical Sciences (KIMS), Bangalore



National Centre for Immunogenicity and Antivirals at Interactive Research School for Health Affairs (IRSHA), Pune, Bharati Vidyapeeth (left) and Medical Device Testing Facility at Palamur Bioscience, Hyderabad (right).

Translational Research Consortia: The National Biopharma Mission identified the growing public health problems owing to two of the most prevalent viral diseases in the country viz-a-viz Dengue and Chikungunya. A program to tackle these issues was envisaged via creation of translational research consortium for these two disease areas. A consortium of premier Indian institutions funded by the Mission has established a multidisciplinary translation ecosystem partnership platform to generate, resources, reagents, infrastructure and knowledge that fast-track national efforts to tackle Dengue and Chikungunya. The

consortia approved for funding for Dengue consists of 3 clinical sites and 5 premier institutes across the country led by ICGEB, Delhi and for Chikungunya (CHKV), consists of four hospitals and three premier research institutes across the county, led by Manipal Academy of Higher Education.

Clinical Trial Network: The mission is supporting Clinical Trial Network's (CTN) to strengthen the clinical trial capacity in the country. In this direction, the Mission had invited Requests for Proposals (RFPs) for establishing CTN's for hospital-based trials on in-patients for testing biologicals in different disease areas like oncology, diabetology, rheumatology and ophthalmology to provide Indian Biotech companies access to sites in the network for conducting clinical trials of Biologics. In addition to this, the program also aims to study epidemiology of Dengue and Chikungunya in already existing Demographic Surveillance Sites (DSSs). Establishment of newer DSSs is also being considered. These sites can then act as platforms for further interventional studies.

Technology Transfer Offices (TTOs): Strengthening the technology transfer capacity of the country is another major focus area of the Mission. Under the mission five incubators have been identified to establish TTOs. The mission is simultaneously working towards generating skilled taskforce in the area; via trainings and workshops. Furthermore, a consultancy engagement to train the personnel at the TTO's is also in the offing.

Building and Strengthening Domain Specific Knowledge and Management Skills: The mission supports trainings and workshops as per its mandate. As on date, about 762 participants have been trained under different training/workshops under the National Biopharma Mission including 220 female participants. Many workshops have been supported under the mission like clinical research, regulatory compliances, technology transfer, biopharmaceuticals and medical devices. Several more workshops are ensued as a regular activity under the Mission.

Knowledge Generation, Discovery Research, New Tools and Technologies

The main focus areas of the Knowledge Generation, Discovery Research, New Tools and Technologies include Basic Research in Modern Biology, Nanobiotechnology, Genome Editing Technologies & their application and Theoretical and Computational Biology (Bioinformatics, Artificial Intelligence and Big Data etc.) Basic research is core strength in all disciplines of life science which addresses issues in modern biology. These efforts are directed at conceiving and developing fundamental new ideas, approaches, and methods for addressing some of the most intriguing and challenging aspects of the living organisms. Department is continuously supporting the basic research in modern biology at various institutions across the country in order to create knowledge driven biotech sector. DBT is engaged in advancing research and promoting innovation through applications of nanobiotechnology to address issues in health, energy, agriculture and environment.Efforts have been made to encourage R&D programmes in emerging genome engineering technologies and their applications. DBT is also supporting projects and programmes under bioinformatics for more than three decades as one of the thrust areas of Biotechnology. Bioinformatics programme has given impetus to the development of new knowledge and discovery research.

Basic Research in Modern Biology

Basic Research is the backbone of technology driven economy. The investment in basic research of technology development leads to research innovation, invention and product development. This Department is continuously supporting the basic research in modern biology at various institutions across the country in order to create knowledge driven biotech sector. DBT's thrust is on supporting the basic science for applying them to resolve fundamental biological questions for the benefit of the biotech industrial sector. Important leads obtained in many of the basic research studies led to strengthening of applied research and better understanding of the basic principles. Eight CoEs and more than 130 projects are being supported. During the year 67 peer reviewed papers have been published. Some of the salient achievements of the projects are as following:

Characterization of protein-protein and protein-ligand interaction studies was undertaken at NCCS, Pune. The studies have made significant progress towards understanding as how the proteins of pathogenic organisms interact with the host components and consequently how such interactions lead to the complex interplay between the host and the pathogen.

Another study at NCCS, Pune focuses on metabolomic profiling of *Mycobacterium tuberculosis* subjected to four microbicidal stresses and identified 87 metabolites that best describe the separation between stresses using multivariate analysis.The coupling of the metabolite measurements with existing genome-scale metabolic model and using constraint-based simulation led to several new concepts and unreported observations in *M. tuberculosis*. The study provides new leads and important nodes that can be used for designing intervention strategies.

In an attempt to understand structure of ionotropic glutamate receptors that are modulated by HIV proteins, structure of GluK3-kainate receptors was solved using cryo-EM technique at NCCS, Pune. The structure highlights the conformational states associated with receptor functions and the role of N-linked glycosylation in receptor modulation.

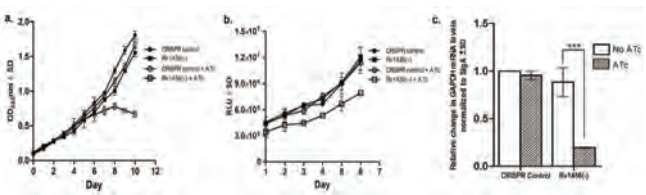
Research work on examining the response of a controller affects process recovery, when disruptive incidences occur under a process analytical technology framework was carried out at IIT, Delhi. The production of lethal toxin neutralizing factor by *E. coli,* which was controlled by a Decoupled Input–Output Linearizing Controller (DIOLC) and the performance of the DIOLC is compared to a proportional integral derivative controller subjected to the same conditions. It was observed that DIOLC performs better after reinstating operating conditions and results in a meaningful improvement in performance.

Study was supported at IIT, Delhi for characterization of critical quality attributes included developing a unique peptide based search algorithm for identification of protein mixture using peptide map fingerprinting which when used along with standard proteomic approaches presents avenues for enhanced protein identification efficiency, particularly for applications such as Host Cell Proteins (HCPs). Moreover, underlying interactions between these "difficult to remove" HCPs and the mAb product were elucidated using

experimental and computational tools to propose a probable mechanism of retention for 10 HCPs. These results can guide downstream process design or avenues for protein engineering during product discovery to achieve more effective removal of the impurities.

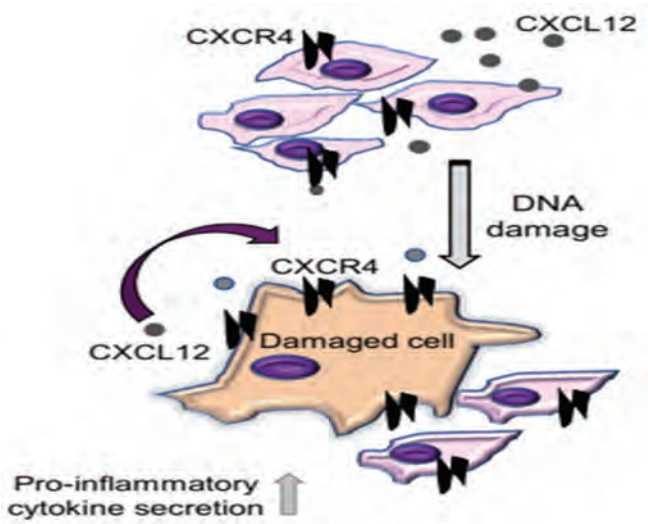
Dr. Reddy's Institute of Life Sciences, University of Hyderabad Campus has identified that an RNA aptamer to the heterochromatin protein Swi6 (HP1), which when tethered is able to enhance HC formation and silencing at the ectopic locus by recruiting Swi6 and the rest of the RNAi machinery. This will be the first report of the tethering strategy as well as large scale screen for RNA elements regulating heterochromatin in *S.pombe* and the technology can be widely applied by researchers to identify RNAs which regulate other processes.

Study carried out at NIPER, Mohali, has identified that *Mtb* GAPDH is secreted into the culture supernatant and is found to be associated with bacterial microvesicles. The kinetics of Tf uptake and efflux and surface-to-internal ratio of Tf binding were determined. Maximum Tf uptake was shown to occur within 2 hours while efflux occurred within 4 minutes. The GAPDH inhibitor ethyl bromo pyruvate inhibited Tf iron uptake by this mechanism.



Silencing of Mtb GAPDH by CRISPRi. Assessment of viability of Rv1436(-) and CRISPR Ctrl strains upon ATc induced GAPDH silencing by a. Growth curve analysis (OD_{600}) and b. cellular ATP levels. c. Confirmation of GAPDH silencing by RT-PCR.

In a study supported at IISc, Bengaluru, it was observed that the ubiquitously expressed chemokine receptor, CXCR4, is upregulated in response to DNA damage triggered by anti-cancer treatments such as chemo- or radiotherapy besides by aging at both cellular and organismal level. The CXCR4 upregulation occurs as a part of DNA damage response (DDR) through an ATM kinase activation-dependent HIF1á-upregulation. This was demonstrated using shRNA mediated knockdown, pharmacological intervention as well as gene expression microarray analysis. A small molecule library screening allowed identification of the signaling cascade downstream to CXCR4 activation, which drives inflammation, primarily by reducing cAMP levels through activation of G-protein Gái/o and the phosphodiesterase, PDE4A. At the organismal level, mouse model of IR mediated DNA damage was used to show that the CXCR4-dependent inflammatory cascade is active systemically as well and the intervention of either CXCR4 receptor or ATM kinase (which blocks CXCR4 upregulation) abrogates inflammation triggered DDR mediated inflammation and tissue injury, and rescues tissue integrity.



Secretion of Pro-inflammatory cytokine in response to DNA damage

The extent of functions of Mixed-lineage leukemia (MLL) in proliferating cells, have been studied in detail along with its sub-cellular localization during the various stages of cell cycle in a study supported at CDFD, Hyderabad. The results demonstrated that MLL localizes to nucleolus and centrosome in interphase. In addition to these, MLL localizes to spindle apparatus, centrosome and midbody during mitosis.

Import of tRNAs into mammalian mitochondria has a lot of clinical significance as number of diseases are due to mutations in mitochondrial encoded tRNA genes. In a study carried out at University of Hyderabad, three additional components of tRNA import into mitochondria i.e. GB, RhoGEF and enolase were identified by using biotin pull down assay. It is reported that GB and RhoGEF are also probably present in the outer membrane of mitochondria and strengthen the idea of their role in RNA import.

A study conducted at NIRRH, Mumbai aimed to identify androgen and estrogen responsive genes using genome-wide NGS-based approach in a normal, unperturbed system of germ cells and Sertoli cells from adult rat testis. Genome wide estrogen and androgen receptor binding sites were obtained by Chromatin Immuno precipitation (ChIP) in germ cells and Sertoli cells by Next Gen Sequencing. List of differentially enriched genes were also obtained which were then subjected to pathway analysis by KEGG and DAVID database. A number of different pathways like metabolic pathways, pathways in cancer, regulation of actin cytoskeleton, prolactin signalling pathways, etc. were enriched. The genes identified showed presence of estrogen response elements and androgen response elements and a few were validated by ChIP-qPCR. Seminiferous tubule culture was carried out using estrogen /androgen agonist and antagonist treatment. All the genes showed alteration in expression after the treatment, thereby confirming the functional relevance of these binding sites.

DBT-IISc Partnership Program Phase-II at IISc, Bengaluru

DBT-IISc Partnership Program Phase-II at IISc, Bengaluru has been supported to upgrade the core and other essential facilities to nurture biology research and human resource training. The Phase-II of the DBT-IISc program was initiated in 2019 to propel biology research to a higher level and has expanded on the interdisciplinary research (chemical sciences, physics and mathematical sciences and engineering disciplines) within IISc. The core and other essential support facilities such as confocal microscopes, biacore facility, mass spectrometry facility, central animal facility, biosafety level-3, SPR Facility, X-ray Crystallography Facility and Fluorescence Activated Cell Sorter have raised the level of biology research at IISc, Bengaluru. The rapidly changing experimental tools form essential components of the contemporary biology research and these facilities at IISc, cater to the needs of researchers from all over the country. In the current programme, research in four major areas of biology has been supported. These include, i) Disease biology with special reference to infectious diseases, cancer and brain disorders, ii) Biological function and form through complex interactions, iii) Bio-molecular structure function and design, and iv) Ecological and evolutionary processes across multiple scales and levels of organization. The research work and facilities supported so far have brought out more than 240 research articles in reputed journals. 03 International and 06 National patents have also been filed and 04 technologies have been developed.

Nanobiotechnology

DBT has been engaged in advancing research and promoting innovation through applications of nanobiotechnology to address issues in health, energy, agriculture and environment. Major thrust areas of the Nanobiotechnology program include new therapeutics and targeted drug delivery vehicles; Enhancing efficacy of existing drugs; diagnostics for early disease detection and imaging; design and development of smart-nanomaterial for medical applications, tissue engineering, bio separation; nanosensors for detection of chemicals and pathogens in food and crops, smart packaging, nano system for pesticides, pheromones, nutrients / fertilizers. The department is fostering knowledge discovery and innovations in all dimensions of biotechnology and allied disciplines by using the nanobiotechnology based interventions as facilitating tools of scientific excellence. **"Guidelines for Evaluation of Nano Pharmaceuticals in India"** developed by DBT along with ICMR and CDSCO, will help large number of researchers to design the experiments in compliance with regulatory requirements and help in enhancing the translational values of the knowledge outcomes. Further the Guidelines for **"Evaluation of Nano Based Agri Inputs and Food Products In India"** have also been finalized. Details of new initiatives and major programmes supported are as follows:

Nanobiotechnology for Agriculture: Nanotechnology has huge potential in agricultutral practices which is not yet exploited. Major areas identified in agriculture sector include Food preservation and toxicity, nanopesticides and nanofertilizers, nano-biostimulant along with soil enhancers through nano-enabled technologies and abiotic stress management. A national Call for R &D Proposals on "Nanotechnology based tools to enhance agricultural productivity" was issued to provide solutions in the area of crop productivity predictions, precision delivery systems, soil-enhancers, field diagnostics development, small electrical needs of farmers & climate change resilient agriculture.

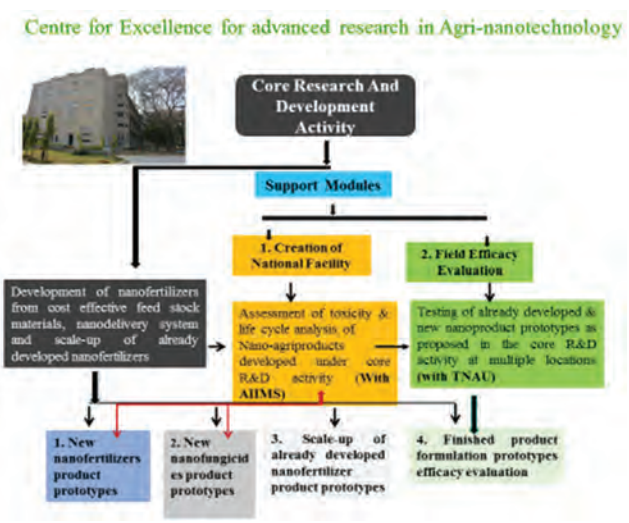
Nanotechnology interventions in Dentistry and Bone diseases: The incidence of dental and bone diseases are increasing in India and globally. Epidemiological data on the incidence of dental diseases is lacking in our country. High prevalence of periodontitis has been reported in India and is considered as the major reason for tooth loss. Acute and chronic dental pain management is another niche area, which needs attention. A national call for proposals was issued to provide nano based solutions for various unmet needs on dentistry as well as orthopedics.

Centre of Excellence for Advanced Research in Nanotechnology

To foster cutting edge research and innovation across the continents, DBT has supported a center of excellence; inter-continental research program between TERI New Delhi and Deakin University, Australia. The program is focused on the advancements in research and education through interventions of nanotechnology across the disciplines.

DBT-TERI Deakin Nanobiotechnology center (TDNBC)-Deakin Research Network *Across continents for learning & innovation Program (DTD-RNA Program)*

- *Train 50 PhD students as future technocrats*
- *Skill enhancement of mid career researchers*
- *Create technology development pipeline*
- *Networking and knowledge exchange to develop multi-disciplinary skill sets and to built IP landscape*



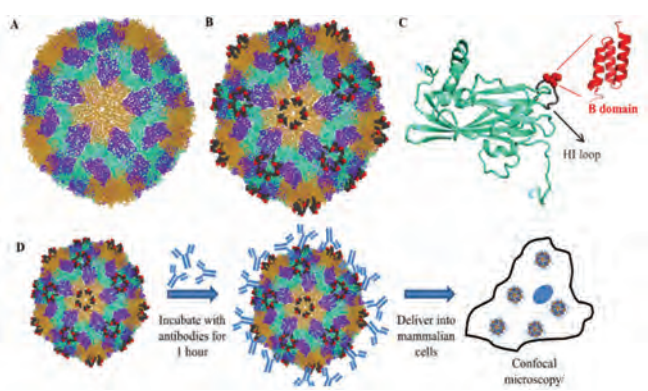
Capacity building/ Skill development:

The Department has supported another center of excellence with the objective to catalyse research and innovation in the field of nanobiotechnology through capacity building and technology generation in the priority areas like nanofabrication and characterization techniques for biologists and medical professionals.

Catalyzing research in nanobiotechnology: supported at IISc Bangalore

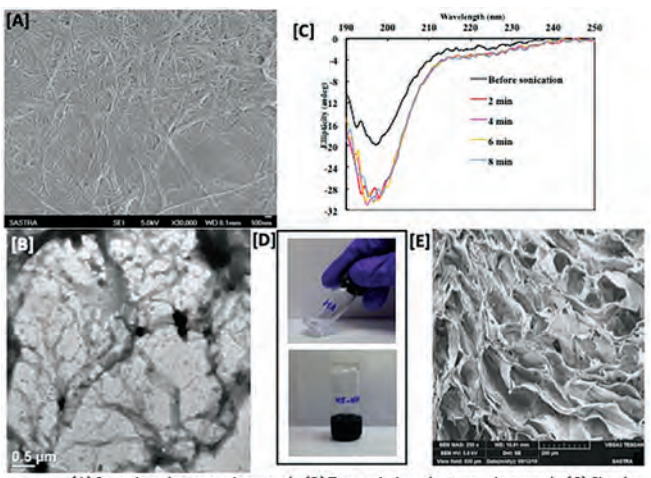
- Essential concepts and hands –on modules in nanofabrication and characterization techniques for biologists and medical professionals
- **Target beneficiaries:** PG students, faculty members and medical professionals.
- **Training level 1:** Two days workshop, 10-12 lectures with 50-60 participants @ 2 times/year
- **Training level 2:** Hands on training together with IP and policy related lectures
- 20 participants per event
- @ 6 times/year

Chimeric plant virus nano particles (VNPs) generated by genetic modification of B domain of *S.aureus* protein A and certain plant viruses were shown to deliver anti-bodies into various cell types which could be used for drug delivery. This chimeric Sesbania mosaic Sobemo Virus based VNPs labelled with fluorophores could be used for *in vivo* imaging due to their 3 months stability. The work has been carried out at IISc Bangalore.



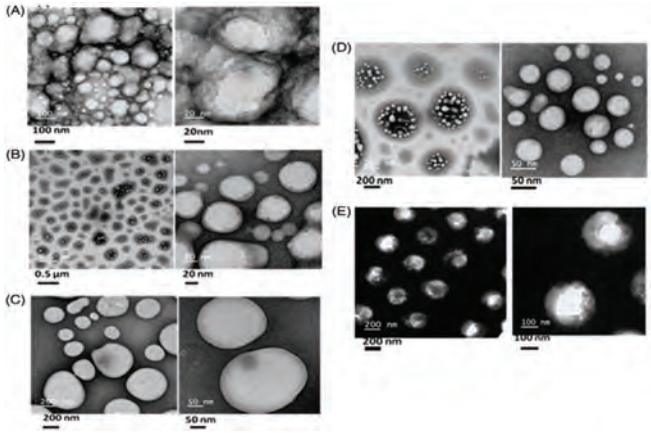
Generation of Chimeric VNPs

Development of *in situ* forming injectable system at SASTRA University with the intervention of silk-based self-assembled nanofibers: Researchers have identified and customized a unique peptide sequence containing few amino acids, where specified sequences imparted stability and silk-like characteristics. Peptide sequences were self-assembled as nanofibers of 47.3 ± 8.18 nm via secondary random coil formation, which mimiced the inner collagen layer of the Bruch's membrane. Further, studies are going on for fabrication of Bruch mimetic membrane.



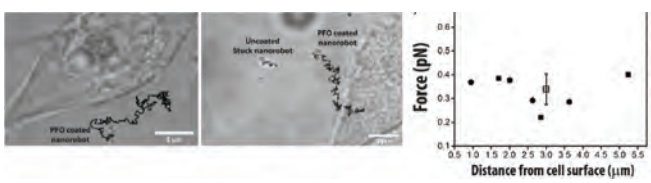
[A] Scanning electron micrograph; [B] Transmission electron micrograph; [C] Circular dichroism spectrum of Peptide nanofibers; [D] Tube tilting of Hyaluronic acid (HA) solution and thiol functionalized Hyaluronic acid (HA-SH); [E] Scanning electron micrograph HA-SH hydrogel

Self-assembled peptide nanostructures for siRNA delivery: Delivering of small interfering RNA (siRNA) remains challenging. Although, several delivery vehicles, including cell-penetrating peptides, have been developed, their implementation is often restricted because of their endosomal entrapment. At KIIT University, Bhubaneswar, water soluble self-assembled peptide nanostructures were developed for siRNA delivery. The peptide nanostructures were found to be efficient for siRNA delivery. Furthermore, the efficiency was found to be comparable with commercially available lipofectamine 2000.



HR-TEM images of self-assembled structures of Cyclic peptides (A:CP I, B:CP II, C:CP III, D:CP IV, E:CP V)

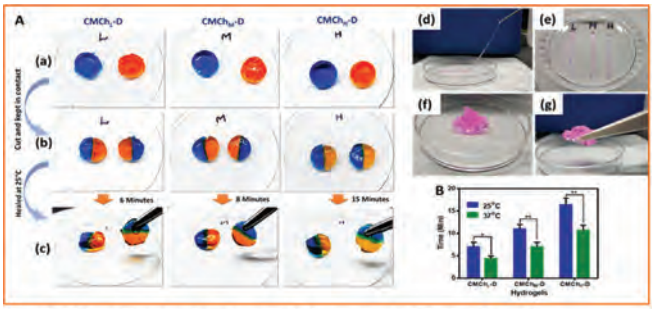
Nanorobots for cancer: Researchers at IISc Bangalore developed nanorobots and identified that they adhere preferentially near cancer cells, this was due to the distinct charge conditions of the cancer-remodeled ECM. Quantitative measurements showed that the adhesive force increases with the metastatic ability of cancer cell lines, while the spatial extent of the remodeled ECM was measured to be approximately 40 µm for all cancer cell lines studied. Specific sialic acid linkages related to cancer-secreted ECM were confirmed to be a major contributing factor in determining this adhesive behavior.



A B

(A) Effect of 1H, 2H, 2H-Perfluorooctyltriethoxysilane (PFO) coating on nanorobots. PFO coated robots do not get adhered to the cancer cells, unlike uncoated robots which adhere to the extr4acellular matrix (ECM). (B) Estimate of force from drag for PFO coated nanorobots. The box represent mean± SD for two experiments.

Self–healing hydrogel: Researchers supported at Institute of Nanoscience and Technology (INST), Mohali have synthesized a self–healing hydrogel capable of supporting chondrocytes proliferation and differentiation. A thermo-sensitive peptide-polymer conjugate has also been designed which showed strain-stiffening behavior akin to the natural biopolymers. The biophysical studies are underway.



Self-healing behaviour of the injectable hydrogel

Peptide based tissue sealant: Engineered improved nature-inspired non-immunogenic multifunctional sealant has been developed. These sealants efficiently promote external and internal blood clotting and suture free wound closure. This is an innovative work done and patented by the researchers at IISER, Kolkata under DBT supported project.

Knowledge generation on NIR Probe Development: As an outcome of DBT funded research at IIT Mandi, researchers made a significant contribution in knowledge generation and demonstrated- (i) development of a small chemical library of NIR probes and established the key role of hydrophobicity for effective interaction with albumin, (ii) development of a mega-Stokes NIR probe CyG with potential of detecting intracellular albumin *in vivo* with high sensitivity and large signal-to-noise ratio, (iii) CyG meets the criteria of imaging contrast agent as its excitation/emission wavelengths are above biological tissues opaque window, (iv) CyG is the first NIR probe for specific liver imaging in vivo with both excitation/emission wavelengths in the NIR region (ëex = 740 nm; ëem = 804 nm). Apart from noninvasive imaging, CyG has also been used successfully to quantify precisely the concentration of albumin in bio-fluids (serum and urine) and (v) the excretion kinetic and intra hepatic albumin binding affinity of CyG have been successfully explored to differentiate between cohorts of mice with fatty liver and healthy liver.

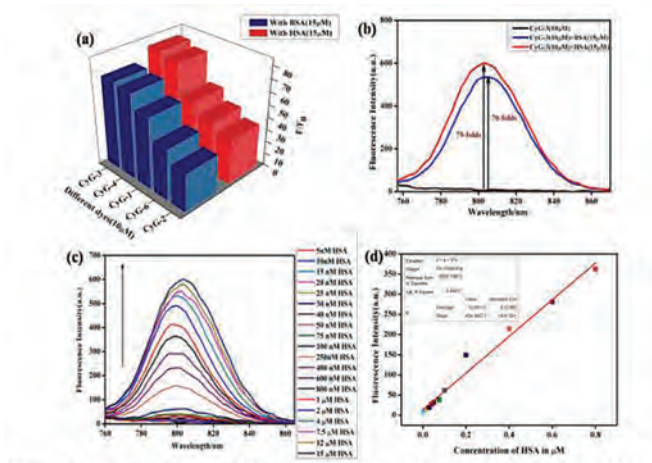


Figure 1. (a) Fluorescence intensity folds' increment of different dyes (10μM) in the presence of BSA (15μM) and HSA (15μM). (b) Fluorescence emission spectra of CyG-3 showing fold increment upon

Other Leads/Technologies Developed	
Nanoformulation/ Drug Delivery	· *Development of an in-situ polymer-based drug loaded hydrogel system* · *Development of novel process to prepare ternary complex as implementation of multilevelcategoric design towards treatment of Ocular Inflammation*
Nanodiagnostics	· *Artemisinin Nano-Formulations were tested and found to have potent in vivo anti-malarial activity.* · *Engineered genetically encoded FRET-based nanosensors for real time display of arsenic (As3+) dynamics in living cells* · *Using RNA aptamers, researchers have developed a label-free strategy for the fluorescence detection of miRNA, which is very useful for disease diagnostics*
Nanotherapeutics	· *Vitamin A loaded graphene quantum dots (GQDs) embedded poly(2-hydroxyethyl methacrylate) (PHEMA) contact lenses were fabricated to providesynergistic effect by light amplification and vitamin A for effective treatment on night blindness.*

	· *PPE18 has a potential for being developed as anti-sepsis therapeutic which along with antibiotics can prove to be more effective*

Outreach Programme: NANOBIOTEK-2019, an international level meeting was organized by the Indian Society of Nanomedicine with partial support of DBT parallel to GlobalBio India 2019 at New Delhi with an aim to facilitate interaction among leading international and national scientists, physicians, government agencies, regulators and industry representatives, students and other stakeholder engaged in research and development in the field of nanobiotechnology.

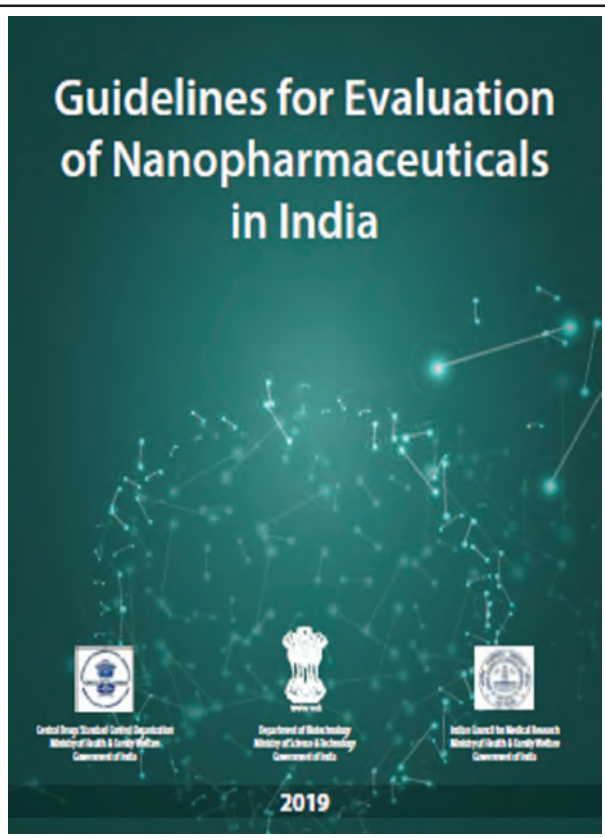
Inter-Ministerial Activities: Various scientists/ stakeholders flagged the need to have specific guidelines for evaluation of products in various sectors of biological sciences developed through interventions of Nanotechnology. DBT is mandated to bring out manuals/ guidelines specifying procedures that will help in regulatory process pertaining to development / commercialization of Nano products in India. Key focus of meetings was "Capacity Building for Translational Research.

To create an enabling ecosystem for product development in the field of nanopharma & making smooth regulatory process for nano based drugs & pharmaceuticals, Hon'ble Minister of Science & Technology has recently released the "Guidelines for evaluation of Nanopharmaceuticals in India" developed by DBT jointly with ICMR and CDSCO.

Further, designing of Nano-Agri input and Nano-Agri products have emerged as a new concept under the domain of 'minimal usage with maximum effect' for agricultural and food applications. New considerations of application of nanotechnology in agriculture thus necessitates the initiation of a scientific decision-making and informing platform for cooperative national module that dedicatedly work on the policy aspects of these products before commercialization. Guidelines for "Evaluation of Nano Based Agri Inputs and Food Products in India" have been finalized and would be released soon.

"Guidelines for Evaluation of Nanophar maceuticals in India": At a Glance

- Jointly developed by DBT, ICMR and CDSCO
- Apply to the nanopharmaceuticals in the form of finished formulation as well as Active Pharmaceutical Ingredient (API) of a new molecule or an already approved molecule with altered nanoscale dimensions
- Facilitate translational research in line with the regulatory requirements
- Provide transparent, consistent and predictable regulatory pathways for nanopharmaceuticals in India.



Release of Nanopharma Guidelines by Hon'ble Minister of Science and Technology & Earth Sciences on 3rd October, 2019

Genome Editing Technologies & Their Applications

Over the past few years, genome editing technologies are making headlines. The simplicity of that platform, compared with the earlier ones, has led to its rapid adoption and expansion of its applications. Genome editing can positively impact sustainable development, environmental management, food security and find applications in therapeutics. Recognizing the power of Genome editing techniques to study and manipulate the genome, DBT has been engaged in promoting research and innovation in the area of genome engineering technology and its applications with a vision to foster innovation and promote development of Genome-wide Analysis and Engineering Technologies to make them accessible and affordable for wider use in Life Sciences. Efforts have been made to encourage R&D programs in emerging genome engineering technologies and their applications. Specific call for proposals given for R&D projects on development of new methods, tools, processes & platforms for genome-wide studies and novel applications & improvement of genome wide technology platforms as well as genome-editing methods. Overall, the program is focused on promoting research and innovation in the area of genome editing technologies and their applications in various sectors.

During the year, some of the important projects supported are synthesis and biochemical evaluations of nucleobase modified tropolonyl-ribose nucleoside in CRISPR-RNA, development of high-throughput genome editing tools for targeted genome-wide knockout mutant in *Brassica napus*, deciphering osteopontin driven regulator(s) of metastasis in triple negative breast cancer using dead cas9-based tools, identification of optimal therapeutic window for efficacious intervention in a Zebrafish model of fragile X syndrome, and development of a cell culture based genome engineered platform for the production of a high value anti-cancer metabolite, *Podophyllotoxin* in *Podophyllum hexandrum*. More than 30 research publications emanated out from the R&D projects supported under the program. Some of the salient scientific and technical outcomes are highlighted below:

In a project on development of genome-wide RNAi screens for understanding of proteostasis implemented at IISc, Bengaluru, cellular senescence and chemoresistance using shRNA-mediated gene silencing, phosphatases and kinases playing significant role in lysosome function, endoplasmic reticulum stress, protein trafficking and cellular senescence have been identified. This has been instrumental in delineating a few novel regulators of cellular homeostasis and has led to identification of multiple potential drug targets for lysosomal storage disorders.

In a collaborative project at IISER, Pune and IISc., Bengaluru, spatio-temporal organization of cancer associated genes in cancer cells and in models of cancer initiation and progression has been studied. A method has been developed using CRISPR-Cas for the targeted tracking of oncogenes in living cells through live-cell imaging approaches. This method can be applied to understand the effect of how chemotherapeutic agents act on the expression, localization and dynamics of oncogenes such as *C-MYC, CCND1, K-RAS and ERBB2* in the nucleus.

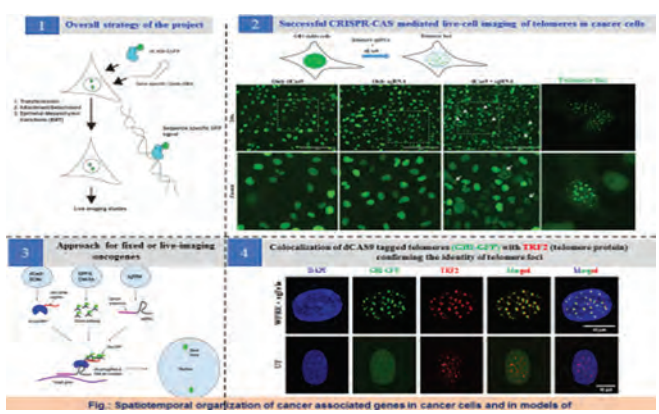


Fig.: Spatiotemporal organization of cancer associated genes in cancer cells and in models of

Genome editing mediated by CRISPR-Cas9 was performed in banana for the *phytoene desaturase* (*PDS*) gene at NABI, Mohali. The edited plants showed photobleaching in the leaves of banana, thus providing an evidence for the applicability of the genome editing tools in banana. The developed tool is being utilized to target genes that could help in enhancing the provitamin-A content in banana fruits. Subsequently, editing of the *lycopene epsilon-cyclase* (*LCYå*) gene was performed in commercial banana cultivar Grand Naine (AAA). Metabolic profiling of the fruit pulp of selected edited lines showed enhanced accumulation of â-carotene content up to 6-fold (~24 µg/g) compared with the unedited plants. These lines also showed either an absence or a drastic reduction in the levels of lutein and á-carotene, suggesting metabolic reprogramming.

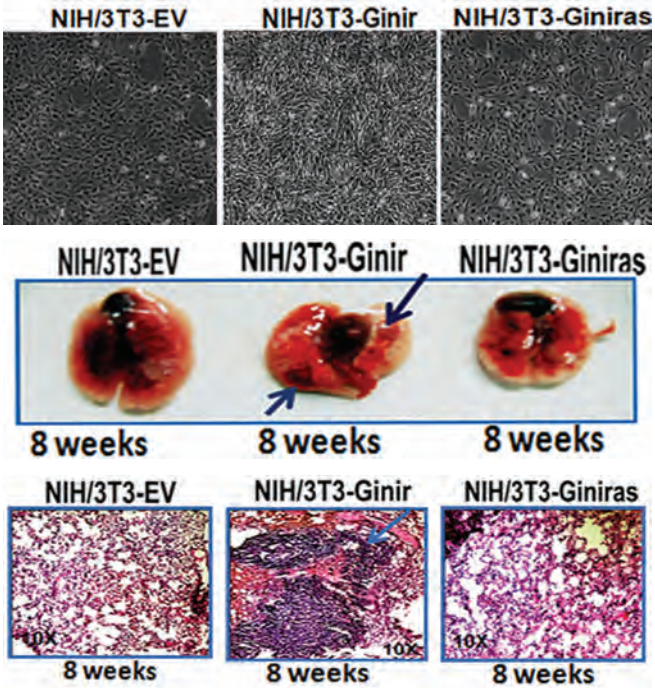
Using CRISPR-Cas-based gene editing system, the role of Plasminogen Activator Inhibitor Type-1 (PAI-1) in the pathogenesis of tissue fibrosis –the excessive scarring of tissue which compromises its function has been established at InSTEM, Bengaluru. Despite contributing to one-third of the deaths worldwide, there is no effective treatment, to date, for fibrosis. This study has established PAI-1 as a novel drug target and pharmacologically targeting this protein may be an effective treatment for combating fibrosis.

Project on target mimicry-based silencing of microRNA167 gene family targeting Auxin Response Factors (ARFs) gene expression during cotton fiber development supported at Gautam Buddha University (GBU), Greater Noida, has revealed the first characterization of transcriptional biases of flowering associated miRNAs in miR167-mimic lines and augmented the understanding of the importance of microRNA-mediated regulation of flowering in plants. Novel insights have been generated into the genetic architecture of cotton fiber initiation and elongation.

Study on identification of microRNAs involved in fragile X syndrome (FXS) carried out at InSTEM, Bengaluru, indicated a novel function FMRP in ribosome biogenesis and translation regulation. The investigation of miRISC composition has further decipher led to the role of FMRP-MOV10-AGO2 interaction in regulating the NMDAR mediated translation regulation at the synapse. These results provide significant molecular insight into the functioning of FMRP and molecular pathology of fragile X syndrome (FXS).

Role of microRNAs and their regulation in pathogenesis of tuberculosis disease has been delineated at IISc, Bengaluru. This study has generated new leads that will aid in understanding of the pathogenesis associated with mycobacterial infections. The identification of specific miRNAs (miR-30-e-3p, miR27a, miR-338-5p, miR-324-5p, miR-150, miR-143), their regulators (KAT5-c-Abl-TWIST triggered BMP signaling for miR27a) and their probable role(s) in cellular processes as enunciated in the sections above could pave the way for a holistic understanding of TB pathogenesis.

In the project on cis-acting pair of novel non-coding RNAs - Ginir and Giniras in Cell growth Regulation and Transformation of mouse and human cells at NCCS, Pune, investiagtors have discovered a pair of long non-coding RNA comprised of complementary, fully overlapping transcripts- Genomic Instability Inducing RNA (Ginir) and antisense of Ginir RNA (Giniras) from mouse melanoma cell line Clone M3. In this study, they have also performed functional characterization of a novel linc RNA pair Ginir/Giniras and shown that this transcript pair is a major player in maintenance of genomic stability and cellular homeostasis. They have further identified two novel interacting protein partners of Ginir – Brac1 and Cep112 and shown their potential to interact with one another and established role of this interaction in mitotic regulation of mouse cells. In conclusion, they have shown that the long noncoding RNA-Ginir functions as an oncogene in mouse and human cells.



Ginir functions as an oncogene in mouse cells (A) phase contrast images of Ginir and Giniras expressing NIH/3T3 cells (B). Tail vein metastasis assay (C). Histopathological analyses of tumor sections stained with H &E.

Indo-US Genome Engineering/ Editing Technologies Initiative (GETin) Program: This 'Indo-U.S. Genome Engineering/Editing Technologies Initiative (GETin) for Overseas Fellowship has the objectives of providing opportunity to Indian students and scientists to gain exposure and access to world class research facilities in leading US institutions, capacity building in the frontline area of Genome Engineering/Editing Technologies and building long-term R&D linkages and collaborations with US institutions/ researchers. This fellowship also has provision of visiting fellowship for US faculty or foreign post docs presently working in US in a field having an interface with genome engineering / editing technologies. The department has provision to support upto 5 individuals in each category. This program has successfully completed two years and is currently in the third year of implementation. So far under the program 10 PhD student interns, 9 postdoctoral Fellows & 2 visiting Fellows have been selected for being fostered and trained in U.S. labs. They collectively represent 20 different Indian higher education institutions across different Indian cities. For the U.S. side, the program has engaged 22 faculty mentors across different universities & departments. Recently in order to assess & evaluate the impact of the program, a day-long Conclave was organized on 9th January 2020 at NIPGR, New Delhi.

In the coming year, the Department is planning to invest more in advancing research & fostering innovation, making genome technologies accessible; establish centre of excellences, human resource development through workshops & specialized training for capacity building in cutting edge areas of genome engineering technologies and their applications. 'Call for Proposals' with preference to the proposal aiming to develop novel technologies or applying known technologies to specific unmet needs has already been given. DBT and BIRAC have also jointly started an initiative to have an access to genome editing technologies and work out mechanism to further sub-license them to the Indian organizations who would like to use this technology for Research & Development. Efforts are also made for setting up Centres of Excellences on Genome Editing Technologies or empower existing Centre of Excellences in areas such as Gene Therapy for monogenic disorders like Sickle Cell Anemia, Development of Transgenic Models for Diseases, Improvement of Crop Productivity & Traits related to Biotic and Abiotic Stresses, Synthetic Biology in Energy and Environmental Research. Development of human resource through specialized training program, workshops and symposia; Creation of virtual knowledge centre to interface research community for interaction and exchange of knowledge are also being planned.

Theoretical and Computational Biology (Bioinformatics, AI and Big Data)

The Department has been supporting projects and programme under bioinformatics for more than three decades

as one of the thrust areas of Biotechnology. The programme has given impetus to the development of Bioinformatics in the country through establishing the necessary infrastructure including the 'Supercomputer' facility. Recognizing the importance of Bioinformatics and Computational Biology at the intersection of various disciplines of Bio-Sciences, DBT supported one of the largest nation-wide Biotechnology Information System Network (BTISNet) to accelerate R&D in biotechnology sector. Several R&D projects are also being supported in various areas such as NGS data analysis, structural bioinformatics of proteins and nucleic acid; computational analysis of metabolic pathways; large scale network analysis; computational image analysis; large scale data-mining, analysis, integration, curation and storage. The BTISNet has made several achievements towards Bioinformatics advancements in the country.

Major Initiatives:

Revamping of BTISNet: Keeping in view, a paradigm shift in information technology and biological research due to generation of large scale biological data using high-throughput platforms particularly with the advent of cost effective next generation sequencing platforms, DBT has decided to revamp BTISNet with establishment of new set of centres involving data driven research, applications of artificial intelligence, machine learning, high-throughput data related informatics etc. in various sectors of life sciences. With the view of directional revamping of BTISNet, proposals were invited from various institutions/universities/organizations not only from existing centres but also other institutions outside the existing BTISNet with a core theme in their area of expertise relevant to this field, framed with a long term objective keeping in view the speedy developments in the area. Revamping of BTISNet of DBT is planned with a focused attempt to engage best expertise in network mode in development of advanced computational tools and technologies and developed national network projects in various areas of Bioinformatics and Computational Biology; apart from the core theme of the proposed centre. The centres under the new BTISNet will be supported during the next financial year.

Manav: Human Atlas Initiative: Department has supported "MANAV: Human Atlas Initiative" for construction of world's most comprehensive human atlas till date by assimilating all the known macro-level and micro-level information from scientific literature and public databases. The proposed human map refers to a computational representation, which will provide knowledge in a holistic fashion from inter-organ dependencies to intra-organ, tissue level, cell and sub-cellular level biological reactions. MANAV can serve as analogous to the 'human reference genome' and will have applications such as patient-specific support for medical/treatment decisions, understanding of pre-clinical and clinical assessment of healthcare products and personal health forecasting. MANAV will also help to identify gaps in the current biological knowledge, which could be the basis for future studies and policies. This project will help to deliver an open source annotation platform, organ (skin) model development, up-skilled manpower and community. Some of the key progress made so far are highlighted below:

1. **Manav annotation platform development:** Manav 1.0 platform has been developed to perform proof-of-concepts (PoCs) on annotation guidelines, data capture, data validation and platform validation by engaging ~100 students. 97% of these students from various background provide a feedback that the platform was intuitive. These PoCs helped to identify the annotation process, data quality, platform functionalities and students' scientific ability to comprehend the scientific articles. Learnings from these PoCs will be implemented while developing next version of Manav platform.

2. **Organ (skin) model development:** Publicly available scientific articles on human skin to develop skin model were identified.

3. **Scientific upskilling and Manav community building:** Multiple outreach and network building activities are being organized to create awareness on Manav project. A pan-country initiative was organized to reach out to student community through various approaches viz. science festivals (India International Science Festival, Kolkata and India Science Festival, Pune), institutional visits (DBT Star colleges/ universities/ medical colleges), beta testing workshops, social media (Twitter, Facebook, Instagram, LinkedIn) and mass communication (Newspaper and television). 1708 students, 64 faculty and 61 reviewers have been

enrolled across 58 cities in 20 states of India. On boarding of educational institution associated with UGC and AICTE is also initiated.

MANAV: Development of most comprehensive and integrated human map from existing scientific literature & databases

Artificial Intelligence: Artificial intelligence (AI) aims to mimic human cognitive functions. It is bringing a paradigm shift to healthcare, powered by increasing availability of healthcare data and rapid progress of analytics techniques. Considering the importance of AI, a call for proposal on Artificial Intelligence Applications for Affordable and Accessible Healthcare - Big Data and Genomics was issued. A total of 22 projects are being supported in the areas of cancer, tuberculosis and pulmonary diseases, diabetic & cardiovascular diseases, ophthalmological diseases, neurological disorders and methods/ drug development. A project on Imaging BioBank for Cancer is also being initiated with an intent to develop AI tools and database for advance research in cancer and will also be aimed at cancer diagnosis/ prognosis and cancer care.

Salient Achievements from ongoing projects:

The studies carried out at Institute of Genomics and Integrative Biology, New Delhi are targeted at Predictive Analytics software for Dyslipidemia associated complications in Type 2 Diabetes condition (PADyAC-T2D). The *insilico* over-expressions or knockdowns of the NF-kappa B system regulators have been employed for inferring the biological significance through numerical output. Through series of simulation exercise employing several *insilico* perturbations, observed that the suppression of constitutive activity of NF-kB, requires multiple interventions each at the level of DNA binding, feedback inhibition and RelA degradation. This model would further be integrated with genes and proteins implicated in diabetic dyslipidemia associated psoriasis and atherosclerosis and would provide predictive utility.

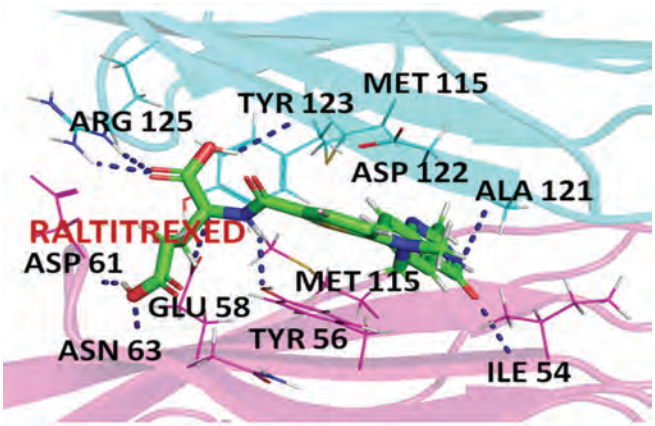
Studies are being carried out at Babasaheb Bhimrao Ambedkar University, Lucknow regarding genome wide identification of iron binding proteins in bread wheat. The wheat genome derived putative proteome was screened for identification of iron-binding sequence motifs. Out of 602 putative iron-binding proteins, 130 were able to produce reliable structural models by homology techniques and further analyzed for the presence of iron-binding structural motifs. The computationally identified proteins appear to bind to ferrous and ferric ions and showed diverse coordination geometries. Glu, His, Asp and Cys amino acid residues were found to be mostly involved in iron binding. These proteins classified on the basis of their localization in different cellular compartments. The identified proteins were further classified into their protein folds, families and functional classes ranging from structure maintenance of cellular components, regulation of gene expression, post translational modification, membrane proteins, enzymes, signalling and storage proteins.

A study carried out at Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum aims to model the effect of mutations of HCN channels in neuronal excitability and impact of GABABR on GIRK and HCN mutations using NEURON. In the study, the effects of these mutations through computational modeling using NEURON simulation environment are being done. Also the interactions of different HCN channel mutations with Gamma-Aminobutyric Acid (GABA) controlled G protein-coupled inwardly-rectifying potassium (GIRK) channel responses are being evaluated.

The Supercomputing Facility for Bioinformatics & Computational Biology (SCFBio) at Indian Institute of Technology (IIT), Delhi has developed 45 bioinformatics web servers in total over the years. SCFBio receives ~ 20,000 hits per day from over 30 countries across the globe. They have also developed a novel method *SEProm* for prokaryotic promoter prediction, based on DNA structure and energetics.

SEProm, is developed by utilizing the in-built structural and energy information of DNA sequences, which is applicable to all prokaryotes including archaea. Compared to five most recent, diverse, current best available tools, SEProm performs much better, predicting promoters with an '*F*-value' of 82.04 and 'Precision' of 81.08. The software is freely available with easy to follow instructions. SCFBio has also developed Bappl+, a web server for predicting Protein ligand affinities which is an improved methodology for predicting the binding affinities of protein-ligand and metalloprotein-ligand complexes. It computes binding affinity based on the most important energetic contributors such as electrostatics, van der Waals, hydrophobicity and entropy of protein and ligand.

Amrita Institute of Medical Sciences and Research Centre, Kochi is doing a study on development of PD-1/PDL-l Checkpoint Inhibitor(s) for Adjuvant Therapy. Design and validation of small molecule drugs for the treatment of sepsis disease using both theoretical and experimental techniques as adjuvant therapy is being evaluated. Virtual Screening (VS) of FDA approved small molecule databases to identify potential PD-L1 inhibitors by the developed structure-based 3D pharmacophore model have been performed. Sequential virtual screening (VS) using pharmacophore modeling and molecular docking based filtering was performed, and the best hits were finally selected as lead candidates to inhibit the PD-L1 downstream signalling. Initially, VS using docking were predicted to identify small molecule PD-L1 leads, and this was integrated with the developed 3D pharmacophore model to bring into effect more stringent criteria of VS. The identified key lead molecules were further integrated with the experimental *in vitro* validation studies.

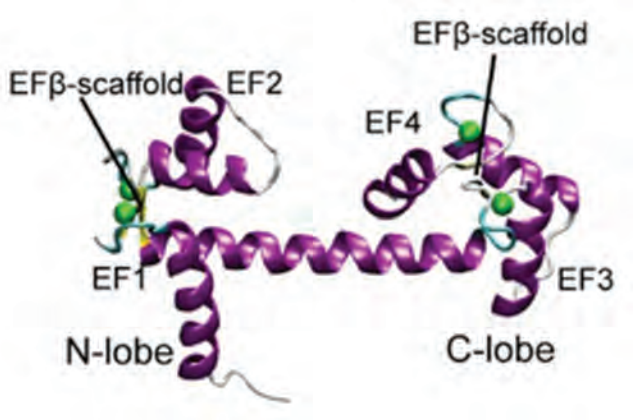


3D Pharmacophore model development by LigandScout software at active site of PD-L1, for virtual screening. Best virtual screened compound Raltitrexed molecular interaction with the active site residues of PD-L1.

Indian Institute of Science, Bangalore is working on exploration of dynamics and mechanism of Horcolin - high mannose glycan interactions with HIV and influenza viral surface glycoproteins. The project is concerned with modeling, MD simulations, In-silico characterization of Horcolin- Manno oligosaccharide and the HIV & Influenza virus glycan interactions and their experimental validation by isothermal titrations and surface plasmon resonance studies which may pave the way for using this lectin as anti - HIV microbicide.

At International Centre for Genetic Engineering and Biotechnology, New Delhi, studies on Multi-Omics in Microalgae: tools and pipelines for data integration and visualization of big data' are being carried out. Development of new web-based application (ALGATool) for analysis and annotation of regulatory metabolic networks in algal systems for production of B^3 Algae (Biomass, Biofuels & Bio-renewables) have been done. Collation of overall information into single database portal consists of 15 genomes (tentatively named as ALGATool - designed to develop a complete integrative database), with interface to perform integrative data mining, an initiative to develop the innovative tool/pipeline for experts in phycology and biofuel research is being done. This pipeline/tool will be versatile and unique for all the scientists and researchers worldwide working in the field of algal biofuels, nutraceuticals, clean energy, etc.

A project on assessing the calcium binding affinity of calcium binding proteins with state-of-the art computational techniques is being supported at Jawaharlal Nehru University, New Delhi wherein computational methods are being developed by using a charge scaling procedure in molecular dynamics simulation. The first application to one of the most important CBP, Calmodulin, showed that the new developed protocol is giving results closer to experiments than the previous models.



Structure of Calmodulin. Green spheres are Calcium ions.

A study carried out at IIT, Hyderabad demonstrated vessel tracing for choroidal Haller's sublayer using tensor voting. A clustering approach to identify the group of neurons having rhythmicity from data obtained through live imaging of neurons has been developed. Fuzzy C-Means clustering was applied on the extracted data to automate the identification of the synchronous neurons. Subsequently, the optimal number of clusters are detected through a cluster validation index. The novel technique has been developed using Artificial Neural Networks, where it has been found that the solution of the proposed algorithm is 97% accurate.

A study carried out at IIT, Bombay is focused on development and validation of multi-scale dynamic and steady state metabolic network models for Polycystic Ovary Syndrome (PCOS) using computational and wet-lab methods. The model has been restructured to study the effect of insulin signaling on PCOS by integrating the signaling molecules that affect steroidogenesis at different levels in the model. The updated model, with the associated pathways, has been shown in figure. This model is being currently validated and will be further used to study the effect of diet on PCOS. The model will eventually be extended to study the effect of stress and lifestyle on PCOS.

Indo-Japan DAICENTER Programme: In order to promote close and effective collaboration between Department of Biotechnology (DBT) and National Institute of Advanced Industrial Science and Technology (AIST) Japan, a programme 'DBT-AIST International Centre for Translational and Environment Research (DAICENTER)' has been supported. The DAICENTER has been established at AIST, Japan, Tsukuba Campus and conducting advanced biomedicine, translational and environmental research in collaboration with Indian Research Institutions IIT, Delhi, RCB, Faridabad, Sikkim University, Sikkim and IIT, Guwahati. Some of the salient achievements made so far in the DAICENTER project are highlighted below:

- Research on the molecular (epigenetic and noncoding) controls of senescence/stress has yielded identification of miR335 and miR-451 as tumor suppressor miRs.
- Big data analytics for protein expression in cancer patients have revealed clinical relevance of CARF (target protein of miR-335 and miR-451) in carcinogenesis and metastasis, which showed that it promotes EMT signaling and is a strong target for cancer therapy.
- Natural product screening for cancer therapeutics during old age revealed honeybee propolis and Ashwagandha as promising candidates. Active ingredients for anticancer and antistress activities and their mechanism of action have been demonstrated with integrated bioinformatics and experimental approaches.
- Screening for hypoxia-modulating drugs resulted in identification of five potential pro-hypoxia compounds which may be useful for hypoxia-related and old-age associated brain diseases.
- Demonstrated Withaferin A is cytotoxic to oral cancer cells which may offer advantage for treatment of oral cancers.
- Performed metagenomic analysis of *Kinema* from India, Nepal and Bhutan and demonstrated that the ethnic fermented food products from Arunachal Pradesh contain high content of a number of bacteria that may add to the functional aspects of these food products.
- Developed a recombinant CHIK Virus that produces EGFP upon infecting mammalian cells. Using this virus, a high throughput assay for *in vitro* screening of anti-CHIKV compounds has been developed.
- Research and development works conducted have brought out 17 publications in the project.

DeLCON: DBT's Electronic Library Consortium (DeLCON) is a topical endeavor for providing access to scholarly electronic resources including full-text and bibliographic databases in all the life science disciplines to the DBT Institutional community across the country. At present, the total members of DeLCON Consortium consist of 33 institutions, comprising DBT autonomous institutions alongwith some institutions/ universities across the states in North Eastern India. DeLCON provides current as well as archival access to more than 1000+ core peer reviewed biology and biotechnology journals and a bibliographic database (SCOPUS) in different disciplines from 22 overseas publishers and aggregators.

Bioinformatics-Drug Metabolism: The international collaboration of department of biotechnology with HHU, Dusseldorf German counterpart providing insights in the area of bioinformatics based drug metabolism to the investigators of NIPER, SAS Nagar for the study of reactive metabolites of anti-cancer drugs like dasatinib and Erlotinib by quantum chemical studies and molecular dynamics studies.

Artificial Intelligence: Researchers from NCL-CSIR, Pune in collaboration with German counterpart with the help of the department of biotechnology is carrying out the machine learning based identification and interpretation of disease-relevant non-protein-coding sequence variation preliminarily in fly data as well as human regulatory regions.

04

PROMOTING ENTREPRENUERSHIP AND INDUSTRIAL GROWTH

Promoting Entreprenuership And Industrial Growth

Indian bio-economy is expected to grow from USD 64 Bn in FY 2019-20 to USD 150 Bn by 2025. This growth trajectory for the sector is an outcome of GoI's constant efforts and initiatives to promote this sector making India a Global Biotech Leader.

1. Startup India

Startup India is a flagship initiative of the Government of India, intended to build a strong eco-system for nurturing innovation and startups in the country that will drive sustainable economic growth and generate large scale employment opportunities. The Department of Biotechnology and BIRAC endeavours to scale up the number of startups in the sector by handholding them from ideation to commercialization of their products/ technologies.

Major Activities under Startup India Initiative

- 45 Bioincubators have been setup across India creating total incubation space of 4,85,000+ sq. ft.
- Make-in-India Facilitation Cell is involved in the various communication and outreach activities for disseminating various initiatives of DBT and BIRAC. The Make in India Cell ensures wider dissemination of the Government programmes and other information relevant to the establishment and growth of startups, SMEs and Companies. A dedicated website has been developed for the information dissemination and handholding of startups and companies (http://birac.nic.in/mii/).
- A Strategy Meet was organized to discuss the road map for achieving $100 Billion Bioeconomy of India by2025.
- FIRST (Facilitation of Innovation and Regulations for Start-ups and Innovators) HUB is created at BIRAC to resolve the queries of start–ups, entrepreneurs, researchers, academicians, incubation centres, SMEs etc. The FIRST Hub has representation from CDSCO, ICMR, DBT, BIS, NIB and BIRAC along with KIHT. It brings stakeholders to a singleplatform.
- BIRAC & Kalam Institute of Health Technology (KIHT) have partnered to facilitate start-ups, entrepreneurs, researchers, academicians, incubation centres & SMEs in the area of testing & standardization of medical devices.
- BIRAC Regional Centers- BIRAC Regional Centers are extended arms of BIRAC to focus on mandated activities addressing specific requirements of the growing ecosystem. Currently, 4 Regional centers are functional namely BRIC at IKP Hyderabad, BREC at CCAMP Bangalore, BRBC at Venture Centre Pune & BRTC at KIIT, Bhubaneshwar.
- Bio-Connect Offices- Currently, 4 Bio- Connect Offices have been established which are acting as linkages that connect Indian biotechnology Startup Ecosystem with other top rated startup ecosystems/ innovation hubs located globally for the purpose of learning, technological exposure and assessment of market dynamics.
- SEED &AcE Funds: SEED (Sustaining Enterprise and Entrepreneurship Development) Fund is Equity based funding support of up to Rs 30 Lakhs to start ups and enterprises through bio-incubators for scaling up. AcE (Accelerating Enterprises) Fund: Biotech Innovation Fund is a Fund of Funds to scale-up R&D and innovation in biotechnology domains of sectors such as healthcare, pharma, medical devices, agriculture, sanitation and many more.
- AcE has been set-up as a 'Fund of Fund' to support Daughter Funds including Early Stage Angel Funds and Venture Funds in the area of Biotechnology and Life Sciences. A total of Rs. 300 Cr commitment for series A investment in Biotech Startups has been targeted including mobilizing Rs. 150 Cr from private venture funds.Two fund calls were announced and about 14 AcE partners have been identified. Contribution agreements are under process.
- Through the Make-in India cell, DBT & BIRAC organized Global Bio-India Summit 2019, a mega international conglomerate of biotechnology stakeholders including International bodies, Regulatory bodies, Central and State Ministries, SMEs, Large Industries, BioClusters, Research Institutes, Investors and Startup a ecosystem.

- Six BioNEST clusters have been recognized to promote networking & resource sharing among BioNEST incubators network of 41+ Incubation Centres.
- Through National Biopharma Mission, 5 Technology Transfer Offices have been approved out of the 6 BioNEST Clusters to support Incubators, Research Institutes, Startups & SMEs in their respective vicinities.

2. Make in India

Devised to transform India into a global innovation and manufacturing hub, GoI launched 'Make in India' program in September 2014. DBT established a Make-in-India Facilitation Cell for Biotechnology Sector in 2016 with the following mandate:

- Facilitating Investments
- Fostering Innovations
- Protecting Intellectual Property
- Building best in class infrastructure
- Ease of doing Business
- Providing Employment in Manufacturing Sector
- State Partnerships to Expand Biotech Innovation Ecosystem
- Create Global Start-ups Connect

Major activities of Make in India Cell in 2019-20:

- **Global Bio-India 2019:** DBT and BIRAC organized **Global Bio-India 2019** from 21st – 23rd November 2019 at Aerocity, Delhi in partnership with Confederation of Indian Industry (CII), Association of Biotechnology Led Enterprises (ABLE) and Invest India. This event is a testimony of growing prowess of biotechnology sector in the country and showcase to International community. The three-day long event witnessed a rich technical program of 40 sessions, CEO roundtables, workshops, product launches, etc. It attracted 3000+ delegates, 190 exhibitors, 25+ countries, 300+ start-ups, 50+ incubators, 60+ Research Institutes, 800+ business meetings scheduling and representation from 10+ states. There were over 60 government, research and educational institutions that took part in the event.

Glimpses of Global Bio-India 2019

- **FIRST (Facilitation of Innovation & Regulation for Start-ups and Innovators) Hub** – FIRST Hub, a facilitation unit, set up by BIRAC, to address the queries of Startups, Entrepreneurs, Researchers, Academicians, Incubation Centers, SMEs, etc. completed one year of successful operation with

support from DBT, CDSCO, ICMR, NIB & BIS. FIRST Hub has addressed 200+queries till date.

Major initiatives of Make in India Cell in 2019-20:

- Hon'ble Minister of Railways and Commerce, Government of India, Shri Piyush Goyal launched an e-portal www.biotech-solutions.com (Biotech Showcase) that showcases BIRAC supported commercialized Biotech Products and Technologies.
- Launch of Biotech Angels Network which would bring together 50+ angel investors, HNIs, early-stage VCs, 10 corporate/family officers expected to lead to 150 investments in Biotech start-ups in 3 years.
- Release of three sectoral reports -
  - ➢ Assessment of Indian Biotechnology Landscape
  - ➢ India BioEconomy Report 2019
  - ➢ India: The Emerging Hub for Biologics and Bio-Similars
- Two editions of Lab to Market Catalogue featuring 111 innovative products and technologies by Indian start-ups.
- DPIIT-CII National Consultation Meeting for Make in India 2.0.: A Pre-Forum discussion with Stakeholders was held to discuss the policy recommendations for Make in India 2.0. These recommendations were further presented to the Honourable Minister, Shri Piyush Goyal in January 2020.
- State Connect
  - o A Biotech State Connect Summit was organized on 7th September, 2019 at Delhi in an effort to facilitate Biotech Startup ecosystem in every state and promote states' Startup/Biotech policies on National as well as International forums.
  - o State Biotech Connect Roundtable Meeting organized on 7th September, 2019.
  - o A Memorandum of Understanding was signed with DSTE–State of Punjab recognizing BIRAC as a knowledge partner to jointly promote biotechnology innovation ecosystem in the state.

BIODESIGN PROGRAMME

A. Biodesign Program

1. School of International Biodesign (SiB)

School of International Biodesign (SiB) is a flagship program of DBT implemented in collaboration with AIIMS, IIT Delhi and international partners in Australia and Japan. The mandate of this program is to train the next generation of medical technology innovators in India. The focus is on innovation and early stage development of affordable and accessible medical device technologies.

Key achievements of SiB for the current year is given below.

1. **Number of Fellows Trained:** Ninefellows have been trained in the year 2019.
2. **Number of technologies developed and validated:** Two (2) technologies have been developed in 2019 including technology for a non-invasive ventilation device for patients with chronic obstructive pulmonary disease, dual device for screening & treatment of pre-cancerous lesions and four (4) technologies have been further developed for validation in the year 2019-20.
3. **Start-ups initiated:** One start-up company has been formed by SiB fellows in the year 2019 viz. M/s. Cureous Labs Private Limited, Kerala formed by SiB fellow Mr. Asish Mohandas.
4. **Awards/ Recognition:** In the year 2019, many awards & accolades were received by the SiB fellows which are summarised below:
   - i. SiB Start-up company M/s. Inochi Care Private

Limited, Assam and inventor for 'Dual Therapy Dressing' technology, developed under SiB has been awarded 2019 NAE Innovator Entrepreneur Award by the Indian National Academy of Engineering (INAE).

ii. M/s. Inochi Care Private Limited, Assam has also been awarded second position at MedTech innovator 2019 Asia Pacific Showcase Program by Medtech Innovator, US held in Singapore in October, 2019.

iii. SiB Start-up M/s Crimson Healthcare has been recognized as one of the best design-led entrepreneurial ventures by TIE Delhi-NCR and QGlue.

5. **Patent Applications Filed:** Ten patent applications have been filed in India and foreign jurisdictions. These include 2 provisional patent applications in India for the technologies developed in 2019-2020, 4 complete applications after provisional patent applications and 4PCT applications the technologies developed by the 2018 batch of fellows.

FlexiOH

6. The 13th Annual Medtech Summit of School for International Biodesign (SiB) was held on 7th Dec, 2019. Dr. Renu Swarup, Secretary, Department of Biotechnology, Ministry of Science & Technology, Government of India, formally launched the FlexiOH®. FlexiOH® is the first of its kind device that comes as an easy to fix wearable material on the fractured part (Short Arm). After wearing this device, light treatment completes the curing process and makes the FlexiOH® cast rigid in just 4-5 minutes. The device was licensed for further development to M/s JC Orthoheal Pvt. Ltd, a start-up company. It has received a grant support of more than Rs 50 lakhs from BIRAC.

Societal impact:

The SIB program has made a huge impact in fostering medical device innovation in the country and training the next generation of medical technology innovators & entrepreneurs. It has emerged as a global hub for international students to immerse in Indian healthcare settings to foster indigenous medtech innovations with a global perspective. The program in the current financial year has also led to the development of two innovative, medical device technologies which will be developed further in India in line with the "Make in India" initiative of the Government of India. The program has also created a start-up company in the year 2019-2020 making the total count of start-ups which have emerged from the program as thirteen, contributing to the 'Start-up India' initiatives.

2. Healthcare Technology Innovation Centre (HTIC) at IIT Madras

HTIC of IIT Madras is an R&D centre established through a joint initiative of IIT Madras and Department of Biotechnology (DBT), Government of India. Since its inception in 2011, HTIC has evolved as the largest and leading med-tech innovation ecosystem in the country, collaborating with over 30 institutions ranging from hospitals, industry, government agencies, and research institutes within the country and internationally. HTIC, in collaboration with these institutions, is developing affordable healthcare technologies for unmet healthcare and clinical needs. HTIC is delivering innovations and technologies that are reaching the field through government and industry partnerships, bringing benefits to lives and our society, and promoting business. With its recent

expansion, it has become an integrated med-tech centre with R&D, technology development, commercialization and incubation. Currently, there are over 80 R&D personnel developing affordable healthcare technologies, and 25 startups incubated in HTIC.

Achievements in the current year are as follows:

- Development of advanced medical technologies
    1. Cuffless blood pressure measurement (ongoing research)
    2. Non-contact neonatal vitals monitoring (ongoing research)
    3. Automated immunodiagnostics (ongoing research)
    4. Minimally invasive image guided surgery (ongoing research)
    5. Deep learning and AI based medical image computing (ongoing research)
- Commercialization of technologies into products through industry partnerships and startups
    1. Immunodiagnostic analysers with minimal sample preparation (product commercialized through J Mitra)
    2. Image guided minimally invasive spine surgery system (ongoing product development in partnership with Perfint)
    3. Fever monitor (technology transferred to Helyxon; manufacturing underway)
    4. Endoscopy video processor (ongoing product development in partnership with Mitra Medical)

Social Impact

a) HTIC's Mobile Eye Surgical Unit, MESU™, a first-of-its-kind technology in the country approved by Ministry of Health, targets the huge unaddressed need for cataract surgeries in rural India. The Mobile Eye Surgical Unit (MESU) is an innovative engineering solution in the form of a stable, self-sufficient and mobile platform that provides a controlled and sterile environment for performing high quality cataract surgery even in rural locations with no basic amenities. The successful clinical pilot of MESU in rural Tamil Nadu with no post-operative complications led to GoI approval from Ministry of Health and Family Welfare to use this technology as a delivery model for cataract surgeries. Following this success, another MESU was developed and commissioned in Jharkhand, funded by Tata trust. Till date, MESU has conducted around 15,000 surgeries in over 100 rural locations and is continuing operations in states of Tamil Nadu, Andhra Pradesh, Karnataka and Jharkhand. Setting up of more units is under discussion.

b) Eye PAC™, an ophthalmic image computing technology, developed by HTIC is creating global impact and has reached 2500+ installations in 26 countries so far with around 2 million eye examinations. The technology powers a revolutionary med-tech product, "3nethra" by Forus Health, a highly acclaimed Indian med-tech start up. Eye PAC platform powers 3nethra to achieve its goal of eye screening without dilatation (thus reducing cost and crucial skill barrier otherwise required). This technology is powering a new product for newborn eye screening, "3nethra neo", which has been recently introduced into the market and has reached 100+ installations in seven countries so far with over 100,000 eye examinations for newborns. This is the first indigenous technology that is available in market for screening retinopathy of prematurity, a critical premature condition.

c) In collaboration with J Mitra, a leading domestic diagnostics company in the country, HTIC has developed the country's first indigenous point of care technology and product for quantitative immunodiagnostics. The product addresses the unmet market needs and requirement of small to medium labs in the community for affordable test kits for non-communicable diseases such as HbA1C (diabetes), Vitamin D, B12, CRP (infection, cardiac), etc. The product has completed pilot manufacturing of 450 instruments and addresses a market of around 50,000 tier-2 labs in the country. The next phase of scaled manufacturing of 1000 instruments is currently underway.

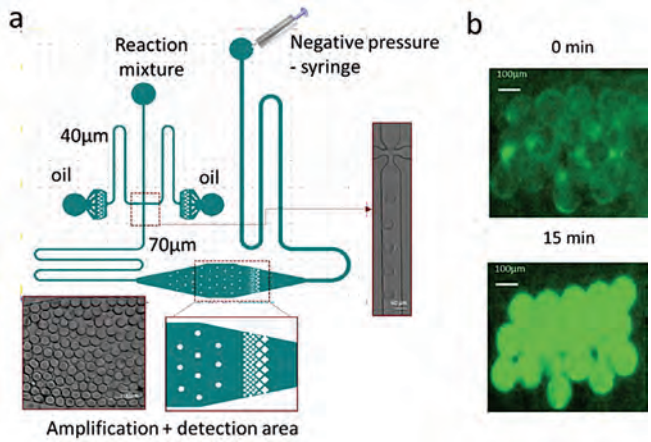
iQuant™ point-of-care immunoanalyser

3. Bioengineering and Biodesign Initiative at IISc, Bangalore

BBI2 is being implemented at IISC Bangalore. The program has resulted in significant achievements – 16 publications, two conference papers and two have been transferred to the startup company. A software has been developed: https://cambum.net/CogSpeech.htm. Summary of key achievements as reported in various sub-projects of the center are as follows:

- One of the objectives in this project was to involve medical doctors as Biodesign Innovators (BDIs) to work on bioengineering/medical instrumentation development. Two BDIs have been appointed. One of the BDIs, an ENT surgeon is working on two projects: i) Developing *cochlear* implant using a MEMS-based resonator system and associated electronics, ii) FDA-approved natural silk-based nanofiber mesh in healing chronic tympanic membrane perforations in both in vitro and in vivo. The other, a neurophysiologist is working on cognitive neurophysiology.

- development of integrated device droplet generation and DNA amplification in microdroplet, optimization of isothermal DNA amplification in pico-liter droplets. Demonstration of ddiNAQ and comparison to ddPCR displayed accurate detection of nucleic acids



Integrated droplet digital isothermal Nucleic Acid Quantification device and operation (a) The schematic design of the droplet based microfluidic device and images of droplets generated and parked during amplification are shown. (b) Fluorescent images of droplets before and after isothermal amplification of DNA in the droplets is shown.

- developed biomicrofluidic device using Corel DRAW X6 and fabricated using CO_2 laser-cutting machine (Universal LASER, USA). The channel height is kept as 1 mm, in commensurate with the thickness of the Polymethylmethacrylate (PMMA) sheet. The LoC devices with implanted electrodes were fabricated using three PMMA sheets of thickness 1mm. The bottom-most layer of the device was used as a substrate for the cells. The devise has been used for analysis of cell morphology, cell viability and for analysis of hMSc and C2C12 behaviour in monoculture in comparison to co-culture. Three papers have been published.

- Through a project on "Modeling and visualization of tissues for endoscopy simulators", an affordable and immersive endoscopy simulator has been made available for trainee doctors The goal of this project is to improve patient care by providing a structured, low-risk (to the patient) training environment. A patent has been filed. The team is working with manufacturers to transfer the technology.

- Surface-engineered Dental/Orthopedic Implants have been developed nanostructures on the surface of commercially-pure Ti, which is widely used in orthopedic devices the idea inspired by the nanostructures on the surface of insect wings such as cicada and dragonfly.

- "A brain-function index apparatus to neurophysiologically evaluate cognition" has been set up and standardized a start-of-the-art, 64-channel, FDA-approved and CE-certified EEG Laboratory at St. John's Research Institute, Bangalore. Preliminary data collection and studies have been carried out and a cost-effective EEG/ERP Instrumentation based on open hardware is being developed.
- "Neuro-protective Intervention in a Realistic, Neurophysiological model of Stroke in Rats" has made bio-amplifiers for recording electro-physiological signals from the rat's brain (motor system). This is a first for India and these multi-electrode arrays are more affordable than those available from the West.
- a simple and accurate method using 3D inkjet powder printing to fabricate patient specific PMMA bone flaps for low cost cranioplasty has been acheived.
- developed online cognitive testing and speech perception program (https://cambum.net/cogTest/index.html) supporting multiple Indian and European languages. In particular, they have implemented Trail Making, N-back, Clock drawing and object recognition tests.
- designed and fabricated a custom planar biaxial cell bio-stretcher to subject cell seeded constructs to uniaxial, equi-biaxial, and non-equi-biaxial stretching.

BIOTECHNOLOGY PARKS & INCUBATORS

To promote equitable opportunities in biotechnology sector across the scale of the country, the Department of Biotechnology partnered with various State Governments to establish Biotech Parks since 2003 and helps to translate research into products and services by providing necessary infrastructure support. The parks have been facilitating networking amongst various biotech stakeholders and providing entrepreneurial opportunities even in remote places of India. These parks are successfully accelerating the commercialization of new technologies, nurturing and maintaining emerging ventures and assisting new enterprises to forge appropriate linkages with other stakeholder of biotechnology sector including academia and Government. Nine parks have been established in the states of Uttar Pradesh, Tamil Nadu (2 parks), Karnataka, Kerala, Telangana, Assam, Jammu & Kashmir, Chhattisgarh. An exclusive biotech park for women entrepreneurs is functional in Tamil Nadu. These are:

(i) Biotech Park, Lucknow, Uttar Pradesh

(ii) Biotechnology Incubation Centre, Hyderabad, Telangana,

(iii) Tidco Centre For Life Sciences (TICEL) Biotech Park, Chennai, Tamil Nadu

(iv) The Golden Jubilee Biotech Park For Women, Chennai, Tamil Nadu

(v) Biotech Park Technology Incubation Centre, Guwahati, Assam

(vi) Biotechnology Incubation Centre, Cochin, Kerala

(vii) Biotechnology Park, Bangalore, Karnataka

(viii) Industrial Biotechnology Parks (IBTPs), Jammu & Kashmir

(ix) Chhattisgarh Biotech Park

Presently Four parks are on-going:

- Biotechnology Incubation Centre, Cochin, Kerala has major infrastructure facilities and houses 22 incubatees.
- Biotech Park Technology Incubation Centre, Guwahati, Assam has 8 incubatees and 6 have graduated. The park has major infrastructure facilities for fermentation, micropropogation, herbal extraction, bioprocessing unit.
- Industrial Biotechnology Parks (IBTPs), Jammu & Kashmir- Two Industrial Biotechnology Parks have been recently set-up focusing on medicinal & aromatic products, enzymes/value-added biomolecules.
- Chhattisgarh Biotech Park -interfaces research institutes with industry for bio-resource based product commercialization.

Based on decade-long experience, DBT has modified the scheme for establishment of parks and has announced the 'National Biotechnology Park Scheme' wherein a private

sector should partner with State Governments for support by DBT. This is to encourage State Government to come forward to scale up activities related to biotechnology sector which in long run will contribute in improving the socio-economic development of the region. The guidelines on "National Biotechnology Park Scheme" are available on the web-link www.dbtindia.nic.in/wp-content/uploads/guidelines_biotech_Park.pdf. As per guidelines, the Department initially would support new BT Park for 3 to 5 years after review of their business plan and detailed project report. It is expected that afterwards, the unit would work towards becoming self-sustainable and will take care of maintenance and upkeep the assets created. Specific objectives of the 'National Biotechnology Parks Scheme' are as follows:

- To develop high quality basic infrastructure and high end central equipment facilities with the required support services for undertaking Research & Development, product development, piloting and validation by SMEs and Biotech Industries.
- To boost the biotechnology sector across the country by incentivizing states for setting up biotechnology parks.
- Strengthening the existing infrastructure facilities in order to make Indian Biotech industry a global leader.
- To foster innovation and entrepreneurship
- To facilitate establishment of a congenial ecosystem for the growth of biotechnology industry
- To enhance competitiveness of biotechnology industry by providing easy access to robust infrastructure and enabling environment

As per National Biotechnology park scheme, the DBT is working with various states for establishment of new parks for anchoring the entrepreneurship facilitation in states. In the current year, the Department has received five proposals for the establishment of Biotech Parks in the states of Telangana, Karnataka, Andhra Pradesh, Himachal Pradesh and West Bengal as per guidelines of National Biotechnology park scheme which are at various stages of processing.

BIOTECH PARK, LUCKNOW, UTTAR PRADESH

Biotech Park, Lucknow is Uttar Pradesh's first technology incubator, set up in 2003 jointly by the Department of Biotechnology, Government of India and Government of Uttar Pradesh on eight acres of land. It became functional in the year 2005. The Park has been promoting growth of bio-pharma, agri-biotechnology and bio-service sectors by inviting biotech industry to the state; working in collaboration with state agencies and central institutes of R&D and learning; and enabling higher crop productivity, better human health, greater employment opportunities and improved quality of life.

Under the Skill and Entrepreneurial Development of the Tribal Youth (sponsored by The National Academy of Sciences, India) Biotech Park trains tribal youth in the areas of production of rose water, essential oils, herbal cosmetics, moisturizers & Aole vera gel, plant tissue culture, and vermicomposting.

BIOTECHNOLOGY INCUBATION CENTRE, HYDERABAD, TELANGANA

This Incubation Centre has been established by CSIR-IICT and Govt. of AP with support from DBT and is owned by the Society for Biotechnology Incubation Centre (SBTIC). World class facilities have been created for use by entrepreneurs on use and pay basis. There are 12 labs of 350 sq. ft each which are given out to companies. DBT has provided support for current good manufacturing practices (cGMP) compliance for pilot plant facilities, required for quality manufacturing and for minimizing contamination. The biotechnology incubator facility would have research laboratories, knowledge based service centres and utility generation facilities. It is mainly designed for development and scale up of bio processes and technologies. A pre-BTIC Process Generator (PBPG) component of BTIC was set up at IICT, Hyderabad to act as a front end facility to provide lab and bench scale process technologies for biotech processes.

With its state-of-the-art R&D infrastructure, furnished laboratories & office space, utilities, support services and amenities, the BTIC has emerged as the best Incubation Center not only in genome valley but also in India, in two years of its operation. The Centre, which is the first publicly owned and privately operated R&D venture in the country,

has now become a role model for other such enterprises. The existing infrastructure has successfully attracted more than 10 new companies in the cluster; most of them being startups/early stage companies. To provide analytical services to the biotech and allied industries, The Advanced Analytical and Characterization Resource (AACR) facility is established as a joint initiative of BIRAC, SBTIC and CSIR-IICT.

TIDCO CENTRE FOR LIFE SCIENCES (TICEL) BIOTECH PARK, CHENNAI, TAMIL NADU

The Park was established by Tamil Nadu Industrial Development Corporation Ltd. (TIDCO), an undertaking of the Tamil Nadu State Government with support from DBT. DBT sanctioned grant for purchasing equipment towards establishing a Biotechnology Core Instrumentation Facility (BTCIF). Laboratory facilities at BTCIF include Microbiology, Molecular Biology, Fermentation, Downstream Processing, Purification, Analytical Support, Animal Cell Culture Facilities and Utilities. This Park has created infrastructure for Biotech R&D on 5 acres of land in Chennai. It has now achieved 100% occupancy with national and international clients. The tenancy area has 74 modules of 1525 sq. ft. each, available for clients to develop their own customized R&D labs of BSL2 standards, upgradeable to BSL3, in accordance with GLP standards. Clients can install their facilities appropriate to perform their independent research.

TICEL is offering the equipment for utilization by companies / scientists / entrepreneurs on non-exclusive basis for their scientific activities / process & product development / sample analysis. The consumables and chemicals / reagents for the operation of the equipment are being sourced by the clients as per their specifications and requirements. The charges for utilizing equipment will be collected from the clients. TICEL clients and external companies / scientists are using the equipment at BTCIF for their scientific activities. The detailed brochure on BTCIF, charges for utilization of equipment, and booking form are available on their website, www.ticelbiopark.com.

THE GOLDEN JUBILEE BIOTECH PARK FOR WOMEN, CHENNAI, TAMIL NADU

The park was established by Govt. of Tami Nadu at Siruseri, Kanchipuram District with support from DBT. This park has been established as a Centre-State partnership along with the Tamil Nadu State Government. This is the first **Women Biotech Park**. The Park has 20,000 sq ft of built up area as modules of 1,000 sq. ft. each, while land modules have been given on long-term lease. The park received 540 lakhs as BioNEST Fund in 2015 and 200 Lakhs as Sustainable Entrepreneurship and Enterprise Development Fund (SEED) fund in 2019. Since its inception the Park has turned over 500 skilled women entrepreneurs, technocrats and workers; presently the park has close to 200 women entrepreneurs & technocrats and workers with 40% of them being skilled. The women workforce is at 60%. Presently it houses 13 companies inclusive of 5 start-ups and 3 incubatees. Over the last few years the Park has had more than 500 interns who have benefitted from the Park and there is an increasing interest among faculty and students who desire refresher programmes and internships.

BIOTECH PARK TECHNOLOGY INCUBATION CENTRE, GUWAHATI, ASSAM

The Biotech Park Technology Incubation Centre has been sanctioned by the DBT at a total cost of Rs. 27.99 crores in 2009 with the aim to develop and commercialize bioprocess and products by serving as a centre for entrepreneurship through development of partnership with innovators from universities, national R&D institutes, academic institutes and industry and help companies quickly commercialize the new technologies and contribute to the strengthening the local and national economies. An interim facility for the Incubation Centre has been built in an existing building of IIT Guwahati. Eight incubatees are currently associated with GBPIC and nine have been graduated out.

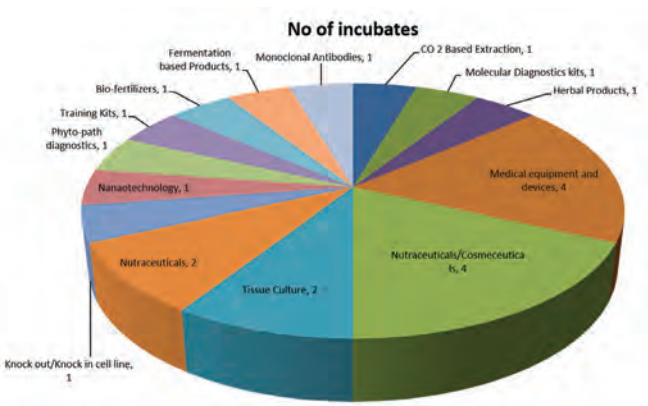
BIOTECHNOLOGY PARK, BANGALORE, KARNATAKA

The project was sanctioned at a total Project Cost of Rs 32.26 Cr; with contribution from Karnataka Biotechnology & Information Technology Services (KBITS), Department of IT, BT and S&T, Government of Karnataka and Department of Biotechnology, Government of India. Bangalore Bioinnovation Centre (BBC) is envisioned to be a state of the art bioinnovation centre catering to the needs of startups in the broad areas of Life Sciences and facilitate Innovation driven Research. Located within Bangalore Helix Biotechnology Park

at Electronic, BBC is located in 10 Acre campus with a total built up area of above 50,000 sq ft. It houses a state of art Central Equipment Facility as well. The Centre is nestled between thriving ccademic institutions like Institute of Biotechnology and Applied Biotechnology (IBAB), Centre for Human Genetics and the upcoming area for anchoring Big Companies/MNC's. The Centre caters to the broad areas of Life Sciences i.e. Healthcare (MedTech/ Pharma/Bio-Pharma), Agriculture, Food/ Nutrition, Industrial Biotechnology and Environmental Biotechnology.

KRIBS BIONEST, KOCHI, KERALA

The Department of Biotechnology has set up a Biotechnology Incubator Center (BTIC) at Kerala Biotechnology Park in 4 acres of land with a total built up area of 50,000 sq.ft. It has been established for accelerating and supporting the research process of entrepreneurs. A common facility lab in an area of 8000Sq.ft is also set up for the entrepreneurs as well as incubatees in the biotechnology park. Rajeev Gandhi Centre for Biotechnology is the Institutional Partner of Kerala Industrial Infrastructure Development Corporation (KINFRA) for operating the lab. At present, Kerala Start Up Mission (KUSUM) and RGCB are managing the facility. The BTIC was made operational in the year 2009 and there are 16 start-ups currently housed in the centre, five companies have graduated in the Business Enterprise Zone (BEZ). At present, 22 incubatees are operating from BioNest and the centre has 100% occupancy. Another set of 5 new prospective proposals were presented before the Executive committee on 17th June 2019. Hence, in terms of the incubation space, we have to create new space to accommodate new incubates.



Incubates working in BIONEST Kochi

INDUSTRIAL BIOTECHNOLOGY PARKS (IBTPS), JAMMU & KASHMIR

The two Industrial Biotechnology Parks (IBTPs) in the state of Jammu & Kashmir" (one IBTP at Jammu and another at Kupwara, Kashmir Valley) have been sanctioned by the DBT at a total cost of 8466.00 lakhs (IBTP-Jammu: Rs. 4200.00 lakhs + IBTP-Kashmir: Rs. 4266.00 lakhs) to be shared between DBT (Rs. 6000.00 lakhs) and Govt. of Jammu & Kashmir (Rs. 2466.00 lakhs) in June 2018for a period of three years. The establishment of these IBTPs will boost the bio-enterprise development along with employment generation for youth and students in the state of Jammu & Kashmir. The project will be executed through CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM), Jammu for setting up to IBTPs and on completion, will be handed over the facility to J&K Industrial Biotech Parks Society. The thrust areas for IBTP, Jammu have been prioritised for the current phase to include the three areas: Micropropagation; Medicinal plants extract preparation and Enzymes/value-added biomolecules. The IBTP in Kashmir Valley would provide the following facilities to promote research based entrepreneurship and development of biotech industry:

CHHATTISGARH BIOTECH PARK

The Chhattisgarh Biotech Park has been sanctioned by the DBT in July 2018 with the overall aim to provide facilities for interface of research institute with industry for better utilization of technology and available bio-resources in New Raipur in the state of Chhattisgarh in collaboration with Govt. of Chhattisgarh. At this stage, steps are being taken for construction of incubation centre and is starting an Incubation centre at temporary site. Two acres of land in the IGKV Campus for establishment of Biotech Incubation Centre have been identified. 3500 sq ft. Building space has been provided by IGKV, Raipur to start Biotech Incubation Centre temporarily, till the construction as new building as per the proposal. The proposals for incubatees have been screened and three potential incubates have been identified. The procurement of equipment process is almost completed. The Park already planned trainings and workshops by utilizing the resources at IGKV campus.

05

BUILIDING INTERNATIONAL COLLABORATIONS AND PARTNERSHIP

International Collaboration

Building international partnerships between organizations, countries, institutes etc is a critical tool for the success of global development initiatives. Developing strategic partnerships strengthens Universities/Institutes in globalizing their programmes to help academics, students, and their faculties to become more competitive in global scenario. Therefore, in order to facilitate academic and research collaborations between Indian Institutions and top leading universities of the World, Govt. of India has been increasingly trying to focus and promote academic and research collaboration with the aim to provide engineering and technological solutions to challenges ranging from climate change, agriculture to healthcare etc. The Department is implementing various international collaborative programs with a number of countries and philanthropic organizations in different areas of biotechnology. Some of the major initiatives during the year and ongoing partnerships under international collaboration are highlighted below

Various ongoing partnership programmes

Major Initiatives and Ongoing Partnership Programmes

Bilateral Program

Australia: The overall objective of the Indo Australian Biotechnology Fund (IABF) is to develop and support collaborative research activities which draw upon strengths in India and Australia. The fund supports Indian and Australian scientists to collaborate in cutting edge areas of science and technology. The collaboration during the last 13 years has led to support of research projects as well as capacity building. A large number of students have been trained under the program. So far, 57 projects have been supported under this collaboration.

Joint working group meeting was held in Australia in September, 2019 to firm up discussions to continue the collaboration in various areas through Research funding and exchange of students for capacity building. Applications for joint collaborative project Indo-Australian collaboration in biotechnology were also invited in different priority areas (Cancer therapeutics / theranostics, Genomics and precision medicine, Pest-resistant crops) this year.

Brazil: Indo- Brazil Collaborative MoU was signed in 2012 for the first time. The current MoU was signed on 30th May 2018 at Brasilia, Brazil. The objectives of the MoU are: a) to broaden and deepen cooperation in science & technology focusing on biotechnology; b). To encourage industrial research and development (R&D) and related investment flows, bilaterally and/or regionally; and c) To promote transparency through exchange of information and cooperation among relevant institutions. The broad areas of collaboration are a) Biomedicine and health, especially biotech based products; b) Agriculture breeding practices; c) Bio-fuels and bio-energy; d) Nanotechnology and bioinstrumentation; and e) Biodiversity and taxonomy. So far 11 joint proposals have been supported under this agreement. A Indo- Brazil joint collaboration meeting was held in January 2020 to discuss and finalize the third call for proposals and areas of collaboration.

Indo Brazil joint collaboration meeting held on 23rd January 2020 at DBT, New Delhi

Costa Rica: The Department has signed an LoI with Ministry of Science & Technology, Republic of Costa Rica on 8th March 2019 at San Jose, Costa Rica for technological cooperation in accelerating overall scientific development in their

respective countries. The areas of mutual interest include a) Biomedicine and Health, especially biotech based products, b) Agriculture & breeding practices, c) Biodiversity, biofuels and bioenergy, d) Nanotechnology and bioinstrumentation, e) Pharmaceuticals, health, vaccines and f) Animal & marine biotechnology. Discussions are underway to arrive at common areas of interest to initiate the scientific activities from both sides.

Cuba: The Department has an ongoing agreement with Ministry of Science, Technology and Environment, Republic of Cuba. The MoU is focused to (a) transparently broaden and deepen cooperation in Science & Technology in Biotechnology and b) encourage industrial and basic R&D, related investment flows, bilaterally and/or regionally in Biotechnology. Following priority areas have been identified for cooperation a) Agriculture of sugarcane & vegetables and livestock health, (b) Agro-ecology especially the integrated food & energy systems and urban agriculture, (c) Human biomedicines especially vaccines and molecules of immune system origin for infectious and diseases and cancers such as Breast, Lung, Prostrate and Cervical as well as for neurological restoration. (d) Aquaculture especially transgenic fishes and marine bio-prospecting, (e) Nanotechnology and (f) Neurosciences and Neuro-technologies. Discussion is underway for starting various activities planned under this program.

European Union (EU): Since 2009, Department has collaborated with European Union (EU) through various partnership programmes such as New Indigo, Inno Indigo, Infect-Era Net and FP-7 (Frame work-7) programme. Exploring these partnerships, about 35 joint collaborated projects were supported so far. Under the Horizon 2020 framework programme, currently the Department collaborates with the EU through i) a joint flagship programmes such as, EU-India Water Cooperation on Research and Innovation and, next generation influenza vaccine for citizens worldwide, and ii) co-funding opportunities in thematic areas such as waste to value, agri-biotech, human health and industrial biotechnology. Under EU-India Water Cooperation on Research and Innovation, three ambitious projects focusing on low-cost purification and recycling of water, and water re-use and resource recovery opportunities for urban and peri-urban areas in India have been recommended for financial support. Under the next generation influenza vaccine partnership, three ambitious projects focusing on advancing the efficacy and safety, duration of immunity, and increased breath of protection against influenza strains have been recommended.

Finland: Memorandum of Understanding (MOU) was signed between DBT and Academy of Finland in July, 2005 and extended till 2018. Memorandum of Understanding (MoU) between Innovaatiorahoituskeskus Business Finland and DBT was signed on 30.11.2018 for period of 3 years to work on identified research areas as well as to promote and nurture start-ups in both the countries. Till date Nine joint calls and one trilateral call for proposals has been announced and forty one projects have been funded in the areas of biomedical devices, medical biotechnology and biofuels. BIRAC provided showcasing opportunity to Biotech Startups at international platform through participation in SLUSH programme – the largest International Startup annual event at Helsinki, Finland. DBT is also partnering with Business Finland under mission innovation program that has achieved commendable success in clean energy.

France: The French Embassy in India in collaboration with Ministry of Science & Technology, GoI, and *Université de Lyon*, EM Lyon, Ministry of Human Resource Development, organised Knowledge Summit 2 in Lyon, France between 17-18th Oct, 2019. Scientists from Department of Biotechnology and its autonomous institutions participated and deliberated on future areas of cooperation. President CNRS, France, Dr Antoine Petit visited DBT and deliberated on rejuvenating the partnership for achieving sustainable impact through the science cooperation between both the agencies.

Knowledge Summit 2 at Lyon, France

Secretary DBT & team with President CNRS & team

Germany: The Department of Biotechnology is actively engaged in scientific partnership with German Federal Ministry of Education, Science Research and Technology (BMBF) and Deutsche Forschungsgemeinschaft (DFG) in the areas of the biotechnology. The Programme of Cooperation between DBT and DFG signed in 2012 has been further extended up to 24th October, 2022. The department of biotechnology in collaboration of German funding agencies (BMBF and DFG) has implemented 37 projects till date through various joint calls with focus on Medical Biotechnology, Agricultural Biotechnology, Innovative Food and Nutrition Technology, Medical devices and bioengineering and Environmental biotechnology areas. In addition to this, the department is in the process of implementating the Phase-II of the DBT-DFG joint collaborative multi-institutional network project. This project encompasses the dynamics of agriculture mediated economic changes focused on societal impact in urban, peri-urban and rural areas of Bangalore that may lead to impact on policy related aspects. During 2019 the department has also announced the 2nd joint DBT-DFG call for fundamental research in biotechnology.

Russia: In October 2019, the program of Cooperation between Department of Biotechnology and Ministry of Science & Higher Education, Federation of Russia was extended till 20th October 2022. A budget of Rs.1.12 Cr was released during 2019-2020. 4 projects are currently being supposed under this agreement. The Department is presently engaged in bilateral communication with the Russian counterpart for inviting a fresh call for proposal.

South Africa: The Department is partnering with South Africa for Flagship Program on HIV/TB, initiated under the Indo-South Africa Bilateral Science and Technology Cooperation Agreement that aims to leverage on the complimentary expertise across India and South Africa by bringing together various accomplished groups from both the sides. Under this collaborative effort, the Department is supporting projects on development of broadly neutralizing antibodies for HIV, biomarkers to identify better diagnostic solutions and PK-PD analysis of second-line therapeutic drug in a cohort of patients.

South Korea: A high-level meeting between NITI Aayog, Government of India and Presidential Committee on New Southern Policy (PCNSP), South Korea was held in October 2019 to enhance cooperation in Biotechnology, Artificial Intelligence (AI), Startups, Tourism, Telecommunications & Trade with South Korea as well as to execute the Memorandum of Understanding (MoU) signed between the Government of India and the Government of the Republic of Korea in the field of Biotechnology, Bio-economy, Science and Technology in 2018. Department of Biotechnology has identified two priority research areas for collaboration – Utilization of Artificial Intelligence in Biotechnology including Viral & Infectious disease biology. The Department is also actively working towards the successful implementation of the call on Korea-India Joint Network Centre program, which will be announced shortly.

A high-Level meeting between NITI Aayog, Government of India and Presidential Committee on New Southern Policy (PCNSP), South Korea held in October 2019

Spain: The Department of Biotechnology through a programme of cooperation (POC) for technological co-operation in biotechnology collaborates with Centre for the Development of Industrial Technology (CDTI), Government of Spain. Focus of the cooperation is to promote and fund market driven research and technology development besides encouraging partnerships and business led R&D and Innovative collaborative projects in the field of biotechnology. The POC for technological cooperation was signed on 22nd November, 2011 and extended up to 21st November, 2020. Under this cooperation the 6th call is underway with broad thematic area of biotechnology including health, industrial technology, nano-biotechnology, agriculture, biofules, bioenergy, bioinformatics and biomedical engineering.

Switzerland: The department has ongoing bilateral partnership with Swiss National Science Foundation (SNSF), Switzerland for promoting science and technology in areas of strategic relevance to India and Switzerland. In pursuance of this during 2019-20 the department has implemented five joint proposals under Blue Sky Research/ Basic Research in life sciences with Swiss National Science Foundation (SNSF).

Sweden: DBT and VINNOVA worked on strengthening their bilateral cooperation in the emerging areas of biotechnology. The focus during the year has been on "Digital Healthcare". A joint workshop was organized on 12th April in New Delhi. About 55 participants from academia, industry, medical institutions and government attended the workshop and various models for implementing AI solutions for addressing healthcare needs were deliberated. This is expected to scale up collaboration across academia and start-ups in Digital Healthcare across both the countries. Based on the deliberations a Joint call was drafted and pre-announced during the India-Sweden High-Level Dialogue on Innovation Policy.

The 6th meeting of the India-Sweden Joint Committee on Science &Technology was held on 3 May, 2019 in Stockholm, Sweden. Department of Biotechnology participated and charted the road map for joint industrial R&D, start-up innovation collaboration, research and innovation infrastructure and test beds. Following this, incubatees from India visited Swedish incubators and start-ups to enhance their network and collaboration. The Swedish incubatees delegation visit is expected to India in the coming year.

India-Sweden Joint Committee on Science & Technology

United Kingdom (UK): DBT partners with Department for International Development (DFID); INNOVATE; British Council; UK Research and Innovation (UKRI); and British Council (BC). It also actively collaborates with Biotechnology and Biological Sciences Research Council (BBSRC), Medical Research Council (MRC), Natural Environment Research Council (NERC), Economic and Social Research Council (ESRC) through Research Councils U.K. (RCUK) in all major areas of Biotechnology.

Considering the increasing health threat due to evolution of Antimicrobial Resistance (AMR) in various pathogens, department partnered with UKRI to address the challenge of antimicrobial resistance in India. One of the funded projects is trying to develop platform technologies for diagnosis of urinary tract infections, mastitis, and detection of -lactum group in milk/aquaculture. A study looking at how AMR in livestock contributes to AMR in people of North East India using an interdisciplinary study investigating antibiotic use, drivers of AMR, and transmission dynamics is also been funded. Other supported projects also focus on AMR in Indian poultry, and Smart regulation of antibiotic use in India.

In another call the department jointly with UK Research and Innovation (UKRI) launched a joint collaborative research call on "AMR the Environment from Antimicrobial Manufacturing Waste". The objective is to understand evolution of AMR due to environmental pollution with antimicrobial compounds, develop techniques for detection and study its impact on health.

The Department also launched Phase II of the Global Research Programme (GRP), addressing the health needs of women and children in the most disadvantaged populations globally in partnership with DFID-ESRC-MRC, UK. A total of three projects have been funded focussing at reduction of adverse pregnancy outcomes, gestational diabetes and maternal vitamin B12 supplementation.

United States of America: The Department has been implementing collaborative programmes with the National Institute of Health (NIH), since inception. Major programmes being supported include (i) Indo-US Vaccine Action Programme (VAP) and (ii) Indo-US collaboration on Vision Research, implemented through collaboration with the National Institute of Allergy and Infectious Disease (NIAID) and the National Eye Institute (NEI), of the NIH, respectively.

(i) Indo–US Vaccine Action Programme (VAP): The Indo-US Vaccine Action Programme is a bilateral programme between Department of Biotechnology (DBT), Government of India and National Institute of Allergy and Infectious Diseases (NIAID), National Institutes of Health (NIH), USA, which supports a broad spectrum of activities relating to new and improved vaccines, for diseases of relevance to India. The programme is under implementation since 1987, based on the bilateral signing of a Letter of Intent (LoI) establishing the VAP. The VAP is recognized internationally and considered as a model bilateral programme in biomedical research.

Priority areas under VAP include supporting candidate vaccine development for rotavirus diarrhea, acute respiratory infections, tuberculosis, malaria and dengue. Under the VAP, focussed efforts are directed at providing continued support for major initiatives on: (i)Tuberculosis (TB) Research through the Regional Prospective Observational Research For Tuberculosis - RePORT India Initiative (ii) Human Immunology-research in the context of infectious diseases in collaboration with HIPC (Human Immunology Project Consortium) (iii) strengthening research on Adjuvant Development in India (iv) implementation of activities for strengthening research bioethics capacity in India. The 31st Joint Working Group (JWG) Meeting of VAP was held on November 15-16, 2019, in New Delhi. The progress of the various ongoing initiatives under VAP was reviewed during the Meeting.

(ii) Indo-US collaboration on Vision Research: The Department has signed a Statement of Intent under Indo-US collaboration on Expansion of Vision Research with the Department of Health & Human Services, Government of the United States of America, with the objective of translating research outcomes to develop potential interventions to reduce eye disease burden in India and the USA. The joint statement was initially signed on 24th August, 2005. The programme has been extended further for a period of five years i.e. from April 2017 to March 2022.

The mandate of this collaboration is to strengthen research focusing on ophthalmic disorders, diabetic retinopathy, genetics of ophthalmic diseases and ocular inflammation. The recent funding opportunity announcement to solicit joint proposals under this programme was issued in September 2019.

Partnership

Bill & Melinda Gates Foundation (BMGF): DBT in collaboration with Bill & Melinda Gates Foundation (BMGF) is supporting basic & applied research focussing on capacity building in mutually identified areas like maternal & child health, agriculture, nutrition, Artificial Intelligence (AI) data and medical devices & technologies based on Global Grand Challenges Model under the flagship program of Grand Challenges India (GCI) that aims to help innovators from both academia and industry to expand the pipeline of ideas for developing new preventive and curative therapies, piloting new technologies, and exploring new ideas. Over the years, GCI has grown both as an idea and as a partnership covering varied themes from maternal and child health to agriculture, nutrition, infectious diseases, vaccines, AMR, health system strengthening, big data, etc. to respond to the ever-changing needs of research in public health in India. Till now, GCI supported six open calls and nine specialized programs in the sectors mentioned above.

Cancer Research UK (CRUK): DBT and CRUK has partnered to launch a £ 10 million, 5 year research initiative focussed on finding affordable approaches to cancer. This research initiative aims to stimulate a focussed bilateral, multidisciplinary research effort to address important challenges in affordability in cancer prevention, diagnosis & treatment and drive collaboration between the two countries. By bringing together the complimentary research expertise

of India and UK scientists, the initiative will accelerate progress in research with a potential to make significant progress against cancer consequences and impact cancer research outcomes. A tripartite agreement between DBT, CRUK and DBT/Wellcome Trust India Alliance has been signed to set out the terms and conditions by which the India Alliance will undertake grant funding activities for the second and the third phase of India-UK Cancer Research Initiative.

DBT and CRUK bilateral research initiative for affordable approaches to cancer will be implemented in three phases; Phase I: Identifying Core Challenges; Phase II: Establishing New Research Partnerships, and Phase III: Program Awards. The Bilateral Initiative has successfully completed phase I with identification of seven thematic areas/core challenges - (1) Prevention, (2) Early Detection, (3) Early Diagnosis, (4) Computational Approaches, (5) Small Molecule Treatment, (6) Affordable Treatment, and (7) Children and Youth cancer prevalence.

Phase II: A joint call inviting seed grant applications for establishing new research partnerships between India and UK was launched on Sept. 2nd 2019 and the window to submit seed grant applications was open up to Nov. 4th 2019. A total of 106 applications were received against the grant call that subsequently went through eligibility checks and remits.

Second Meeting of the DBT CRUK Advisory Panel held on 20th & 21st January 2020 in Mumbai.

Multilateral Program

Advances in science and technology plays an important role in making significant improvements in people's lives. Strategically applied, S&T programs provides an important and powerful means to reach the society at large and advances the frontiers of knowledge for the benefit of all. In order to leverage foreign alliance and partnerships to maximize and fasten development in key priorities areas of national interest the Department is actively pursuing and negotiations are underway for developing partnership in every region of the world from Asia, Africa, Europe, Latin America etc through various multilateral platforms such as SAARC, BRICS, BIMSTEC G-20, ASEAN etc.

DBT-EUREKA: EUREKA is an intergovernmental organization for publically funded market driven industrial R&D involving 44 countries. The department under the initiative of 'Global Stars Initiative in Field of One Health' had announced the 1st joint collaborative call with the EUREKA. Under this initiative three joint proposals were implemented with UK, Netherlands and Spain during 2019.

DBT-TaSE: The Department of Biotechnology under the TaSE (Towards Sustainable Earth) initiative which is a multilateral collaboration between The Natural Environment, Economic and Social, Arts and Humanities Research Council of UK Research and Innovation; Japan Science and Technology Agency; National Natural Science Foundation, China and The Swedish Research Council for Sustainable Development had announced a call for proposals for 'Human-Environment Interactions and the Sustainable Development Goals' under which six proposals have been jointly implemented.

06

SPECIAL PROGRAMMES Program for societal relevance – Rural,SC/ST Population and women

Program for Societal Relevance-Biotechnology Based Programmes for Societal Development

The Department has been supporting projects for promotion of use of biotechnological processes and tools for the benefit of the society comprising rural, SC/ST and women community. The programme aims to create platform for self-employment generation among the target population by diffusion of proven and field-tested technologies through demonstration, training and extension activities. The broad focused areas supported under this programme includes agriculture and animal husbandry including fish farming, poultry farming, pig production, goat farming, value added products, floriculture, hybrid seed production, integrated farming system, entrepreneurship development, bio-resource utilization, women and child health, hygiene and nutrition. More than 12,000 rural, SC/ST and women population including youth have been benefited through the implementation of these projects.

Programmes under the Scheme:

- Aspirational Districts Programme (Rural Bioresource Complex Innovation Hubs)
- Programme for Rural Development
- Programme for SC/ST Population
- Programme for Women

Major Initiatives during the year:

During 2018-19, the Department had implemented 09 proposals to address pertinent issues related to health and nutrition, agriculture & allied areas using biotechnological tools, techniques and processes in 11 aspirational districts in 7 states of India, namely, Assam, Manipur, West Bengal, Jharkhand, Odisha, Meghalaya and Punjab.

Under the second phase (2019-2020) of the aspirational district programme, a call had been given inviting concept notes from various institutions for transforming aspirational districts in Kerala, Karnataka, Maharashtra, Telangana, Andhra Pradesh and Tamil Nadu. After screening the proposals received, 8 were recommended for support by the Steering Committee.

- Project entitled "Plant Tissue Culture Hardening Based Skill and Entrepreneurship Development training cum demonstration programme in rural areas of Washim and aspirational districts of Vidarbha region" submitted by Dr. Darasing Ramsing Rathod, Dept. of Agricultural Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Krishi Nagar, Akola Maharashtra. The project will be implemented in Aspirational districts of Vidarbha region, Maharashtra. The project involves pre-hardening and hardening activities of plant tissue culture in various pockets where banana/other crops are cultivated. Additionally, counselling and project consultancy services related to agri-business incubation on the basis of primary and secondary hardening start up program and encouraging farmers for adoption of Hi-Tech agriculture, plant tissue cultures, off-season seedling production are the other objectives.
- Project entitled "Empowering rural population through bio-inoculants and bio energy technologies in the Aspirational district (Virudhunagar) of Tamil Nadu" submitted by Dr. R. Thamizh Vendan, Professor, Dept. of Agriculture Microbiology, Agricultural College, Tamil Nadu Agricultural University, Madurai Tamil Nadu. The project will be implemented in Virudhnagar district of Tamil Nadu. The project involves on-farm demonstrations for utilizing agricultural wastes for biocomposting technologies and demonstrations of the production of bioenergy resources (biochar) from unwanted plant materials and develop bio-resource group and society.

Programme for SC/ST Population

Highlights of few major projects being supported are presented below:

Dissemination and demonstration of pheromone/ dispenser technology for the area wide management of codling moth in Ladakh, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar

This project aims to provide awareness for the management of codling moth by using pheromone baited traps and Pheromone dispensers, burlapping for targeting the overwintering populations. Severe damage caused by this pest has attracted the attention of both the governments and the researchers due to heavy economic losses witnessed during the last few years.

This year 04 training programmes were conducted at Nurla, Bazgo, Hardas and Phang regions of Ladakh. Additionally, demonstrations on 'Pheromone dispenser technology' was done at Phang, Nurla, Saspool, Bazgo, Shilichey, Goma, Mangbore and few orchardists in Khalsi, Trespone Villages. More than 100 beneficiaries have been trained and also made aware about the importance of the management of codling moth in Ladakh.

Hands on training programme in fruits and vegetables preservation and its marketing by SC/ ST and weaker section farm women of Varanasi and Mirzapur Districts, Banaras Hindu University, Varanasi

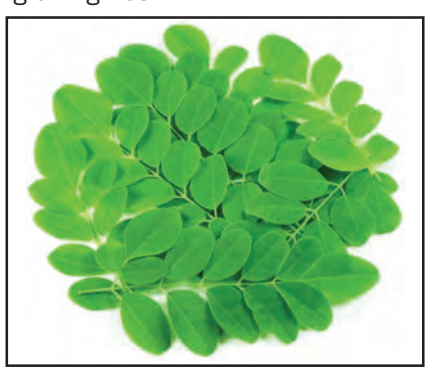
This project is being funded to support training programmes in preservation of fruits and vegetables and its marketing by SC/ST and weaker section including farm women of Varanasi and Mirzapur Districts. Under this project, 15 days-training programmes were organized to educate women about harvesting, storage, preservation and marketing methods. 100 beneficiaries were trained in two villages. Thereafter, selected beneficiaries in both villages trained in scientific cultivation of vegetables, preservation and packaging by different methods was taken up. They were also educated about nutritional knowledge and benefits of vegetables. Kitchen garden in every household was also developed.

Sustainable Livelihood promotion through Integrated Farming System (IFS) in Schedule Tribal (ST) dominated areas of Central Brahmaputra Valley, Assam, Assam Agricultural University, College of Fisheries, Nagaon, Assam

This project aims to promote sustainable livelihood through Integrated Farming System (IFS) in ST dominated areas of Central Brahmaputra Valley, Assam. A baseline survey was conducted and five villages per district were identified to implement the project. Under each district two clusters have been formed comprising of 25 farming families per cluster. Based on resources in the farming family and experience, from each district, 50 farming families were identified for each IFS module i.e. Fish cum Pig farming (50 farming families) and fish-poultry farming (50 farming families). SHG (Self-Help Group) has been formed at cluster level. Four awareness and training programmes were conducted at cluster level in both the districts and 100 farming families have been trained on scientific fish farming and Integrated Fish Farming system. Additionally, a handbook on Fish Farming in Vernacular Language has been published.

Poverty alleviation through popularization of locally available medicinal-dietary plants for the prevention of malnutrition among the SC/ST children and women, National Botanical Research Institute, Lucknow

This project is being implemented to promote the importance of dietary medicinal plants in human nutrition and their cultivation. Four training & demonstration/ awareness programmes in Lucknow and Barabanki districts of Uttar Pradesh were conducted in which 350 beneficiaries were trained. Two nutraceutical products namely, *Moringa oleifera* leaf powder capsule and herbs-fortified chocolates have been developed which can be helpful to prevent malnutrition problem in growing kids.



Leaves of Moringa oleifera *commonly also known as moringa, drumstick tree, horseradish tree, and ben oil tree or benzolive tree*

Programme for Rural Development

Highlights of few major projects being supported are presented below:

Amelioration of infertility in dairy cows through nutritional and biotechnological interventions, National Dairy Research Institute, (NDRI Deemed University), Karnal, Haryana

The project is focused on amelioration of infertility in dairy cows through nutritional and biotechnological interventions. A major achievement of this project is the development and launching of a portal https://www.livestockfarm.org/ for digital transmission of information on dairy farming such as breeds of cow, selection of dairy cow, housing, feeding, reproduction and health management, which will help farmers to access the information on dairy cow rearing at any time through online.

Additionally, 17 veterinary health and infertility camps were organized this year in the Dairy Vikas Kendra in Nadia District of West Bengal in which 1308 farmers had brought 1930 animals and based on the health and productive status of the animals, they were treated with deworming, vaccination and supplementation on mineral mixture. Reproductive health status was assessed based on breeding history, gynaeco-clinical examination, rectal examination of reproductive organs, and nature of reproductive secretions etc. 325 infertile cows were treated through non-hormonal approach and inseminated. 75 cows suffering with repeat breeding and anestrus conditions were treated with progesterone based controlled internal drug release device and inseminated.

A training programme of 32 days duration on "Artificial Insemination and Veterinary First Aid" was organized and 14 numbers of participants attended. The trained youths could serve as Artificial Insemination (AI) worker in the nearby villages and generate self employment.

Setting up of Rural Biotech Innovation and Application Centre (RBIAC) in Kandi Area of Punjab, Punjab State Council For Science & Technology, Sector-26, Chandigarh

This DBT-supported project aims to set up of Rural Biotech Innovation and Application Centre (RBIAC) in Kandi Area of Punjab. An RBIAC has been set up in Talwara block of District Hoshiarpur, Punjab focusing on generating sustainable livelihood in the area by promoting three innovative S&T interventions. In this sub-mountainous region, cultivation of bamboo has been identified to prevent soil erosion on one hand, while value addition through bio-technological interventions can also provide avenues for livelihood generation among local population.

Mother nursery of *Bambosa tulda* has been established and 57 farmers were supported by providing about 7600 saplings as well as organizing exposure visit of adopted farmers.

Since sugarcane is one of the important crops in the area besides wheat and maize, efforts are being undertaken to promote scientific and chemical free jaggery production. Similar studies are also being carried out for Hill lemon (*Citrus pseudolimon*) at Center of Innovative and Applied Bioprocessing (CIAB), Mohali to optimize and characterize the extraction of pectin, essential oils & calcium citrate from its pomace, peel & juice respectively.

v **Promotion of integrated farming with introduction of organic farming concept and mushroom cultivation and its value addition in North Bengal through establishment of rural Bio-resource Hubs with biotechnological applications, Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal**

This project was implemented to promote the practice of integrated farming with introduction of organic farming concept and mushroom cultivation and its value addition in North Bengal through establishment of rural Bio-resource Hubs with biotechnological applications. Extensive training programs were undertaken in six districts of North Bengal (Darjeeling, Jalpaiguri, Alipurduar, Dakshin Dinajpur, Coochbehar and Malda) involving farmers, rural women, unemployed youth and school children in all four identified components. 2616 farm families have been trained in the project. Several commercial units of mushroom, value added vermicompost and aquaculture have been developed.

One of the important outcomes of this project was recognition of the whole program by the Government of West Bengal, which allowed inclusion of surplus mushroom produced by growers in the mid day meals of schools.

Additionally, 45 women Self Help Groups/ farmer Producer Organizations have adopted the cultivation techniques of Koi fish in plastic (tarpaulin) tank.

Programme for Women

Highlights of few major projects being supported are presented below:

Gujjar and Bakarwal Women Empowerment through Improved Managerial Practices in Livestock Rearing and Awareness in Aspects of Personal Health, Hygiene and Sanitation, Sher-E-Kashmir University of Agricultural Sciences & Technology of Jammu, Main Campus Chatha, Jammu

DBT funded project on Gujjar and Bakarwal women empowerment through improved managerial practices in livestock rearing and awareness in aspects of personal health, hygiene and sanitation was implemented during this year. Various clinical veterinary camps, medical camps, awareness programme on personal health, hygiene and animal husbandry trainings were organized where medicines for human beings as well as veterinary needs were distributed. Besides, free first-aid veterinary kits were also provided to the migratory Bakarwals.

Malnutrition was found to be the major cause for poor growth and reproduction in animals. Goat and sheep pox, ecto and endoparasitic infestations, mastitis were found to be very common in the animals. Haemoglobin levels were found significantly increased in kids and calcium and haemoglobin levels increased significantly in adolescent girls post supplementation during these medical camps.

Enhancement of livelihood security based on locally available resources for Disabled women, Tamil Nadu Agriculture University, Madurai, Tamil Nadu

This project aims to enhance livelihood security based on locally available resources for disabled women. 145 disabled women were selected for enhancement of livelihood security based on locally available resources. 330 beneficiaries were trained in dry flower processing, fresh flower bouquet making and banana fibre extraction.

DBT-DFG (German Research Foundation – DFG) joint international collaboration: Under DBT-DFG joint international collaboration, investigators from University of Agriculture Sciences, Bangalore are engaged in the network project with University of Kassel, Germany for studying the transition in the Rural-Urban Interface of Bangalore in the Space of agriculture, economics and Society. This network project is spanned under three themes as Cluster A: Intensification and Efficiency of Resource Use; Cluster B: Ecology, Economy and Services and Cluster C: Patterns of Land Use, Social Fabric and Consumption with amalgamation as well as use of interdisciplinary approaches. In one of the sub-project under this network project investigators have collected more than 1000 of bees belonging to more than 20 different species from farms and surroundings across a gradient of urbanization. More than 100 species of plants were identified, along with data on flowering at each site. About 1000 bees were observed in the visitation study that was carried out to understand the relationship between bees sampled in the surroundings and the flow of pollination services into cropland. The study shows that urban areas support a high diversity of bee species compared to rural areas that have greater abundance but lower species richness.

Artificial Insemination in pig for socio-economic upliftment of the rural poor in Goa was implemented at ICAR Research Complex, Goa. More than 100 pig farmers were benefitted through implementation of artificial insemination technology.

Prasad Kit Programme at Vaishno Devi Temple.

Carp seed production in FRP hatchery and development of integrated rearing system for livelihood development of SC/ST communities in Khordha District of Odisha implemented at ICAR-CIFA, Bhubaneswar.

Biofarming of anthurium (Anthurium andreanum) and gerbera (Gerbera jamesonii) was promoted for adoption of farmers in Terai-Dooars region of West Bengal.

Mission programme of Bbiotech-Krishi innovation science application network (BIOTECH-KISAN)

The Mission Programme on Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) has made significant progress during the year by expanding its activities in 92 Aspirational Districts. The efforts have been continued in establishing Biotech-KISAN Hub in each of 15 agro-climatic zones of the country under the leadership of a champion, who will act as the Facilitator. Each Hub will create a network by developing strong linkages with top quality scientific institutions / State Agricultural Universities (SAUs) / Krishi Vigyan Kendras (KVKs) / existing state agriculture extension services / system and other Farmers' organizations in the region as well as linkages with leading international institutions / organizations. Biotech-KISAN Hub will also have a tinkering laboratory. The significant progress made during the year is summarized below:

At Himalayan Environmental Studies and Conservation Organization (HESCO), Dehradun, a total of 1405 farmers have been directly and 2788 famers indirectly connected and benefited from the Hub. The Hub has provided all possible services to farmer's community and also helped to improve their local ecology and economy. Improved agriculture, horticulture practices, sustainable use of bio-resource and soil and water conservations are major initiatives of the project. In order to promote local farmers, first time a science-based leadership has been created within farming community. Within two years period, a total of 10 biotech farmer leaders have been identified, who in turn are connected and providing mentorship to 210 farmers. For the promotion of farm produce and value-added products, 3 Biokiosks in different locations have been established. These Biokiosk helps farmers from seed to farm services on one hand and mastering farm management to market. More than 3000 farmers have been benefited through such Kiosks. The activities have now been expanded in two Aspirational Districts – Haridwar and Udham Singh Nagar of Uttrakhand.

At Bihar Agricultural University, Sabour, two low ODAP (â-oxalyl-L-á, â-diaminopropionic acid) containing varieties of grass pea (*Lathyrus sativus* L.) i.e. Ratan and Prateek is popularising among the farmers through the partner institutions (Krishi Vigyan Kendras, Barh, Patna, KVK, Lakhisarai and KVK, Manpur, Gaya). A total of 210 acres farmers field is under demonstration on Grass pea cultivation with the supervision of partner institutions, KVK, Barh, Patna; KVK, Lakhisarai and KVK, Manpur, Gaya. Six training programmes were organized and 120 farmers were trained on cultivation of grass pea varieties Ratan and Prateek. One technical Film is produced to popularise grass pea/lathyrus cultivation among farmers. Printed Extension literature on Grass pea cultivation was prepared and distributed among the farmers. Improved Variety of Makhana (Sabour Makhana-I) seed is distributed among the farmers of Araria, Katihar and Purnea though the concern Krishi Vigyan Kendras. A total of 75 hectares (25 hectares from each KVK) farmers field is targeted for demonstration (FLD). A Workshop-cum-Training Programme was successfully organized on "Makhana Production Technology" for the thirty farmers of Purnea. he activities of the Hub have now been expanded in six apsirational districts of Bihar (Purnia, Katihar, Khagaria, Banka, Araria and Aurangabad).

A total of 819 women farmer have been trained with modern know-how of scientific sheep and goat rearing at West Bengal University of Animal and Fishery Sciences, Kolkata. A book on sheep and goat rearing, mineral mixture, vaccine, medicine etc. has been distributed amount he beneficiaries. Establishment of elite germ plasm centre at Mohanpur has been started with 380 Garole sheep and 450 Black Bengal Goat from the farmers of Sunderban. A mobile App (MUUK) has been developed to provide the solution related to animal husbandry. 400 quality garole gheep and Black Bengal goat kid have been distributed among the 200 women farmers of Sunderban along with goat and sheep feed and preventive care. An international research paper on Socio-Economic Status of the Sheep and Goat Farmers in Sundarban, West Bengal has been brought out. The activities have now been expanded in five Aspirational Districts (Nadia, Murshidabad, Birbhum, Maldah and Dakshin Dinajpur) of West Bengal.

At Foundation for Agricultural Resources Management and Environmental Remediation (FARMER), Ghaziabad, use of improved variety and quality seed and planting material contributed in enhancing crop yield by 16.88%. Organically grown agriculture produce have higher preference among consumers and fetched higher price up to 30-32%, thereby increasing farmers' income. Use of modern agriculture

machinery and waste decomposer for in-situ crop residue management has contributed batter conservation of agriculture and in increasing crop yield by 5 to 10 %. Increased space (line to line) coupled with intercropping in sugarcane crop contributed in sustaining sugarcane yield at par with lesser space crop and in fetching additional income of ₹ 75,000 to 1,50,000 per acre. Growing breeder potato seeds in insect proof net house by farmers could ensure disease free production of breeder potato seeds. Thus, farmers' income will be increased and will also ensure availability of disease-free seed. An analysis of cost benefit ratio by dissemination of technology showed that cost benefit ratio in the form of net income from the fields of FLDs was higher (7.54 to 30.47) than control plot. Trainings to 150 farmers in application and production of organic inputs, seed production, organic farming and sugarcane cultivation were imparted in IARI, New Delhi and Sugarcane Breeding Institute and Regional Centre, Karnal. Fellowship to five selected farmers belonging to Ghaziabad and Gautam Budh Nagar districts was awarded.

Video Conference Units have been developed in all the Sub-Hubs at Acharya N.G. Ranga Agricultural University, Lam, Guntur to have regular contact with the scientists and focused farmers directly for quick timely and easy transfer of information. Knowledge on Wheels for all the Sub-Hubs has been developed. Value-addition units have been developed in all the Sub-Hubs viz., mini pulse processing units in Srikakulum and Visakhapatnam districts and cold pressed oil extraction units in Ananthapur and Kurnool districts. A portal, and mobile app have been developed. About 3936 farmers were registered in the portal and the events and its outcome are being maintained in the portal and the information is being added to the portal through app directly by farmers, scientists and manpower engaged in project. Text messages and voice messages are being delivered directly to more than 2000 farmers of different districts of the Andhra Pradesh state. 45 Trainings, 33 farmer-scientist interaction meetings, 510 field visits, 120 method demonstrations, 22 field days, 13 workshops, 12 exposure visits and 16 DBT project team visits were conducted and around 10,000 farmers were benefitted during 2018-19. Eighty demonstrations in rice fallow urdbean, 16 demonstrations in rajmash, 17 demonstrations in rice fallow moongbean, 20 demonstrations in redgram, 57 demonstrations in groundnut and 50 demonstrations in chickpea were conducted during 2018-19. 500 copies each of production technologies in pulses (Urdbean, Moongbean, Pigeonpea and chickpea) and Groundnut and 300 copies of farmer's diaries were printed and distributed. The activities are being expanded with a target to reach 66 per cent more beneficiaries in existing districts and selection of 60 farmers in three Aspirational Districts (Kadapa, Vizainagaram and Visakhapatnam) of Andhra Pradesh.

The selection of the elite planting material and multiplication by macro propagation technology in specially designed humidity chambers and hardening facility was undertaken at Assam Agricultural University, Jorhat and Institute of Horticulture Technology (IHT), Mandira, Assam. 69,930 clean and true-to-type elite market preferred banana Cv. Malbhog plants have been produced through macro-propagation and given to farmers. Two-acre area established under an elite population of Banana Cv. Malbhog for demonstration and propagation. The ultimate aim is to develop a hub for the quality planting material for Malbhog Banana in Mandira, Assam and provide quality planting material for banana cultivar in the State.

At Indian Society of Agribusiness Professionals (ISAP), New Delhi, a total of 366 demonstrations have been laid out, out of which 108 were set up (98 by KVK, Bidar, 130 by KVK, Gulbarga and 30 were set up by RARS, Palem). Total 320 were set up in Kharif season and 35 demos in Rabi season. ISAP has set up a Horticulture Research and Resource Centre at Anthapnal, where demos were laid out for Hybrid Seed Production of Vegetables. In Kharif season, demos were set up for red gram, hybrid okra, watermelon, tur, onion, cotton, capsicum and sugarcane. In Rabi season, demos were set up for jowar and chickpea. 12 Demos were set up on IFS, wherein farmers were encouraged to practice allied activities along with conventional farming. There were demonstrations on high value crop i.e., papaya of variety Taiwan-786 in 2 project farmer's area. Five farmers were provided with drip irrigation system. Three farmers were provided support for goatry. Some farmers were provided saplings of curry leaves, drumsticks etc. Goat Resource Centre has been set up under the program. 29 goats of breeds Barberi, Jamnpuri, Shirohi and Osmanbadi have been procured at GRC. Kid goats of these breeds have been provided to farmers in that region.

This will help in running GRC sustainably. The activities are being expanded to two Aspirational Districts (Yadgir and Raichur) of Karnataka.

Two villages, Buxikhera block Hasanganj and Arerkalan block Miyaganj of Unnao district were selected for beekeeping training at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. They were demonstrated bee-keeping unit at KVK, Unnao. Farmers of two villages, Buxikheda and Munshikheda were selected for training and two training programmes were organised for goat rearing. Farm women were selected from Dhaura and Maljha villages of Hasanganj block for providing training in mango processing and entrepreneurship development.

At Tamil Nadu Agricultural University, Coimbatore, low cost hydroponic demonstration unit, silage making facility, moisture meter, nutritional forage cafeteria and power backup facility for uninterrupted power supply to the demonstration units were developed. Six scientists from the partnering institutes were selected and trained on improved fodder varieties and its cultivation and preservation. Seed/planting materials of improved fodder crops viz., Fodder Sorghum CO (FS) 29, Fodder Maize (African Tall), *Stylosanthus*, *Desmanthus* (CO 2), Lucerne (CO 2), Fodder Cowpea (CO 9), Cumbu Napier (CO (BN) 5), Guinea grass (CO (GG) 3) and *Cenchrus* (CO 1) were distributed to partnering institutes towards the establishment of nutritional fodder cafeteria. Five days training programme were organized on 'Improved fodder varieties and production technologies' to identified beneficiaries. The seed / planting materials of improved fodder crops were distributed to the beneficiaries from selected districts towards the establishment of nutritional fodder cafeteria. The activities are being expanded in two Aspirational Districts (Virudhunagar and Ramanathapuram) of Tamil Nadu.

Biotech-KISAN hub was established to demonstrate and disseminate production of safe food in Basmati rice-wheat-summer moong cropping system in three farm clusters of 20 ha each in districts of Patiala, Sangrur and Ferozepur at Punjab Agriculture University, Ludhiana. The real success of the project will be success in the marketing of 'No-pesticide use' or 'safe produce' of the project. Farm diaries on Good Agricultural Practices in Summer moong, Basmati rice and wheat have been published and supplied to the farmers. Project farmers were able to grow basmati rice after summer moong incorporation without or less use of chemical fertilizers. They were convinced for the same by demonstrating use of Leaf Colour Chart (LCC). All the farmers were convinced to produce pesticide free basmati rice and success was achieved by supplying and demonstrating use of bio-fungicide, *Trichoderma* and bioagents, *Tricho*-cards. Basmati exporters/ purchasing agencies were approached for marketing of the pesticide free produce. One exporter also took the basmati samples from farmer fields for residue testing and the efforts will be continued for the same during next crop season. Efforts are being made to produce 'no-pesticide use' or 'pesticide residue free wheat' and develop localized PAU-certification system for facilitating the marketing. The activities are being expanded in two Aspirational Districts (Moga, Ferozepur) of Punjab and one Aspirational Districts (Chamba) of Himachal Pradesh.

At ICAR-Research Complex for Eastern Region, Patna, Bihar, the activities have been initiated in three villages of Ranchi district (Sarwal, Koiribeda and Hahap villages of Khijri Block) and one village of Ramgarh district (Govindpur village of Mandu block) along with KVK, Ranchi and KVK Hazaribagh. For technology demonstration on Endo and Ecto parasite control and location-specific mineral mixture supplementation in animals, two animal health camps were organized in which a total of 246 animals were treated for control of endo- and ecto-parasite. Location-specific mineral mixture was provided to 110 farmers. For technology demonstration on round the year cultivation of mushroom, three training programmes of one day duration were conducted in which 100 farm women were provided training on mushroom cultivation. Technology demonstration on oyster mushroom cultivation has been done in five farmers' fields. For demonstration and implementation of IFS model and piggery unit, two 5-days training programme was conducted at KVK, Ramgarh (30 farmers) and KVK Hazaribagh (25 farmers), respectively. For improving the income from vegetable cultivation, technology demonstration on improved varieties of vegetables viz. cabbage, cauliflower, bitter gourd, French bean, onion, tomato, brinjal, amaranthus, potato has been demonstrated in 160 farmers' fields covering a total area of 2.42 ha. For effective management of rice fallow, technology demonstration on wheat and chick pea cultivation has been done in 50 farmers' fields. The activities

are being expanded in Aspirational Districts of Jharkhand (Bokaro, Khunti, Ramgarh, East Singhbhum) and Bihar (Jamui, Nawada and Sheikhpura).

At ICAR-National Bureau of Agriculturally Important Microorganisms (NBIAM), Kushmaur, Mau, ingredient-based Rapid Composting Technology was standardized at mass scale (to the tune of one ton of agrowaste per cycle). A 5-day farmer training was organized from 14.11.2019 to 18.11.2019 in which 28 farmers from different background were trained on "microbial inoculant application technology", "rapid agro-wastes bioconversion (rapid composting and compost fortification)", "soil health management using microbial inoculants and fortified compost products" and "potential benefits of application of microbial inoculants and beneficial microbial species in vegetable and flower commercial crops, plant nurseries and field crops". They were encouraged to apply the rapid composting technology for their source of income generation through enterprising of microbial inoculants and composting products. Rapid composting units of 5 bioconversion units at each farmer's fields were established in 10 villages of Mau districts. The capacity of each of the bioconversion unit (5 beds at every farmer field) is 0.8 to 1.0 tons per cycle of compost production within 60 days. During establishment, 10-20 farmers have been trained on the rapid composting technology and the technical support is provided to them from the institute as and when required. The activities are being expanded in two Aspirational Districts (Balrampur and Sravasti) of Uttar Pradesh.

Biotech KISAN Hub established at Krishi Vigyan Kendra, Durgapur, (Badnera) Amravati focused on integrated pest and disease management in cotton with major emphasis on conservation of agriculture. This hub disseminated the technologies for integrated pest management to adjacent 36 villages of Hingoli, Akola and Amravati district. 150 demonstration have been laid out with innovative package and practices with major emphasis on intervention of IPM in cotton. The intervention of IPM in cotton on one hand facilitate for control of pest in cotton and on the other hand precautionary (preventive) measures for overcome on the incidence of pest and diseases in kharif crop. The techniques viz pheromone traps, yellow sticky traps, trichocards have saved the money of farmers and due to this intervention and innovative package and practices adopted by farmers they have obtained average yield 10 quintal/acre as compare to other farmers yield which is having around 7 quintal/acre. Looking to the success of technology more than 800 farmers of adjoining villages also adopted this innovative technology in cotton which saves the expenses on plant protection measures. Demonstration was safeguard due to intervention of yellow sticky trap that minimised the damage of sucking pest. Finally, farmers secured good yield and the technology adopted was widely appreciated. The activities are being expanded in two Aspirational Districts (Gadchiroli and Washim) of Maharashtra.

At ICAR-Indian Agricultural Research Institute, New Delhi, a total of 210 farmers participated on the occasion and seeds/inputs were provided to the farmers for laying out on-farm demonstrations (Anandpur: 25 male + 15 female; Kandhawniyan: 32 male + 19 female; Kalla: 26 male + 30 female; Bhabhai: 22 male + 8 female: 8; Semariya: 19 male + 9 female). Bench mark survey of five selected villages viz., Anandpur, Kandhawniyan, Kalla, Bhabai and Semariya Jagannathbasi was done during 11-14 October 2019. In each village, 100 farmers were selected for bench mark survey. This survey was done with the help of IARI and KVK Chitrakoot. On-farm demonstrations on mustard, lentil, chickpea and vegetables (Vegetable pea, tomato, onion, carrot, palak) were organized involving 524 farmers. Nutritional kitchen garden was also established with 187 farm households. Total 13 training programmes (on campus 8, off campus 5) were organized at KVK, Chitrakoot. Total 526 farmers were trained on sowing techniques and input distribution, value-addition of Anola, cultivation techniques of vegetable pea and input distribution, impact of Azotobactor in wheat crop and their distribution, and promotion of the different method of organic manure production.

The Biotech-KISAN Hub at Sher-E-Kashmir University of Agricultural Sciences and Technology, Srinagar selected 23 farmers for rejuvenation of apple orchards. Many innovative approaches were used to rejuvenate the orchards with new and exotic varieties. The plants are expected to yield after a period of two years which in comparison to traditional orchards will be early by at least 6 years. The Hub has established model high density orchards in five apple growing districts of Jammu and Kashmir by using cluster approach.

Total number of growers covered under scheme is 09 and one orchard has been established on KVK. The orchards shall act as farm science schools for training to farmers of the concerned regions. The varieties used are all exotic high yielding spur bearers. Normally a traditional orchard bears after 08 years while these orchards will bear fruits only after 1st year. The high-density orchards established by the hub are on the pattern of developing the farmers as entrepreneurs which is very different from using traditional approach of subsistence or commercial farming. Practical trainings were held on farmers field and regular trainings were provided to the farmers. Kisan gosthies and group discussion were held in almost all the districts of Kashmir including union territory of Ladakh. 2000 farmers trained at different places at different levels under biotech KISAN Hub SKUAST-K and its partnering centers including 145 female farmers during year 2019. The activities have been expanded in Baramulla and Kupwara Aspirational Districts.

Pigs are reared in a hygienic condition under constant supervision by KISAN Hub at ICAR Research Complex for NEH Region, Umiam, Meghalaya. A total of 144 piglets along with 48 packets of Pig feed (50kg/Packet) were distributed to 72 piglet beneficiaries of eight villages. A total of 141 piglets were vaccinated against Classical Swine Fever Low cost pig house has been successfully constructed in four villages (Mawlein, Mawkhan, Nonglakhiat and Lumshyiap) and four are under progress. Seven days training programmes on "Training on Value Addition of pork and pork products for beneficiaries under Biotech- KISAN Project" and "Training on Diseases and management of piggery for Artificial Insemination (AI) and Paravet beneficiaries" was organised from 5th to 12th November, 2019 for Value addition and AI and Paravet beneficiaries. Eight villages were adopted and the villages were divided into four Clusters (Two village in one Cluster) i.e. Cluster-1 (Mawlein and Mawkhan) Cluster-2 (Nonglakhiat and Lumshyiap) Cluster-3 (Thadnongiaw and mawbri), Cluster-4 (Umshorshor and Lummynri) by the Sub-Hub at KVK, Ri Bhoi, Meghalaya. Awareness and sensitization on pig farming under Biotech KISAN organised from 14th to 16th May, 2019 and a total of 45 beneficiaries attended the Programme. One day training program on Scientific pig farming for farmers organised on 17th September, 2019 and a total of 55 beneficiaries attended the programme. Five days Training programme on "Scientific Pig Husbandry Practices" organised by ICAR- NRC on Pig, Rani, Guwahati from 25th to 29th June, 2019, specially for AI and Paravet beneficiaries and 12 beneficiaries attended the Programme. 25 piglets (Yorkshire breed) were distributed to 24 beneficiaries. The activities have now been expanded in the Namsai (Arunachal Pradesh), Hailakandi (Assam), Chandel (Manipur), Kiphire (Nagaland), Dhalai (Tripura), Mamit (Mizoram) and West Sikkim (Sikkim) Aspirational Districts.

KISAN Hub established at village Bagwara block Budhni to transfer the technologies for Rice-wheat cropping system by Manthan Gramin Evam Samaj Seva Samiti, Bhopal. The farmers are been trained and groomed with new techniques and thus technology has been transferred on the farmers field. The farmers have obtained the average yield of 22 quintal/ acre as compare to other farmers yield. Looking to the success of technology more than 500 farmers from adjoining villages also adopted this innovative technology. The Sub-Hub established at Amalah, Sehore focused on soybean-wheat based cropping system with major emphasis on conservation agriculture. This Sub-Hub disseminated the innovative crop technologies to adjacent 100 village of Icchawar, Ashta, Sehore block of District Sehore. The demonstrations have been conducted with innovative package and practices with major emphasis on intervention of Broad Bed Furrow. The intervention of Broad Bed Furrow on one hand facilitate for irrigation during water crisis, and on the other hand during excess rain this helps out in removal of excess rains. In order to translate this technology on the farmers field, the scientist visited on farmers field and trained farmers on various stages of crop and simultaneously farmers also visited to partners institute and scientist groomed them with the emerging technologies. A new variety of Soybean JS-2069 has been introduced which was taking little more time in maturity but there was complete seed replacement on the farmers field. In soya crop, the average yield of more than 6 quintals and highest yield is 8 quintals has been obtained as compare to 1.5 to 2 quintal yield on other farmers field. The technology adopted was widely appreciated by farmers as well as by district authority. The activities have now been expanded to seven Aspirational Districts (Vidisha, Guna, Khandwa, Barwani, Chhatarpur, Damoh and Rajgarh) of Madhya Pradesh.

At Agri Biotech Foundation, Hyderabad, 206 soil and 105

water samples from farmers' fields were analyzed followed recommendations and distribution of soil health cards. Two vegetable seedling nurseries were established at two villages (Reddipalli & Narpala) with two women entrepreneurs. The entrepreneurs raised the vegetable seedlings (Tomato, chilli and crossandra) and sold to fellow farmers. Two on-farm *Trichoderma* production units were established under entrepreneurship activity, one at Katekaluva and Rotaripuram villages. The entrepreneurs produced *Trichoderma* and distributed to the fellow farmers. Hands on skill-based trainings have been conducted on activities like application methods of bio-fertilizers and bio-pesticides (seed, seedling & soil application), portray vegetable seedling technology, vermicomposting, hydroponics technology for animal feed, mushroom cultivation. Portable soil testing training as an entrepreneur activity, skill-based trainings on bio-fertilizers followed by field level demonstrations and skill-based training on Azolla, hydroponics for vegetable production have been conducted. The activities have now been expanded in three Aspirational Districts (Khammam, Asifabad and Bhoopalpalli) of Telangana.

Biotech-KISAN Hub has been recently established at Zandu Foundation for Healthcare, Ambach, Gujarat. The frontline demonstrations of good agricultural practices on cultivation of *Mucuna pruriens* in 15 acres by 16 farmers, *Withania somnifera* in 7 acres by 3 farmers and *Gymnema sylvestre* in 3.15 acres by 12 farmers is carried out so far. Farmers selection for frontline demonstration of Good Agricultural Practices on cultivation of *Bacopa monnieri* is completed.

07

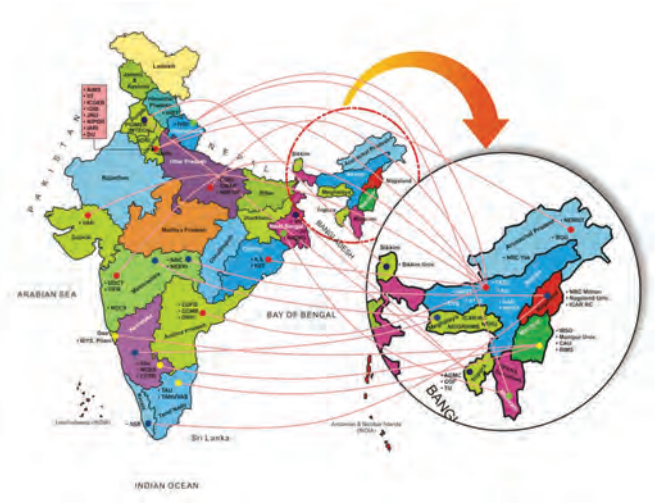
PROMOTING BIOTECHNOLOGY IN NORTH EASTERN REGION

PROMOTING BIOTECHNOLOGY IN NORTH EAST REGION

The North Eastern Region, because of its geographical location, difficult terrain, high rainfall, large forest areas and a large number of ethnic groups, faces challenges in several sectors including health, agriculture, management of bio-resources, environmental and ecological issues. Research & Development in the field of biotechnology has a potential to create solutions for many of the problems which NER is facing presently. Keeping this in view, the Department has been supporting and implementing various programmes specially designed for the region.

Major Research and Development Programmes

Twinning R & D Programme for NER: This programme initiated in 2010 has made a huge impact by catalyzing vibrant collaborations between institutions from NER and those from the rest of India, evolving NER-specific projects and their implementation across all eight states of the region. During the year 2019-20, fifty six Twinning R&D projects have been supported in all areas of biotechnology involving about 45Institutes from all states of NER.



Collaborating institutes in the twinning program

Under the twinning program, three new Ornamental Fishes were discovered from Chindwin, Barak, Surma and Meghna river Basins of Northeast India, baseline data was generated on diseases like Elephant endotheliotropic herpes virus, sero-prevalence data was generated for Japanese Encephalitis infection in pigs from different districts of Assam which has the potential to provide advisory to the medical health department of the state, mass production technique along with their nutritional profile was generated for edible insects consumed by local people of Nagaland. In another project C-dot silver nanohybrid material was developed for mosquito vector control by rupturing the cuticular layer of mosquito. Following patents were filed under the twinning programme : (i) A medicament for the treatment of disease by biofilm forming microorganism by IIT Delhi and IIT Guwahati , (ii) Antimicrobial formulation/composition to control multi-drug resistant MRSA by Tezpur University (iii) Medicated Urea Molasses Block "MUMB (Herbal) anthelmintic" by College of Veterinary Sciences (C. V. Sc),Khanapara, Guwahati Assam.

Block of MUMB (Herbal) anthelmintic developed by C.V.Sc Khanapara, Assam

Units of Excellence (U-Excel) in NER: The programme aims to identify and nurture outstanding mid-career scientists with an excellent track record in research, who possess innovative ideas and are desirous of pursuing research in frontier areas of biological sciences.During the year,2019-2020 support was continued to 12 young outstanding scientists from the North East Region.Under one U- Excel project, IIT Guwahati has developed a very exhaustive seri-bioresource databaseof NER for potential textile and non-textile application.In another project,techniques were developed for studying function of intrinsically disordered proteins. Patents titled "Endophytic *Streptomyces* having antimicrobial effect and its applications thereof" and "Novel validation method for surface sterilization of streptomyces and applications thereof as biocontrol agent in preventing and treating plant diseases of tomato" were filed by Mizoram University.

Network R&D Programmes:

(a) Agriculture Biotechnology:

Agriculture provides livelihood support to 70% of the population, which is largely rural. The population is largely dependent on local crop varieties for its sustenance. Department has initiated programmes focussing on these local crops with the aim to improve agriculture scenario in the region.

1. Under DBT's Scented Rice programme for NER implemented by 12 NER Institutes and 15other institutes, whole-genome sequence data of four Joha and four black rice genotypes from the NE region has been generated. Introgression of the black pericarp trait was done into two popular high yielding varieties (HYV) of Assam *i.e.,* (Ranjit Sub-1 (RS1) and Bahadur Sub-1 (BS1). These hybrid lines will be used for the development of anthocyanin fortified Ranjit Sub-1.

Black rice of NER

Efficient plant regeneration and *Agrobacterium*-mediated genetic transformation protocols were developed for the NE Black rice, and these protocols can be used for further work on Black rice improvement using yield-related and other useful genes. In another project the growth-inducing potential of endophytic bacteria (EB) was utilized to develop a solid form of bio-fertilizer. This biofertilizer emerged as an effective alternative for increasing grain yield of indigenous scented rice (*Joha rice* varieties of Assam) which generally does not respond to chemical fertilizers.

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Major network programme on NER-Banana has been initiated with 39 institutions including 18 from NER Institutes and 22 other institutes. Under the consortium two new species of *Rhodochlamys* (Musaceae) from Arunachal Pradesh were discovered. Three wild species of banana from Arunachal Pradesh, namely *Musa itinerans, M. cheesmanii* and *M. saddalensis* have been safely conserved in the *in-vitro* Gene bank at ICAR-NBPGR. These are new collections for NBPGR genebank. A patent has been filed titled "Method of preparing nutraceutical and pharmaceutical products based on *Musa balbisiana* and uses thereof" from IASST Guwahati and THSTI Faridabad.

(b) Bioresource and Environmental Biotechnology:

North East Region of India is a hotspot of biodiversity and natural resources. There is a vast scope for harnessing the use of biotechnological interventions in the region, especially towards development and utilization of bio-resources for the overall socio-economic development of the region.

Centre of Excellence on Bio resources and Sustainable Development is being established in Arunachal Pradesh. As part of the project following three priority processing units are being set up in Arunachal Pradesh:

- State-of-the-Art Orchidarium in the main Centre at Kimin for conservation and multiplication of priority orchid species along with establishing satellite units in selected villages with a view to promote orchid based entrepreneurship in rural areas of Arunachal Pradesh.
- Banana fiber processing unit in collaboration with other leading institutions from South India.
- Medicinal and Aromatic Plants Garden for *ex-situ* conservation of priority species along with establishing essential oil distillation units. Some programmes on promotion and cultivation of aroma crops at farmer's level will be undertaken along with buy-back arrangement with industries.

The collaborative programme on the chemical ecology of the NER between NE institutions from Nagaland, Arunachal Pradesh, Mizoram, Meghalaya and Bangalore institutions viz. NCBS, UAS, and IISc, has led to the formation of a strong

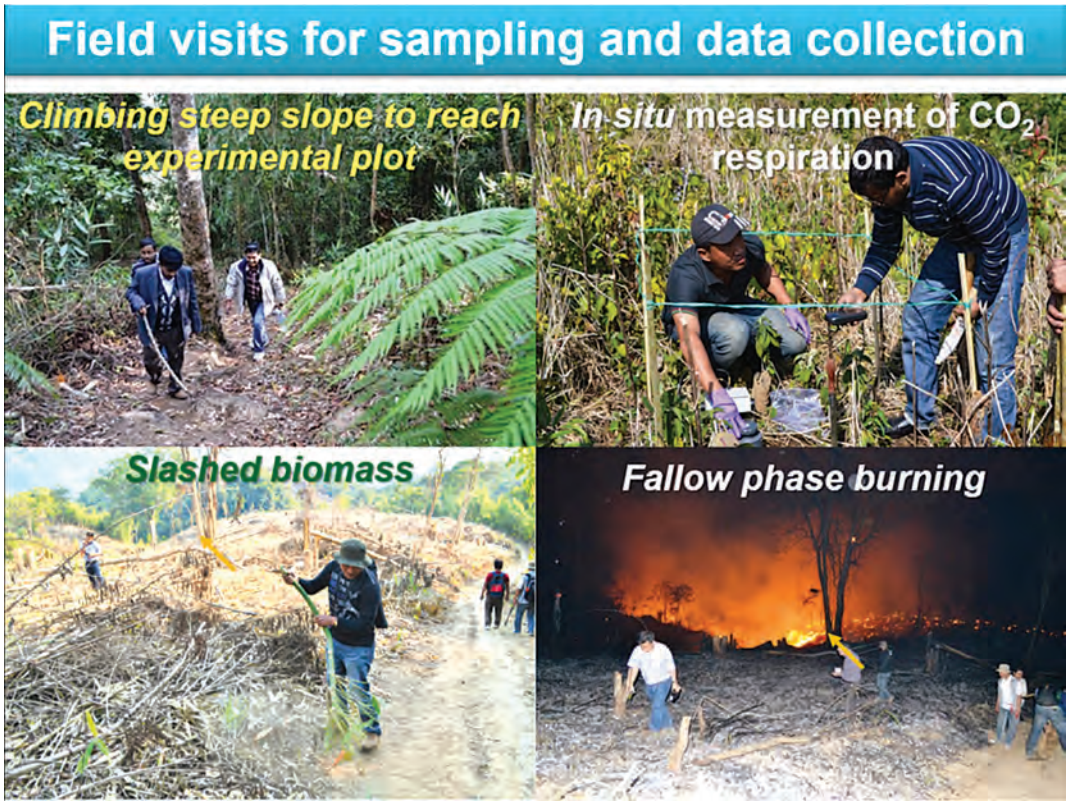
interlinked group of a new generation of chemical ecologistsin the NER for investigation of the biodiversity-rich and unexplored North East region of India and to obtain new insights into as how every component of the ecosystem talk to each other using the language of chemicals.The program has provided an opportunity for young researchers from the NER to be trained in the state-of-the-art research techniques in Bengaluru and to explore a multi-regional and multidisciplinary research environment in NER. Programme has produced 14 successful Ph.D registrations from NER, expanded the horizon of 8 postdoctoral researchers. The program has also built a platform for future chemical ecologists in NER by series of training, workshop, lecture series, social outreach, and online courses. Under this program major leads of the NER student driven projects are as follows:

- Sericigenous insects consumed as traditional food in some NER communities were shown to act as a dietary supplement and combat malnutrition (contains ù3 and 6 fatty acid and antioxidants).
- Endophytes isolated from *Panax sokpayensis*were shown to produce ginsenosides compounds i.e. Rg2, K and Rf *in vitro*.
- 2-(2-Benzothiazolylthio) ethanol extract was isolated and characterized from *Artemisia* and has substantial mosquito repellent activity.

A unique insecticidal compound is isolated and characterized as isosecotanapartholide from the methanol extract of *Artemisia vulgaris*. The compound is highly toxic against stored grain pests such as *Sitophilusoryzae*, *Tribolium castaneum* and *Corcyra cephalonica*.

Chemical Ecology Program in the North East

In a project on improving the productivity of *jhum* and restoration of sustainable *jhum*agro ecosystemin NER, a liquid biofertilizer formulation "CAU-*Jhum* Bioenhancer" and AMF formulation "AMF Biofertilizer" in vermiculite base was developed for its application in mixed*jhum* crops by IASST, Guwahati. The effectiveness of "CAU-*Jhum* Bioenhancer" was tested in *jhum* crops (rice, peas, broccoli, and ginger) and "AMF Biofertilizer" was tested in upland rice on the experimental *jhum* plots of Nagaland, Mizoram and Diphu (Assam). Application of "CAU-*Jhum* Bioenhancer" could increase the yield of jhum rice over the existing traditional *jhum* practice from 21.6 to 25% in rice and 18 to 22% in ginger. Application of "CAU *Jhum* Bioenhancer" in combination with 50% RDF (recommended dose of fertilizers) could produce comparable yield of broccoli and peas compared to that in 100% RDF.



Jhum Program of the North East

(c) Medical Biotechnology:

- The Department is establishing a state of the art **"DBT-Animal House Facility for Biotechnology Research" at Regional Medical Research Centre, NE Dibrugarh** to provide a stimulus to the Biomedical Research in the North East Region. The facility will hold small laboratory animals at different levels of the bio-safety environment (excluding containment level BSL3 & above) and will provide animal breeding facilities. It's a well-equipped lab for genetic and general health monitoring of animals and essential experimental procedures for various research activities. The facility shall be based on core scientific and technical principles with a commitment of handling animals ethically. It shall cater not only to the needs of RMRC, Dibrugarh but also to the scientific fraternity in the entire NE region. The facility is expected to be available by March 2021.
- To boost research in biological sciences and health engineering in North East Region, an advanced research facility called North East Centre for Biological Sciences and Healthcare Engineering (NECBH), has been established at IIT-Guwahati. This endeavor envisages the creation of several state-of-the-art research facilities at IIT Guwahati to modernize the research infrastructure in this region for its use by the entire NER workforce.Under this program, DBT is also funding small and medium budget research projects for the scientists / facilities across North-East in collaboration with the faculty of IIT-G. Under this initiative handholding is done for researchers with their first time grant. Apart from getting scientific mentorship, they are also trained in grant writing and general administrative rules so that in the near future they can become independent and can successfully compete for extra-mural funding. Overall the main aim of the programme is to elevate elevate the research ecosystem in the North-East.

Workshop on NECBH Twinning Programme

Demonstration and scale-up programmes for Societal upliftment in NER

- A project on pilot-scale demonstration of cultivation of Strawberry with improved Agrotechnology in Farmers field in Meghalaya has been supported to introduce and popularize strawberry cultivation in Meghalaya. Under this project a demonstration for the same will be carried out in 25.40 acres comprising of 50 demonstrative units atfarmer's field in Khasi, Jaintia and Garo Hills. Agro-technologies will be standardized for the strawberry plantation for utilization in these demonstration units. About 350 farmers from Meghalaya will be trained in these technological interventions and the market tie-up will also be established for the beneficiary farmers.
- A demonstration project on the tissue-cultured cut flower orchid production has been supported for an end to end capacity building in 50 villages of Assam and Meghalaya, covering an area of 6000m^2. Under the project vase life and post-harvest technology, systems will be standardized for orchid cut flowers. Project beneficiaries will be provided quality planting material and 3500 farmers/entrepreneurs will be trained in these technologies for using them in their village units. Market tie-ups will also be established for the beneficiaries.

Human Resource Development Programmes for NER

Establishment of Biotech Hubs across NER: DBT has established a network of 126 Biotech Hubs across NER, providing necessary infrastructure at universities/ colleges/ institutions and the required training in sophisticated technologies to support and promote biotechnology education and research. At this juncture, there are 6 State-Level and 106 active Institutional Level Biotech Hubs including 6 hubs in 5 aspirational districts identified by the Government in NER, spread across all the eight states of NER. Together these hubs have conducted more than 2000 hands-on training programmes and benefitting more than 50,000 participants across the region and more than 500 research articles/papers have been published by these Hubs including 130 in this year both in national and international journals. These biotech hubs have produced more than 70 Ph.D students and 50 such scholars have been placed at various institutions/organizations across the country.

Hands on Training programme in Mushroom cultivation

Overseas Associateship Scheme for NER scientists: The scheme has provided an opportunity to researchers from NER to enhance their scientific skills through research/ trainings at leading overseas institutions. So far, a total of 205 scientists have been awarded associateship to work in many reputed overseas institutions. These awardees have contributed in publication of 102 research articles in peer-reviewed national and international journals besides securing 84 extramural projects from funding agencies. During the year 14 NER researchers were awarded overseas associateship, in reputed institutes across the globe.

Biotechnology Labs in Senior Secondary schools (BLiSS) of NER: An unprecedented growth in the field of biotechnology makes it imperative to create awareness about it at the school level and also to provide an environment

of access to a well-equipped laboratory. Recognizing this need, DBT has initiated a scheme for establishing "Biotechnology Labs in Senior Secondary schools (BLiSS)" in NER. The BLiSS programme which currently comprises of 88 schools has strengthened the practical teaching within the schools by imparting excellent practical training for their students as per their syllabus in class 11th and 12th. Sixteen 16 BLiSS schools are in 6 aspirational districts identified by Government in NER. More than 2000 school students utilized those facilities for their science practical's and minor projects during the year.

Major outcome under the NER programmes of DBT for the year 2019

Manpower Trained in NER

- 450 students trained as JRF/SRF under Twinning Programme
- 292 students trained as JR/SRF/RAs under 112 Biotech Hubs in NER
- 14 NER Scientists availed Overseas Associateship for training in international laboratories

Publications

- 90 publications in peer-reviewed journals from Twinning, U-Excel and other major Network Projects
- 130 publications in peer-reviewed journals from 112 Biotech hubs

Patents filed

- Four patent applications filed before the Indian Patent Office

Technologies developed/Research Leads/ licenced/commercialised

- Whole-genome sequence data of four Joha and four black rice genotypes from the NE region has been generated
- Introgression of the black pericarp trait was done into two popular high yielding varieties (HYV) of Assam *i.e.,* (Ranjit Sub-1 (RS1) and Bahadur Sub-1 (BS1). These hybrid lines will be used for the development of anthocyanin fortified Ranjit Sub-1
- Efficient plant regeneration and *Agrobacterium*-mediated genetic transformation protocols were developed for the NE Black rice, and these protocols can be used for further work on Black rice improvement using yield-related and other useful genes.
- In the Banana consortium two new species of *Rhodochlamys* (Musaceae) from Arunachal Pradesh were discovered.
- Three animal vaccines/ diagnostic kits developed under ADMaC project being validated by State animal Husbandry departments in NER
- Technology developed for breeding of 3 commercially viable fish species in NER, at CoE in Fisheries at College of Fisheries, Tripura. Scaling up with farmers is under process.
- Four technologies commercialized by DBT-AAU Centre, Jorhat

Entrepreneurship Development

- Technology Incubation Centre for Entrepreneurship Development on Mushroom Culture & Farming developed at Bodoland University, Kokrajhar, Assam. A total of 2284 people have been trained including 250 during 2019 and 48 small scale entrepreneurs groomed and mentored.

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08

AUTONOMOUS INSTITUTIONS AND PUBLIC SECTOR UNDERTAKINGS

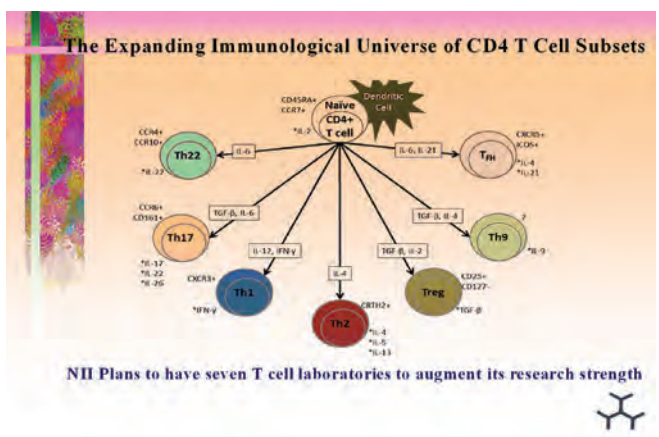
AUTONOMOUS INSTITUTIONS AND PUBLIC SECTOR UNDERTAKINGS

To have an in-depth knowledge of scientific pursuits, especially Modern Biology and Biotechnology, it is imperative to have dedicated institutions who are involved in knowledge generation and dissemination. The Department has set up 15 theme based autonomous institutions and also supporting one International Centre. These institutions facilitate flow of knowledge from basic science to translational research in the area of Health, Agriculture, Bioresource and Basic and Emerging Biotechnologies. Besides, they are also responsible for various other activities which directly or indirectly play a role in dissemination of knowledge, especially in terms of interaction having science open day and interact with school students and public to create interest and inclination towards biotechnology and biological sciences. These institutes are also playing an important role towards Capacity Building, Training and Skills upgradation of young scientists, students and researchers. During the year, the research outcome of DBT Autonomous Institutions (AI) has resulted in about 800 Publications and filing of 60 Patent applications. DBT AIs are implementing following flagship programmes to generate tools and technologies for application in Healthcare and Agriculture section. Various activities carried out during the year by these institutions are as follows:

NATIONAL INSTITUTE OF IMMUNOLOGY (NII), NEW DELHI

The National Institute of Immunology (NII) is the first autonomous institute of the Department of Biotechnology set up with the aim of promoting research in basic and applied immunology, and also in allied areas of the biological sciences that broadens the understanding of working of the immune system, and of the pathogens responsible for causing disease. During the last three decades, the institute has diversified its research from being engaged majorly in vaccines and reproductive biology to modern emerging biological research areas. The research focus is on infection and immunity, cell and reproductive biology, molecular design, cancer biology and immunotherapy, nanotechnology and regenerative medicine and chronic diseases and ageing etc. At NII, the scientists continuously interact with industry with an aim to quickly and effectively translate research leads into quality health care solutions.

Major Initiatives : A Flagship Programme on Immuno Engineering. This programme will use and create novel tools in the areas of Synthetic Immunology, Nanotechnology, Artificial Immune Systems, High Definition Cellular and Molecular Imaging, Biomaterials and Microfabrication, Therapeutic Delivery System, and Immunophysics. To begin with, the Programme will focus on three areas: (i) Immunotherapy for Cancer (ii) Creation of Cell Therapy Platforms, and (iii) Discovery and Development of Adjuvants from the Natural Products Repository of India. As the programme evolves, it is expected that the knowledge generated will pave the way for development of novel vaccines, new therapeutics for autoimmune diseases; contribute in the areas of regenerative medicine and implantable chips.



Salient Achievements: One of the research findings at the Institute indicated that PLGA-PEG nanoparticle might be used to co-deliver multiple chemotherapeutic drugs with different properties for enhancing antitumor efficacy. In the area of Tuberculosis (TB), research showed that *Mycobacterium tuberculosis* kinase PknB is essential for bacterial growth and survival. Study conducted at the Institute provided mechanistic insights for *Mycobacterium indicus pranii*-elicited protective response against M.tb infection. Another study from the Institute found a key role for caspase-10 in determining cellular metabolic outcomes and epigenetic control of gene expression, with major implications for tumor progression and metastasis. Another research findings of the Institute suggests a crucial role of Atg8 protein in the survival of the Leishmania parasite during life cycle

and stress situations, differentiation to amastigotes, and competency to infect. Another study showed that *Leishmania donovani* induces autophagy in human blood–derived neutrophils. Institute reported a finding that is new, of how *Leishmania*-induced human polymorphonuclear neutrophil (hPMN) autophagy regulates the silent mode of parasite transfer to macrophages by influencing the engulfment of infected cells. During the reporting period, the institute published 74 research papers in reputed journals and filed 14 patent applications. During the year, new collaborations have been forged with NCR Bioscience Cluster/ Thematic Cluster, INMAS (DRDO), IIT Delhi and EU to foster research and development.

Societal impact: The Institute has been engaged in running "Science Setu" program which has a great societal impact. So far, MoU signed with 16 undergraduate colleges of Delhi University and Manav Rachna International University, Faridabad has been executed. During the year training has been provided to 9 undergraduate students. Besides Science Setu, one-day science popularization programme and a road Show was also conducted for apprising the society of the research activities and R&D outcomes of the institute. On this occasion, a lecture series of NII's eminent scientists was arranged. Besides, the institute participated in IISF, 2019 at Kolkata and was a part of Global Bio-India, 2019 held at Aerocity, New Delhi.

Foundation Day Lecture on 06.10.2019 by Dr. Anil Gupta, Prof. G. P. Talwar being facilitated by Dr. Renu Swarup, Secretary, DBT

NATIONAL CENTRE FOR CELL SCIENCE (NCCS), PUNE

NCCS is involved in cutting-edge research in several areas of cell biology relevant to human health, including the biology of diseases like cancer, malaria, tuberculosis, metabolic disorders like diabetes and obesity, as also neurobiology, stem cell biology, immunology and microbiology. It contributes immensely to capacity building of the nation through high-quality human resource development in cell biology research. The NCCS was established at Pune with a mandate of three main functions:

(a) To carry out research in cell biology.

(b) To serve as a national cell repository.

(c) Human Resource Development.

Major initiatives: a) Establishment of a BIRAC-funded GMP-compliant National Repository for banking, safe deposit and supply of characterized cells for use in biopharma: this project is aimed at establishing a state-of-the-art GMP-compliant National cell banking facility to provide a "safe deposit" for cell line storage to the Indian industry; to obtain quality controlled cell cultures under license agreement; characterization and expansion of cell lines for distribution to the Indian biopharma industry and academia at affordable costs.

b) Dr. Renu Swarup, Secretary, DBT, formally inaugurated the Pune Biotechnology Cluster, 'Model Organisms to Human Disease' (23 August, 2019).

Salient Achievements: a) Contributions made by the National Cell Repository: Facilitated cell biology research across India by supplying 2608 cell cultures to 448 scientific organizations. 50 cell lines were authenticated.

b) Research Achievements: Research impetus continued during the year in areas of cell biology relevant to human health, including the biology of metabolic disorders like diabetes and obesity, diseases like cancer, malaria, tuberculosis, as well as neurobiology, stem cell biology, immunology and microbiology. The institute forged major research and development collaborations (14) during the year.

Research articles in journals		Reviews		Books / Book Chapters
Total: 76		Total: 13		4
International	National	International	National	
72	4	12	1	

Some Research Highlights:

- NCCS made a breakthrough when the structures of two key brain receptors were elucidated by Dr. Janesh Kumar and his research group, of which one was published as summarized below:

✓ Paper published in Nature Structural & Molecular Biology

This is the first structure of a receptor from the orphan delta family of glutamate receptor ion channels.

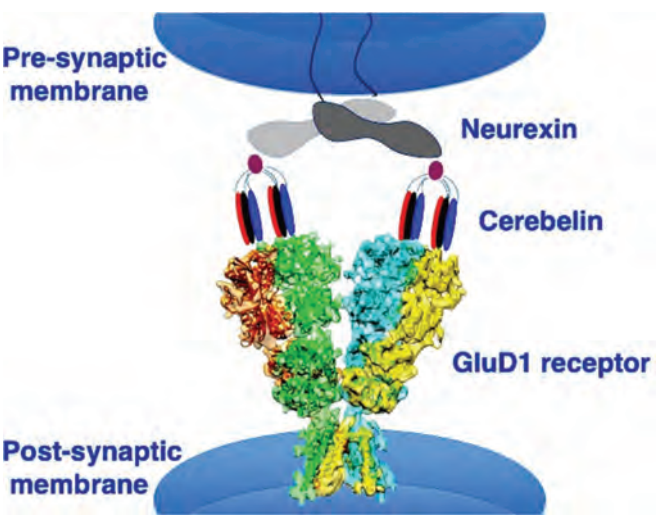


Figure Description:

Model depicting the trans-synaptic interaction mediated by GluD receptors. Receptor structure is shown in form of ribbons fitted in EM density map highlighting unique non-swapped architecture observed in glutamate receptor ion channel family.

Publication: 'Cryo-EM structures of the ionotropic glutamate receptor GluD1 reveal a non-swapped architecture', Ananth P. Burada, Rajesh Vinnakota and Janesh Kumar.Nature Structural & Molecular Biology

A new bacterial species isolated from a hypersaline lake in India, and identified by Dr. Yogesh Shouche and his team at NCCS, was named after Dr. Renu Swarup *(Natrialba Swarupiae)* in recognition of her invaluable role in simplifying some of the provisions of the Biodiversity Act 2002 to ease the deposition of strains for taxonomic descriptions, and for being instrumental in the establishment of the NCMR. The institution filed 6 Indian patent applications and 02 PCT applications. 01 US patent was granted.

Awards & Honors: NCCS scientists bagged several prestigious awards and fellowships such as Eminent Mass Spectrometrist Award, the National Cancer Research Institute (NCRI) Future of Research Bursaries Award, Best Poster Presenter award at the Mumbai healthcare summit, Best Poster Award at the 5th International Conference on Translational Research: Recent trends in pre-transational research, Pune the European Molecular Biology Organization (EMBO) short-term fellowship, the DBT Indo-US GETin Fellowship etc.

Societal impact: a) Capacity Building - NCCS contributes immensely by generating high-quality human resource in the field of cell biology, though different teaching and training programmes.

(i) Beneficiaries of the NCCS Academic Programmes during the said year

1	Research Fellows who received a Ph.D.	20
2	Students who joined NCCS for the Ph.D. programme	19
3	Students who registered for a Ph.D	26

4	Students who received research training at NCCS:	80
5	Students who enrolled in the Ph.D. coursework (conducted by NCCS for the Dept. of Biotechnology, S. P. Pune University	48
6	Postdoctoral Fellows / Early career scientists who joined NCCS:	8
7	Beneficiaries of the academic programmes currently on roll:	132

(ii) Beneficiaries of two hands-on training workshops on Cell Culture Technology conducted by the National Cell Repository at NCCS during the said year: 44

a) Outreach: ***(i) IISF-2019:*** Hundreds of students and citizens of all age groups, and from different backgrounds were familiarized with various aspects of cell biology, the excitement of research, and opportunities in biology, through outreach platforms like the India International Science Festival (IISF-2019) at Kolkata and a pre-IISF Open day at NCCS as an IISF-2019 outreach event.




The NCCS exhibits at IISF-2019 at Kolkata drew huge crowds from diverse demographics




A public talk on cancer was delivered in Marathi by Dr. Anjali Shiras

Open Day at NCCS - IISF 2019 outreach event

CENTRE FOR DNA FINGERPRINTING AND DIAGNOSTICS (CDFD), HYDERABAD, TELANGANA

CDFD has been at the forefront of DNA-based forensic identification and medical diagnostic research and services for the past two decades. CDFD has also been offering Basmati Rice purity testing to rice exporters using DNA markers. In particular, the Centre undertakes research in several frontier areas of modern biology. The major thrust areas include Microbiology, Cell Biology, Disease Biology, Genetics and Epigenetics, and Computational Biology.

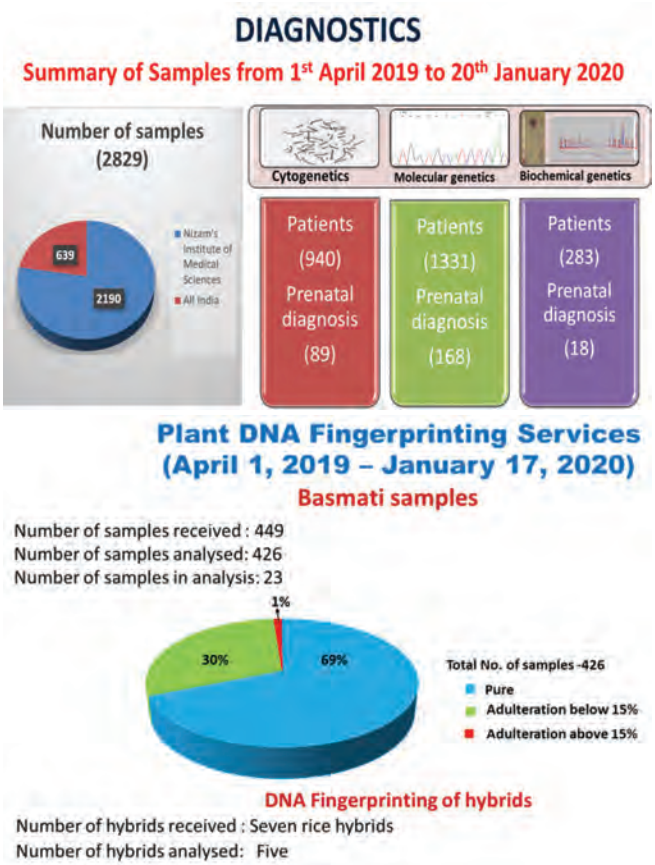
Mission and Vision

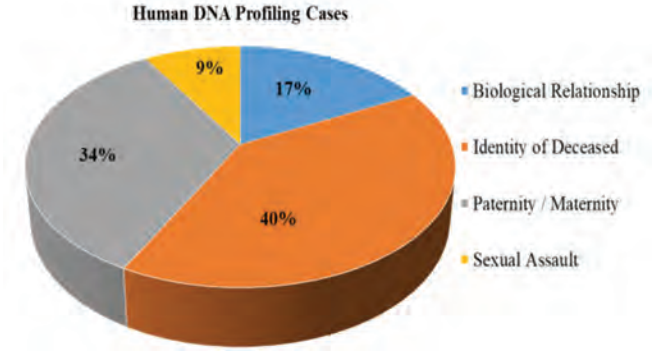
To carry out scientific research, services and training; to achieve global excellence in fundamental and applied research; and simultaneously endeavour to transfer the benefits of modern biology to every section of the society.

Main objectives of CDFD are to provide DNA fingerprinting services to the judiciary and to law enforcing agencies, to establish DNA diagnostics methods for detecting genetic disorders, to use DNA fingerprinting techniques for authentication of plant species (e.g. basmati rice), and to undertake basic, applied and developmental R&D work. Another important mandate of CDFD is to provide highly trained and skilled manpower in the domains of modern biology through its PhD and various other training programmes.

In the year 2019-20, CDFD has provided:

1) High quality forensic DNA fingerprinting services in 92 odd cases to the various Courts of law, law enforcement and investigative agencies of the country.
2) Genetic diagnostic, prenatal diagnosis and clinical genetic counselling services to more than 2829 families with rare genetic diseases.
3) Plant DNA fingerprinting services for Basmati Rice for 449 samples, which has contributed to the increase in Basmati exports, and acted as a major deterrent to adulteration in Basmati export consignments.





Total 92 cases were received for human DNA Fingerprinting services till January 20, 2020.

Salient achievements:

1) A Flagship Programme **"Development of genomic technologies for predictive genetic health and forensic profiling"** was initiated.

2) Under the flagship programme 'Transformation of Aspirational Districts' of Government of India, **CDFD has established a DBT NIDAN Kendra at Yadgir district hospital for** "Unique methods of management and treatment of inherited disorders" **(DBT-UMMID)** programme.. The program aims at screening of 10,000 antenatal mothers annually attending the district hospital of the Yadgir district for thalassemia, followed by prenatal diagnosis for prevention of Thalassemia,

CDFD-DBT NIDAN Kendra at Yadgir district hospital for DBT-UMMID programme. Clock wise a) Inaugration of Nidan Kendra by Hon'ble Minister, Science and technology, Dr. Harsha Vardhan, b) Yaadgir district shown in map of Karnataka, c) Outpatients at Yadgir NIDAN Kendra, d) Yadgir district hospital where NIDAN Kendra is located, e)The medical team at Yaadgir NIDAN Kendra.

3) **Establishment of DBT National Genomics Core:** The core consists of three centres at National Institute of Biomedical Genomics, Kalyani, Kolkata, Centre for DNA Fingerprinting & Diagnostics, Hyderabad, and University of Allahabad. The core aims to create a distributed, high-throughput genomics facility of international standards for stimulating transformative research and development of genomics applications for national economic growth, social and health benefits, and cultural enrichment of communities.

India International Science Festival 2019

Global Bio-India Meet 2019

DBT Scientists' visit under capacity & skill building programme

MoU with CCMB to create an Expert group for diagnosis of genetic disorders

Molecular Microbiology Meeting 2019

Open Day Lecture by Prof. Samir Brahmachari

4) 43 research papers were published and 02 patent applications were filed. CDFD scientists bagged several prestigious awards and fellowships such as GP Talwar Young Scientist Award, TATA Innovation Fellowship,Wellcome Trust-DBT India Alliance Senior Fellowship, Fellowship of the Indian National Science Academy, Fellowship of the Indian Academy of Sciences (IAS) etc.

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

The National Institute of Plant Genome Research (NIPGR) is an autonomous research institute funded by the Department of Biotechnology (DBT), Government of India. The Institute has witnessed exponential growth in its research programs since its inception over 20 years ago and has become renowned both nationally and internationally. The research activities of the Institute are carried out in the following broad areas of Plant Biology such as: Genome analysis and molecular breeding; Development and signalling; plant responses to biotic and abiotic stress; Nutritional enhancement of crops and Computational Biology. Currently, the Institute has 30 scientists, who are leading independent groups conducting cutting-edge research in these areas.

Vision and Mission: The Vision of the Institute is to generate new knowledge in the area of plant genomics, assimilate it with current knowledge, and translate the same for genetic enhancement of plants for social benefits. The Mission is to undertake, aid, promote, guide and coordinate research of high calibre in basic and applied plant molecular biology.

Major initiatives:

1. NIPGR has initiated a flagship program entitled "Ímparting sheath blight disease tolerance in rice". Sheath blight is a major rice disease and this multi-institutional program is aimed at developing newer ways of managing the disease. In this program, molecular breeding, genome editing and transgenic approaches are being used in an attempt to develop newer varieties that have enhanced tolerance to sheath blight. The other institutes involved are: National Agri-food Biotechnology Institute (NABI); Indian Agricultural Research Institute (IARI); Indian Institute of Rice Research (IIRR); International Rice Research Institute (IRRI) and the National Institute of Immunology (NII).
2. A Structural Biology group is being established at NIPGR. The group will focus on understanding the structure-function relationships of plant proteins
3. A Metabolomics facility has been inaugurated at NIPGR by Dr. Renu Swarup, Secretary, DBT. A major focus of this facility is to quantitate phytohormones and plant secondary metabolites.

Salient Achievements:

Development of an extra large seeded kabuli variety: A molecular marker for large seeded character has been developed and used in marker assisted selection to make an extra large seeded derivative of the commercially important kabuli variety, KAK2. Extra large seeded kabuli types find favour in the export market. The 100 seed weight of KAK is 36 gm while the 100 seed weight of Improved KAK2 is 56 gm. Improved KAK2 not only produces larger seeds but it also leads to ~10% increase in yield and in protein content. This line is being evaluated in "ICAR-AICRP (All India Coordinated Research Projects) on Chickpea" Advanced Varietal trial-1 (AVT1) during rabi season 2019-20 (under extra large seeded kabuli category). This work is in collaboration with IARI, New Delhi and ICRISAT, Hyderabad.

Development of a chickpea variety with optimum plant width that is amenable for high density planting and mechanical harvesting: A DNA marker has been identified that is associated with desirable plant architecture in chickpea and used in the development of a variety that is amenable for high density planting and mechanical harvesting. In experimental fields this line showed a 15% increase in productivity. It is being evaluated in "ICAR-AICRP (All India Coordinated Research Projects) on Chickpea" AVT1 during rabi season 2019-20 under the category of varieties that are amenable for mechanical harvesting. This work is in collaboration with IARI, New Delhi and ICRISAT, Hyderabad.

Development of chickpea lines with increased root biomass and enhanced yield: A chickpea enzyme that degrades cytokinin has been expressed in root cells and it has been observed that reducing cytokinin levels in roots lead to enhanced root biomass without affecting shoot biomass. Besides, yield of the transgenic line is 13%-25% more, content of iron and zinc in the seeds is higher and the drought tolerance appears to be better than the parental line

Biochemical control of glucosinolate diversity in Brassica crops: The molecular structure of a key enzyme involved in biosynthesis of glucosinolates has been established. Glucosinolates are not only important defense molecules of Brassica crops but also contribute towards pungency and flavour that a consumer prefers in these crops. Mutational studies have provided important insights about the residues that contribute to substrate specificity of the enzyme. This paves the way for future work aimed at tailoring Brassica crops for production of desirable glucosinolates that can help in better protection against plant pests/pathogens as well as in enhancing flavour or desirable health attributes for humans. This research has been published in Plant Cell.

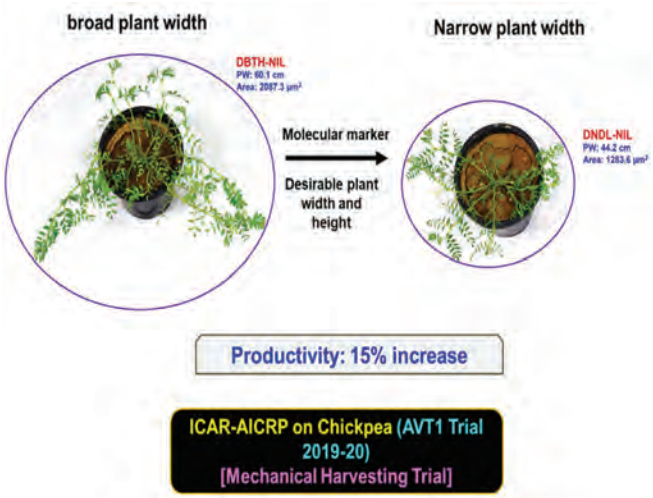
Societal impact:

NIPGR Open Day: With a view to popularize science and showcase the various facets of research and development to young innovators, students, teachers, and individuals interested in the field of plant sciences, and also as a curtain raiser for the India International Science Festival 2019, the Institute had organized an Open Day/Public Outreach Day on 23rd October 2019. In this event, approximately 1000 students and teachers from 28 schools and 5 colleges from the NCR visited the institute. The NIPGR community presented 13 posters and 21 exhibits on plant science. To give students a feel for a real laboratory experience, a demo lab has been set up to show them the basic molecular biology experiments. The feedback received from students and their teachers was very positive.

Regional Young Investigators Meeting: In order to promote stronger local interactions, a meeting of young Investigators of the NCR Region was held on August 6th and

7th 2019 at NIPGR. The meeting was attended by ~125 faculty, post-doctoral researchers, PhD students and funding agency representatives from the NCR. The meeting was marked by stimulating presentations, invigorating discussions and networking. The overall experience was greatly appreciated by all participants.

Training for school teachers of NCR: A one day workshop on advancements in biology was conducted on September 6th 2019 for biology teachers from schools in the NCR. The workshop was attended by 61 teachers from 50 different schools and enabled the teachers to be acquainted with recent developments in biology and update their knowledge in this field.



Development of a chickpea variety that is amenable for high density planting and mechanical harvesting

NATIONAL BRAIN RESEARCH CENTRE (NBRC), MANESAR, HARYANA

National Brain Research Center (NBRC) is a premier research and education Institute dedicated to conducting advanced research in Neuroscience, and excel in providing education and training. The mandate of NBRC is to pursue research to understand brain function in health and disease, generate trained human resources to carry out interdisciplinary research in neuroscience and promote neuroscience in India through networking among institutions across the country. NBRC is a Deemed -to-be-University, which runs M.Sc. and Ph.D. programs besides other post-graduate and post-doctoral programs to generate trained human resources with knowledge and skills required to conduct interdisciplinary research in advanced neurosciences. The broader vision is to discover underlying causes, and develop diagnostic markers and cures for various diseases affecting the brain and mental health through innovative approaches in basic and translational research. NBRC has been recognised as an Institution of Excellence by Government of India.

Major initiatives: During the year, NBRC took up a program 'Comparative mapping of common mental disorders (CMD) over the lifespan' as its Flagship Programme, which aims to understand how information processing networks in the brain are affected in common mental disorders such as anxiety, depression, obsessive-compulsive disorder and post-traumatic stress disorder. The goal is to understand underlying brain mechanisms that differentiate between these disorders, and if these networks are affected in the same manner in different age groups. The data will help establish age-specific diagnostic markers for these disorders. In the next phase, it will be expanded into a multicentric nationwide programme and genetic investigations will be carried out.

The second major initiative of NBRC, Dementia Science Programme, a national level program, enters the patients recruitment phase. Dementia in elderly is ballooning into a major health problem with rapidly aging population of the country, and the change in social structure towards nuclear families. Goal of this program is to determine the factor such as lifestyle, genetics and previous medical history that result in a subset of people progressing from Mild Cognitive Impairment (MCI) to dementia, so that possible intervention could be developed. There are four hospital-based sites at AIIMS New Delhi, NIMHANS Bengaluru, SCTIMST Thiruvanthapuram, and BIN Kolkata, and three community based sites in the north, south and east India, where rural, urban and tribal cohorts are being set up for long-term follow-up. Harmonised protocols for data collection have been finalised. The work now enters the patient recruitment and data collection phase.

Salient Achievements: Some of the achievements of the NBRC research program are highlighted below:

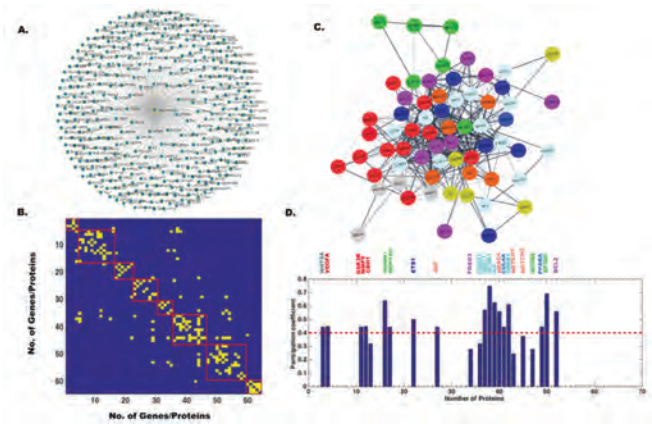
Encephalitis, caused by Japanese Encephalitis Virus (JEV), and other viruses remains a major public health challenge. NBRC scientists have identified hubs in miRNA target gene networks using human neural stem/progenitor cells (NSPCs) following JEV infection. They have utilized computational

biology approach to analyse networks generated from protein interaction modules and hub proteins, which might be the key host factors for viral infection in NSPCs. In collaboration with sister NCR cluster institutes RCB and THSTI, they have demonstrated that the platelet factor 4 (PF4) promotes rapid replication and propagation of Dengue Virus (DV) and JEV. These findings suggest that the PF4-CXCR3-IFN axis is a potential target for developing methods to treat viral infections including DV and JEV. Moreover, CXCR3 antagonists including AMG487 can be advantageous for treatment of JEV and DV infections, and possibly for other viruses as well. Zika virus infection in pregnant mothers has serious neurological consequences for the unborn babies. Zika virus causes microcephaly, a condition in which size of the head of babies becomes small due to underdevelopment of the brain. NBRC scientists have delineated the cellular and molecular mechanisms by which Envelop (E) protein of the virus slows down proliferation and differentiation of fetal neural stem cells during brain development, even before the birth. They have identified specific microRNAs that regulate the functions of human neural stem cells thereby affecting their stemness, and overall development of the human brain. A group of NBRC scientists have shown that the expression of tyrosine hydroxylase, the rate-limiting enzyme in the synthesis of catecholamines and DARPP-32 (dopamine and cAMP-regulated phosphoprotein), which is expressed in dopaminoceptive neurons can be used to delineate different subdivisions of the caudal nidopallium (NCL, analogous to the prefrontal cortex) in house crows, indigenous to India. Members of the genus Corvidacea which include crows, rooks, starlings and jays are increasing being used to study advanced cognitive abilities such as attention, learning and memory, tool use and theory of mind in birds. These findings lay down a foundation for future studies linking brain structure to complex behaviours and the problem-solving abilities demonstrated by these birds. Scientists studying the nature, extent and mechanisms of brain reorganization following spinal cord injuries have shown changes in the functional interaction between the somato sensory network and the Default Mode Network (DMN). Posterior Cingulate Cortex (PCC, a part of DMN) showed increased correlations with the deafferented hand region of both somato sensory and motor cortex. These results link changes in the brain-wide information processing networks with developing imaging tools for assessing the ongoing recovery process due to therapeutic intervention. Working on *C. elegans*, a powerful nematode model system for neuroscience research, scientists have shown that insulin signalling (IIS) contributes to the age-related decline in axon regeneration. Loss of insulin receptor DAF-2 or any other downstream kinases like AGE-1, PDK-1, AKT-1/2 in the IIS pathway promotes regeneration and functional restoration despite the animal's age. This paves the way to further investigate if similar pathways play a role in regeneration and repair in mammalian systems. Development of early diagnostic marker for Alzheimer's Disease (AD) from multi-modal MR imaging and neuropsychological tests is an important area of research at NBRC. Role of major antioxidant, glutathione (GSH) and its conformational changes in various brain regions for the onset of AD in Indian population and cohorts from other continents is being investigated. It has been found that major antioxidant glutathione exists in two conformations and the potency of these forms to scavenge the radicals is an important area to investigate with respect to AD pathology.

Societal impact

NBRC understands its societal responsibility and stands responsive to the larger needs of society besides delivering productive outcomes through research with an aim to reduce the burden of neurological disorders amongst the general population, NBRC offers neurological out-patient department services at Civil Hospital, Gurgaon to patients from the city as well as neighbouring districts. Patients with epilepsy continue to come to NBRC for sophisticated investigations using the Magneto encephalography (MEG) facility set up in collaboration with AIIMS, New Delhi. 'DALI' a tool in Indian languages for dyslexia assessment in children developed at NBRC remains in high demand, and is being increasingly adopted countrywide. NBRC scientists have developed a specialized tool called BRAHMA for integrating inputs from neuroimaging data and the clinical information to help in diagnosis of various brain diseases such as Alzheimer's and Parkinson's. The tool is standardized on a robust Indian brain template that is representative of the Indian population-specific brain anatomy. NBRC organizes open days for children from various schools, and other citizens to visit the campus and interact with our students and faculty. The visitors are given a tour of the laboratories to introduce them to the excitement of neuroscience research. Given their enthusiastic response, the number of open days has been increased. This

is in addition to the visits of students from schools and colleges organized throughout the year upon request. NBRC faculty members also deliver popular science lectures in School and Colleges across the country.



Network analysis showing an miRNA (miR-9-5p) target gene networks, modularity/ community detection in gene networks and the identification of hub genes based on participation coefficients

Students from a school for the blind learning about the human brain by touching a model.

INSTITUTE OF BIORESOURCES AND SUSTAINABLE DEVELOPMENT (IBSD), IMPHAL, MANIPUR

North East Region of India is a genetic treasure trove of plants, animals and microbial resources. This region falls among the World's top 10 Biodiversity Hotspots. Realizing the importance of the rich biodiversity and the unique bioresources of the region, the Department of Biotechnology, Ministry of Science and Technology, Government of India established the Institute of Bioresources and Sustainable Development (IBSD) at Imphal, Manipur in the year 2001. It is not only a unique institute of its kind in India but also amongst the very few of its kind in the world. The main mandate of this institute is conservation and sustainable utilization of bioresources for the socio-economic development of the region. Research and Development activities are pursued under core areas such as medicinal plants, horticulture, algae, microbes, insects, fisheries and other aquatic bioresources with emphasis on bioresources database development, bioresources education, Human Resources Development (HRD).

Major Initiatives:

During the last couple of years, IBSD has taken several new initiatives that include a focused research program on Bioenergy, product development, black rice improvement, development of super-foods applying microbial process, development of bio-pesticides, research on conservation of endangered plants and animals and other programs of value addition which can create more employment, in addition to its ongoing R&D programs.

Salient Achievements:

- A state-of-the-Art Orchidarium was inaugurated at IBSD, Shillong which would cater to the development of a Floriculture based industry in North-East.
- National Bioresources Park at Haraorou, Imphal was further strengthened by the inauguration of Orchid Production Unit, Farmers Training Hostel, Transit Accommodation Facilities, Rain Water Harvesting facilities and an Outreach Activities Centre.
- Based on leads obtained from *Ficus cunia*, development of a phytopharmaceutical drug against Type 2 diabetes is on the anvil.
- Conservation, Propagation and Mass Multiplication of Selected Orchid species from North-East has been initiated and a pilot project has been sanctioned for developing bio-based entrepreneurship in North-East India.

- IBSD developed Pre-Treatment Technologies for the production of Bioethanol from invasive weeds like para grass and mixed phumdi biomasses of Loktak Lake.
- A DNA Chip based analysis platform was developed for assessment of microbial risk associated with traditional fermented foods of North-East India.
- IBSD has trained 1770 farmers and unemployed youth in orchid production to promote orchid based bio-entrepreneurship.
- Under the Aspirational District Programme of DBT, a Rural Bioresource Complex is being set up at Ri Bhoi District, Meghalaya that will benefit the local population.
- A total of 30 acres of land have been adopted by IBSD for demo plot plantations of aromatic crops from two villages in Manipur. 13 farmers have cultivated *Cymbopogon* species in more than 300 acres of land. Totally 34 farmers from Manipur have been benefitted for awareness programme for commercial cultivation and processing of selected aromatic crops.
- Scientists at the institute published 13 research publications and filed 03 patent applications.

Societal implications:

The Open Day of IBSD was organised on 23rd October 2019. The programme was participated by three hundred and twenty school and college students. All of them visited the laboratory of our institute. Thirteen students along with their faculties of Dhanamanjuri University, Manipur had 2 days hands-on training on molecular biology on 16-17th January 2020.

Fresh water Algal Repository which has collection of more than one thousand strains at IBSD, Imphal

Pilot protected cultivation facilities developed by IBSD for production of capsicum/cucumber/pumpkin at Thindawl, Mizoram.

INSTITUTE OF LIFE SCIENCES (ILS), BHUBANESWAR, ODISHA

Institute of Life Sciences (ILS) was established in 1989 by the Government of Odisha (*then Orrisa*) and has successful and productive 30 years of scientific excellence. ILS is pursuing the defined mandate "*Betterment of Human Health and Welfare*" through its highly energetic and experienced faculties, dedicated and bright students, and committed and enthusiastic support staff in the area of life science research, education and outreach. The efforts are being intensified and consolidated through sustained support from the Department of Biotechnology, Govt. of India since 2003. The scientific groups of ILS are involved in cutting edge science and technology interventions in the field of cancer biology, infectious disease biology and plant and environment biotechnology.

Major initiatives:

Initiatives for improving food health and nutritional status in selected tribal regions of Odisha:

Given the prevailing situation and emerging challenges for ensuring sustainable food, health and nutrition security and overall human well-being, Institute of Life Sciences (ILS), Bhubaneswar started a comprehensive flagship program on "Tribal Health and Nutrition". ILS has established "omics" based research pipelines as well as storage and data management structures and has initiated collection and analysis of samples from Tiljora village of Sundergarh district of Odisha inhabited by 6 ethnic tribes. The ILS has also initiated and implemented a program for Economic Empowerment of Tribal Farming Communities in

Nabarangapur (one of the Aspirational Dist) of Odisha focusing on enhancing productivity and profitability of the farming system, establishing nutrition gardens and imparting nutritional literacy, and training and capacity building for value addition and income generating activities, in collaboration with ICMR-RMRC and KISS University, Bhubaneswar. In partnership with National Academy of Sciences, similar development activities are also being undertaken in Tigiria block of Odisha.

An initiative to understand and intervene Gall Bladder Cancer in India:

As a "DBT-National Cluster for Bioresources and Life Sciences" activity ILS, RGCB and IBSD have initiated a program on Gall bladder cancer.

Salient achievements:

Infectious Diseases Biology: The infectious disease biology is one of the major focuses of ILS with a vision to work towards human health and welfare. Recently, the amino acid requirements in the malaria parasite are being examined and explored as new targets for transmission. An ultra-sensitive diagnostic method for *P. falciparum* was developed in collaboration with Jigsaw Biosolutions Pvt Ltd., Bangalore. In the studies on tuberculosis, it was identified that NCoR1 depletion enhances mycobacterial infection by controlling autophagic flux. On the other side, the same NCoR1 depletion induces strong anti-viral responses upon activation by TLR9 ligand in dendritic cells. Moreover, a machine learning algorithm was also developed to predict antimicrobial resistance using the whole genome sequence of clinical Mtb strains.

Studies on the Chikungunya virus (CHIKV) have shed light on two novel host factors. It was observed that the host factors P38 and the JNK Mitogen-Activated protein Kinases interact with CHIKV Non-structural protein-2 (nsP2) and thereby regulate TNF production during viral infection in macrophages. Hence, this information might be useful in rationale-based drug designing strategies towards a possible control measure of CHIKV infection in future. Studies on the IRGM protein have demonstrated that it could be targeted for broad antiviral activity and autoimmune diseases. The structural biology group has completed the high-resolution crystal structure of Thymidylate Synthase enzyme from the shrimp White Spot Syndrome Virus (WSSV) and the same has been crystallized in complex with known inhibitors.

Cancer biology: Numerous studies have been undertaken on host gene expression and regulation associated with cancer group at ILS. The investigations in breast cancer have revealed that the gene XEDAR (X-linked ectodermal dysplasia receptor), a target of tumor suppressor ERRâ, was found to have a critical role in cancer cell proliferation and migration. The studies in oral cancer have shown that the Mcl-1 inhibitor triptolide can reverse chemotherapy-induced cell death in chemoresistant oral squamous cell carcinomas.

Apart from that, the bioinformatics studies have identified interactions between circular RNA, miRNA and mRNA in oral squamous cell carcinoma.

The study on Chronic Myeloid Leukemia (CML) has unveiled for the first time, up-regulation of the splicing regulator Polypyrimidine Tract Binding Protein 2 (PTBP2) in CML.

Genetic & Autoimmune Disorders: The T-cell group has investigated on Innate and Adaptive Immune cells in controls and patient samples and has been able to ascertain at least two types of aberrant T cells in Auto Immunity and a Metabolic disease namely Diabetes. They have also been able to ascertain the T helper cell that harbors malaria parasite in rodent models that allows parasite growth. These cells were then targeted and viability and parasite clearance was observed to be enhanced. These studies will now be examined in human disease conditions.

Otosclerosis is the abnormal bone growth of stapes that causes hearing loss. The study revealed that genetic polymorphisms of COL1A1, BMP2, BMP4 and SERPINF1 plays an important role in otosclerosis susceptibility and affects mRNA and protein expression in case and control stapes. In another study on congenital hearing loss, we identified novel mutations in CLDN14, c.495C>T in sporadic cases and c.423C>A in familial cases showing the digenic inheritance with GJB2. Further, structural and functional characterization of these variants will elucidate the mechanism involved in the etiology of hearing loss.

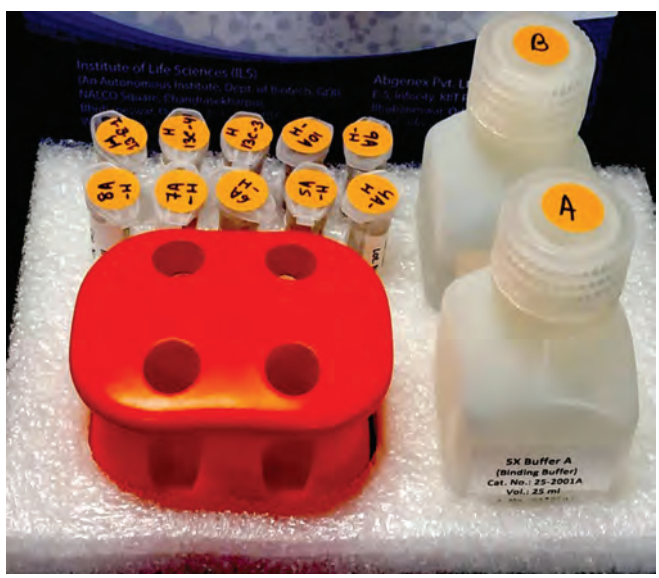
Plant and Microbial Biotechnology: ILS is involved in the designing and testing of novel chimeric promoter. The current research has led to the development of a chimeric promoter FUASCsV8CP by inter-molecular shuffling of the Upstream Activation Sequence (UAS) of *Figwort Mosaic Virus* (FMV; –249 to –54) at the 52 -end of the *Cassava Vein Mosaic Virus* (CsVMV) promoter fragment 8 (CsVMV8; -215 to +166). The FUASCsV8CP promoter with complete heterogeneous sequence showed higher transcriptional activity compared to CaMV35S promoter. The FUASCsV8CP promoter was constitutive and Salicylic acid-responsive and hence can also be used for ensuring effective gene expression in plants under constitutive as well as specific inducible conditions.

The structural biology group has reported high-resolution crystal structures of Arabidopsis thaliana AtFKBP53 domains that have been complemented by interaction data with histone oligomers and nucleosome core particles.

Other activities/achievements: Institute of Life Sciences (ILS) and Regional Medical Research Centre (RMRC), Bhubaneswar organised Open Day on 25th and 26th October 2019 at ILS. The visitors had the opportunity to understand the ILS and RMRC R&D activities through interaction with scientists and visit to the laboratories. Other research institutes from Bhubaneswar also showcased their R&D activities. About 2000 visitors came to ILS over these two days.

A number of faculty and research students participated in many national and international conferences and have been recognized with best presentation/ poster awards and also received fellowships viz. fellow of National Academy of Sciences, India, EMBO Global Investigators, Biotech Product and Process Development and Commercialisation Awards 2019, Intermediate Fellowship grant etc. 25 publications depicting the significant and seminal findings from our research studies have been published in internationally reputed and peer-reviewed journals and our scientist have filed 03 Indian patent applications. A total of 26 research students have submitted their Ph.D. thesis and 15 of them have been awarded the degree.

Technologies transferred/commercialized: ILS has launched two products during the year (a) QuikSort Magnetic Cell Separation Kit with research application in purifying different cell types from human PBMC and mouse splenocytes and (b) Mono- and Poly-clonal antibodies for non-structural proteins (nsP1, nsP2, nsP3 and nsP4) of Chikungunya virus for research on infection and advance basic knowledge in the area of chikungunya biology.



QuikSort ™ (Magnetic cell sorting kit) (Co developed by Institute of Life Sciences and Abgenex Pvt. Ltd). Currently human CD3 positive cell separation kit and mouse CD3 positive cell separation kit are commercially available.

RAJIV GANDHI CENTRE FOR BIOTECHNOLOGY (RGCB), THIRUVANANTHAPURAM, KERALA

The mandate of RGCB is Discovery, Innovation and Translation in Biotechnology and Disease Biology. India's engagement

with biotechnology, life sciences and medicine is dynamic and constantly evolving. RGCB sees itself as a key player in this development process. Research is focused on understanding disease biology and processing this knowledge for better management and design of potential therapeutics. The institute also translates biotechnology for societal benefits by providing advanced molecular diagnostics and forensics besides developing new products and processes. RGCB operates from three campuses, one concentrating on discovery, the second, an innovation focused research facility and the third, a Bio-Nest for translation of research into applications and products. The Major areas of intervention RGCB is focusing on are:

Fundamental Research: Our research efforts aim to understandi the biology that defines basic mechanisms involved in the disease process and its implications for human health. Some of the significant achievements during 2019-20 are:

- Results from the two doses versus three doses of the human papillomavirus vaccine resulted in the recommendation to use 2 doses separated by 6 months or more for routine vaccination of young girls (now accepted by WHO).
- Clinical trial of oral curcumin as a chemopreventive agent demonstrates its pharmacological and clinical ability to prevent malignant transformation in oral premalignant lesions.
- Functional correlation between energy metabolism and the relative levels of different proteins during different stages of TB infectivity has provided a whole new target for therapeutic intervention to prevent reactivation of latent infections
- Analytical database on triple negative breast cancer is now is highly referred by breast cancer biologists worldwide
- Detecting the structural assembly pathway of human antimicrobial peptide pores at single-channel level to develop peptide based therapeutics is underway

Salient Achievements: RGCB faculty has published more than 100 publications in the year 2019 and gained an h-index of 57 with a total citation of 1623 in the current year. Major research findings were published in journals such as *Cell Proliferation, Nucleic Acids Research, Carcinogenesis, Cancer research, Clinical Science, Papilloma Virus Research, BMC Public Health etc.* Two Patents have been filed/granted during the year:

Translational Science: RGCB focuses on Trans-disciplinary health science to benefit individual, clinical, and public health decision-making to improve health. During the year, the Centre has achieved notable contributions in HPV vaccine trial Policy decisions, key publications in HPV, Oral Cancer, Chemoprevention, Drug Discovery tools and assays. RGCB has established Phase I of the Bio-Innovation Center in the institute with state-of-the-art facilities for Genomics, Bio Imaging, Small & Transgenic Animal Research, Microbiome Research, Viral Disease Biology, Chemical Biology and Laboratory Medicine & Molecular Diagnostics. The Centre will allow high-end translational science and medical research in the institute.

Technology Development: Turning research into technology innovation and on to business is another mandate of RGCB. Significant achievements during the period are:

i. A patent and technology transfer for "Mouthwash composition for treating Oral mucositis". The technology for management of Oral Mucositis developed jointly by RGCB and Regional Cancer Centre, Trivandrum has been transfered for commercialization to Ceego Laboratories.

ii. A patent and technology transfer for Utroside B- a potent anti-hepatocellular carcinoma molecule.The technology has been transferred to the multinational company, Q Biomed (https://adisinsight.springer.com/drugs/800048876);https://qbiomed.com/index.php/pipeline/uttroside. An MoU has been signed between RGCB and Oklahoma Medical Research Foundation (OMRF), USA, for a multi-disciplinary, multi-institutional, and international collaboration for the clinical evaluation of the compound. This work has been presented in the EACR-AACR-ISCR Conference held at Jerusalem, Israel during October 9-11, 2018 and received the Keystone symposia global health travel award by Bill and Melinda Gates foundation, for attending the Keystone Symposium, 'Why So Many

Ways to Die? Apoptosis, Necroptosis, Pyroptosis and Beyond'November 19—23, 2019, São Paulo, Brazil.

iii. RGCB invented a low cost strip that identifies the type of poisonous snake from the blood within 2 minutes of a snake bite. This will help the doctors administer the antivenom as early as possible.

Academic Excellence: RGCB launched M.Sc. Biotechnology Program in July 2019, a highly innovative degree cource with three unique specializations – Disease Biology, Molecular Diagnostics & DNA Profiling and Molecular Plant Sciences. The M.Sc. program of RGCB is affiliated to the Regional Centre for Biotechnology an "Institution of National Importance" providing education, training and research established by the Department of Biotechnology, Government of India under the auspices of the United Nations Educational, Scientific and Cultural Organization or UNESCO, a specialized agency of the United Nations (UN) based in Paris. This MSc program at RGCB is unique, as it will cover the fundamental fields of theories in Biotechnology, while focusing on laboratory exercises and industrial as well as research applications. The students will be introduced to the concepts of "Enterprise and Entrepreneurship". This allows students who wish for a career beyond the laboratory in an existing biotechnology industry or for those who dream of starting a new biotechnology enterprise. Students get trained in a real business & technology development bio-incubator where startup companies function. RGCB MSc students will receive a stipend of Rs. 6000 per month for the first year and Rs. 8000 for the second year of the MSc program.

Awards and Honours: During the year, RGCB has been honoured in many ways. Some of the significant Awards and Recognitions received by RGCB scientists are: Management Leadership Award of the Trivandrum Management Association, Sun Pharma Research Award in Medical Sciences 2019, the ICMR Chaturvedi Kalawati Jagmohan Das Memorial Award, the Best Women Scientist Award, National Academy of Biological Sciences, National Woman Bioscientist Award, Young Scientist Award from the Indian Society for Parasitology, Swarna Jayanthi Fellowship, the Merck Young Scientist Award in Biological Science etc. RGCB received the Best Pavilion award in the Mega Science Technology & Industry Expo, India International Science Festival, Kolkata.

Outreach Activities

1. RGCB celebrated National Science Day 2019 by opening its gates to excited young students from schools of Trivandrum. Scores of children celebrated science with exceptional aptitude, creativity and temperament.

2. RGCB conducted an outreach program for school students in its main campus ahead of the India International Science Festival 2019. More than 200 students visited our laboratories and got a glimpse of our research activities..

3. RGCB stall at the Mega Science Expo, IISF 2019 showcasing RGCB's achievements of preparing captive elephant ID cards and containment of zoonotic viruses.

REGIONAL CENTRE FOR BIOTECHNOLOGY (RCB), FARIDABAD, HARYANA

Regional Centre for Biotechnology (RCB) is an Institution of National Importance established by the Department of Biotechnology, Govt. of India, under the aegis of UNESCO with a mandate to impart education and training, and conduct research in the frontier areas of biotechnology. RCB has continued to accelerate its efforts in these directions with full vigour and has made significant advances towards achieving its mandate.

The vision of RCB is to produce human resources tailored to drive innovation in biotechnology, particularly in areas of new opportunities and also to fill the talent gap in deficient areas. The mandate of the Centre is to provide a platform for biotechnology education, training, and research at the interface of multiple disciplines. The Centre conducts multidisciplinary innovative research in biotech sciences in the following broad areas: Infectious Disease Biology, Molecular Medicine, Cancer Biology & Therapeutics, Agricultural Biotechnology, and Systems and Synthetic Biology.

Major Achievements

Academic Programs: The RCB PhD program started a few years ago has continued to grow and a total of 97 students are pursuing the PhD program in various laboratories during 2019. During the reporting period, 14 students were awarded the PhD degrees. The integrated MSc-PhD degree program

started during the academic year 2018-19 received much attention from students during 2019 when 14 students were enrolled including a foreign student. Regional Centre for Biotechnology recognized various institutions of higher learning for their academic programs and in this direction, after the due diligence, RCB has granted academic recognition to the PhD and Master's degree programs at the Centre for DNA Fingerprinting and Diagnostics, Hyderabad; National Institute of Animal Biotechnology, Hyderabad; National Agri-Food Biotechnology Institute, Mohali; Center of Innovative and Applied Bioprocessing, Mohali; Translational Health Science & Technology Institute, Faridabad; Institute of Life Sciences, Bhubaneswar; Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram and National Institute of Biomedical Genomics, Kalyani. A total of 219 students from these recognized centres stood registered for their respective programs with RCB in 2019.

Scientific Programs: RCB scientific achievements in terms of quality of publications and the ability of our faculty to attract extramural grants have shown consistent growth. RCB continued to conduct cutting-edge scientific research in the broad areas of Infectious Disease Biology, Molecular Medicine, Cancer and Cell Biology, Agricultural Biotechnology, and Systems and Synthetic Biology. The Agribiotech group identified key virulence proteins from the pea powdery mildew pathogen and functionally validated their role in disease development. These virulence proteins and their plant targets can serve as important tools for the development of biotechnological strategies for preventing powdery mildew infection in legumes of agronomic importance. RCB scientists developed the first animal model for Freeman Sheldon Syndrome, a genetic disease that affects the muscle in humans. Using this model, the group explored the molecular basis of muscle defects in this disease, which should lead to new strategies to treat patients born with this disorder. The research program on Dengue has shown that Platelet Factor 4 (PF4) stimulates the replication of Dengue and Japanese encephalitis viruses in host immune cells. The structural biology group has elucidated the mechanism utilized by DNA polymerases to prevent ribonucleotide incorporation in the genome. The study provides the possible cause of certain cancers and can also lead to novel engineered DNA polymerases for use as reagents in research and diagnostics. The group has also shown that the proofreading domain of the DNA polymerase involved in duplication of the apicoplast genome of the malaria parasite protects the AT-rich genome from mutagenesis due to oxidized nucleotides. The study suggests that inhibitors of the proofreading activity may serve as powerful potentiators of the activity of available antimalarials. The RCB Flagship Research Program on the development of antivirals has been initiated harnessing the expertise of the in-house structural biologists and virologists. During 2019, RCB scientists published 65 research articles in various reputed journals and one Indian patent application was filed.

RCB made recruitments against several administrative, technical and academic positions after an extensive search process. The three additions to the RCB faculty during 2019 would strengthen its research program, specifically in the area of Infectious Disease Biology and Agriculture Biotechnology. Besides, RCB continued to nurture the young investigators though the various funding mechanisms such as RCB Young Investigator Award, INSPIRE Faculty Award, and National Post-doctoral Fellowships etc. Besides, RCB has provided industrial consultancies and carried out national and international collaborations with various institutions.

Training activities: Towards human resource development in the advanced areas of life sciences and biotech sciences, RCB conducted several training programs. Notable among these was the 2nd Bioimaging School highlighting the popular imaging systems that are extensively used in biology and biomedicine. The other training workshops were in areas of genomics, proteomics and cell biology, introducing to the participants the latest methodology and instrumentation in these important areas of modern bioscience research. An international meeting was convened on 'Structure-assisted Development of Novel Therapeutics' highlighting the latest developments in this key area of drug discovery and development. RCB in association with UNESCO organized a 'Regional Training Program on Developing Effective and Inclusive Science' in pursuance to the Sustainable Developmental Goals of the United Nations, focusing on capacity building among the South-Asian science policymakers. The BIRAC-funded Bio-Incubator added another dozen of start-ups as its incubatees this year. Besides, the Bio-Incubator conducted several entrepreneurial development activities including the MindSpar 2.0, a unique

ideathon competition in November 2019.

Societal Impact: RCB has contributed significantly to the human resource development by training students and young researchers for their skill enhancement and academic degree programs. RCB has been catalyzing the entrepreneurial activities in the National Capital Region through its Bio-Incubator which is supporting several start-ups in the area of life sciences. RCB Flagship program aims to develop prophylactics and therapeutics against viral diseases highly prevalent in the Indian population.

UNESCO Representative addressing at the World Science Day event jointly organized by RCB & UNESCO, New Delhi

Director, UNESCO, New Delhi during RCB-UNESCO Workshop on STI Policy

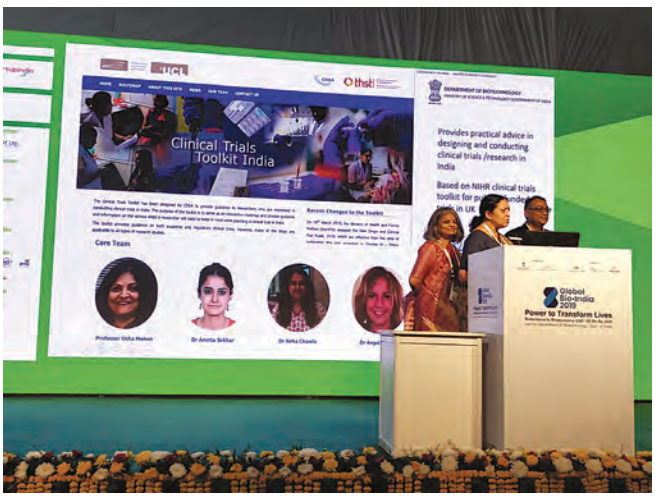
Translational Health Science and Technology Institute (THSTI), Faridabad, Haryana

The Translational Health Science and Technology Institute (THSTI), in the NCR Biotech Science Cluster in Faridabad aims to facilitate development, optimization and evaluation of technologies to provide innovative solutions for challenges in public health in India. THSTI collaborates widely in India and internationally for leadership in innovative translational research and entrepreneurship.

The Translational Health Science and Technology Institute, established as a Society on 15th July 2009 completed a decade as an Autonomous Institute of the Department of Biotechnology this year. THSTI's focus is on health sciences through eight centres that were sanctioned through SFCs and were in a project mode completing their tenures in December 2018 (except Paediatric Biology Centre which has been extended till 2020). The year 2019, was thus, a year of transition for this young institute as the centre-based structure reorganized into a theme-based structure with four strategically prioritized thematic programs complemented by four core facilities under the Translational Research Program (TRP) funded by DBT. In September, the Governing Body approved the proposal to begin Phase-3 construction work within the sanctioned budged of THSTI for the expansion of R&D activities.

Vision, Mandate and Objectives: THSTI follows a three-pronged approach by: (i) creating new knowledge for innovation, (ii) developing innovative solutions based on existing knowledge and (iii) devising new strategies for implementation of existing solutions. The institute complements discovery, design and development of interventions by building rigorous research capacity though high-quality training. The Institute is addressing issues of national priority through theme-based research programs on infectious diseases, maternal and child health, metabolic diseases and diagnostics (for infectious diseases).

Major initiatives:



Dr. Renu Swarup, Secretary, DBT launching the Clinical Trials Toolkit of India (CTTI) at the Global Bio India 2019. Also seen is Prof. Usha Menon who leads the team which developed CTTI at the CDSA.

THSTI, University of Oslo, and IAVI entered into a 3 years' Collaboration Agreement for the project entitled "Developing HIV broadly neutralizing antibodies as a prevention product for global access through antibody half-life extension engineering" funded by Norway Research Council under GLOBVAC program. Teams from three continents will work to engineer and optimize antibodies to extend their half-life, an improvement designed to increase the duration of antibody activity and potentially lead to longer intervals between protective doses. THSTI continued its association with IAVI by entering into a collaboration for a new research program entitled **Antibody Translational Research Program** that will focus on setting up technologies, assays, protocols, and relevant skill-sets in the areas of antibody discovery, antibody characterization.

- CDSA supported the launch of ICMR TB vaccine trial for healthy household contacts of TB patients. This is the first-ever government-led vaccine trial after the BCG vaccine trial that was undertaken decades ago..
- The Aryabhatta Data science and AI Program at THSTI (ADAPT) was inaugurated at THSTI.
- The Clinical trial toolkit developed by THSTI, CDSA and the MRC CTU at UCL was launched at DBT's Global Bio India 2019. The Clinical Trials Toolkit for India (CTTI) has been developed to make the process of clinical trials simpler and less confusing for researchers.
- Under a collaborative agreement with Jiva Ayurveda, THSTI will work to understand non-alcoholic fatty liver disease (NAFLD) in Indian patients. The intent is to create a scientific bridge and understanding between "AYUSH" and "Modern Science" for non-alcoholic fatty liver disease (NAFLD) by collecting information on disease phenotype in Indian population across the geography.

Important meetings/workshops:

- CDSA organized national workshops on regulatory compliance for accelerating innovations at six venues across India during this period.
- CDSA and ICMR have joined hands to work in many areas and capability building in biomedical research is one of them. ICMR pioneered the GCLP Guidelines by releasing it in 2008. CDSA conducted Good Clinical Practice (GCP) and Good Clinical Laboratory Practice (GCLP) programs at the ICMR Headquarters, New Delhi on April 11th and 12th, 2019.
- CDSA organised a half-day '*Interactive meet on New Drugs, and Clinical Trials Rules 2019: It's understanding and impact*' on May 17, 2019, at THSTI, NCR Biotech Science Cluster in collaboration with Central Drugs Standard Control Organization (CDSCO), Ministry of Health and Family Welfare.
- The 2019 World Conference on Access to Medical Products: Achieving the SDGs 2030 was convened from 19-21 November 2019 in New Delhi where THSTI partnered with the MoHFW, and the WHO, ICMR and BIRAC to organize.
- THSTI hosted a short course on Vaccinology for Clinical and Public Health Practice from 18th-21st November 2019 in collaboration with (JIPMER, LSHTM, NUS, HITAP).

Salient Achievements: The year saw several major initiatives made through development and continuation of academic and industrial partnerships that brought in complementary expertise in important areas. The institute

had more than 60 publications, 11 patent applications and one technology developed - A novel "Integrative Expression Vector" developed in collaboration with M/s Bioheaven 360.

School and college outreach:

- This year MoUs were signed with Hansraj College and Deen Dayal Upadhyay College both under the University of Delhi under the Science Setu Program, taking the total number of collaborating colleges under the program to eight.
- Two Open Days were organised with a total footfall of more than 400 students – one on THSTI's Foundation Day and the second one as a pre-event of the India International Science Festival 2019.

Prof. Shinjini Bhatnagar, Dr. T. Ramamurthy and THSTI's team with students from DAV, Gurgaon on THSTI's Open Day;

Ms. Hina Latif Nizami and Ms. Akanksha Kothidar during a Science Setu talk with girl students at GSSS, Bhankri village, Faridabad

INSTITUTE FOR STEM CELL SCIENCE AND REGENERATIVE MEDICINE (INSTEM), BENGALURU, KARNATAKA

Located within the Bangalore Life Science Cluster campus in Bangalore, the year 2019 began with the inauguration of inStem's laboratory building. inStem's mandate is to address complex problems in areas of directed differentiation and tissue regeneration with disease relevance through collaborative research programs involving interdisciplinary teams with translation emphasis. Our efforts have focused on building core strengths in stem cell biology and manipulations with outcomes in areas reflecting the focus on injury repair and mechanisms underpinning cell fate decisions. Major milestones in large multi-institutional partnerships have also been reached this year.

Major initiatives

- Under the aegis of the DBT supported **Novel Approaches to Hematological Disease (NAHD)** programme and in collaboration with CMC Vellore, a thalassemia and sickle cell disease Control Program is being coordinated at Odisha under the leadership of Prof. Alok Srivastava, CSCR, inStem – CMC Vellore. Training in monitoring, diagnosis and counselling is provided in workshops conducted by by CMC Vellore, arranged at different levels (State / Regional / District levels) for doctors / other healthcare workers of Odisha. In collaboration with the Department of Health and Family Welfare and the National Health Mission of the Govt. of Odisha, six districts have been identified to implement the first phase of this programme. Tools for diagnosis are being amplified under this programme, with plans to extend to several aspirational districts in Odisha.
- The Haplobanking project in the NAHD program at CSCR involves identifying HLA homozygous donors from the Indian population and generating iPSC lines from their cultured cells through good manufacturing practice (GMP). The Centre for Stem Cell Research (CSCR) and Christian Medical College (CMC) collaborate with the Blood Stem cell registry DATRI, a non-governmental organization located in Chennai for the collection of blood samples from suitable donors across India, which

are HLA typed and screened for infectious diseases at the CMC, Vellore. A cost- effective protocol has been established at CSCR to generate iPSC lines from cultured erythroid cells derived from peripheral blood mononuclear cells (PBMNCs).

- In the DBT funded programme entitled, **Accelerator Program for Discovery in Brain Disorders using Stem Cells (ADBS),** focusing on neuropsychiatric disorders, a partnership between inStem, NIMHANS and NCBS in Bangalore and CiRA in Kyoto Japan, has completed the recruitment of 1500 individuals. Marking a milestone in this ambitious long-term program, two-year follow-up for the earliest participants in the study have also been initiated. Notably, all affected individuals are ensured full access to medical care.

- The DBT funded, **National Electron Cryo-Microscopy facility**, a partnership between inStem and NCBS began its activities in 2018 (http://ecryom.instem.res.in/application-form-link), with the aim of training and building capabilities in the use of Cryo-EM to address questions in biology in India. In its efforts to improve its capabilities, in 2019 the facility incorporated different binder libraries in Yeast 2 hybrid systems, and the necessary Flow Cytometers to analyze and sort proteins as often the size of the proteins can limit the analysis using EM. A 3-D printing set up is also installed and working in the facility. Approximately 8 publications included data generated from the facility.

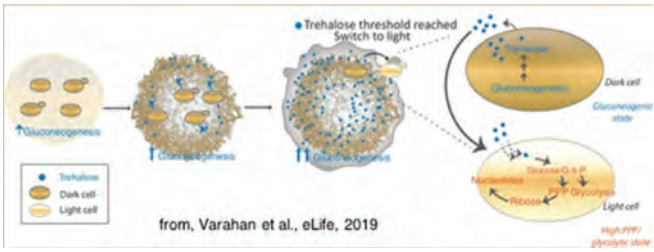
Salient Achievement: More than 40 original research articles have been published in 2019. Reflecting core endeavors at inStem, the publications focus on repair and regeneration of skin (Bhatt et al., Cell Reports, 2019) and the gut barrier (Singh et al., Nature Communications 2019). A commentary on newborn stem cell banking (Brown et al, J. Clin. Med.2019); mapping changing molecular signatures from stem cells to aging cells (Rao et al., EMBO Reports, 2019, also appearing as a journal cover); a description of the generation and characterization of embryonic stem cell lines with targeted deficits in FMRI, which constitutes an important resource in the fragile-X field (Giri et al., Stem Cell Research, 2019); molecules that regulate cell fate transitions (Krishna et al., EMBO Reports, 2019 and Varahan et al eLife 2019), amongst others. A few of these are highlighted below:

Gut Reaction – damage control in gut barrier function: A research group at the Institute for Stem Cell Science and Regenerative Medicine (inStem), focused on the modulation of signaling at the gut barrier interface with the potential to restore barrier function in diseases such as inflammatory bowel diseases (IBDs) and alcohol liver disease. The group successfully identified small molecules that trigger overexpression of chemicals naturally produced by the body to restore barrier function. Since the functioning of natural gut metabolites is sensitive to gut pH, degradation by digestive enzymes, poor absorption and prolonged retention, the group has employed their skills in medicinal chemistry to develop a new chemical entity, which overcome these limitations and provided demonstration of a therapeutic outcome in preclinical IBD *in vivo* models.

Blocking superbugs with naturally occurring anti-microbial peptides in skin: A major medical problem raising the alarm of public health officials worldwide is the increasing number of "superbugs". In an exciting scientific advance, Colin Jamora and his laboratory at the Institute for Stem Cell Science and Regenerative Medicine (inStem) in a collaboration with Unilever have discovered a way to unlock the release of natural substances called antimicrobial peptides (AMPs) from our skin. These naturally produced AMPs effectively kill superbugs.

Going from one to many: Metabolic control of multicellularity

As a single cell divides to form a multi-cellular organism there is resultant division of labor. Sunil Laxman and his group in the Regulation of Cell Fate theme at inStem, recently reported their findings on how multicellularity emerged in single-celled microbes by the manipulation of metabolic activity (Varahan et al eLife, 2019). The group studies yeast *(Saccharomyces cerevisiae)* cells, for the ease of manipulation and precise measurements. This work is of particular relevance in the context of microbes, which can form drug-resistant biofilms (multi-cellular) and are implicated in many diseases caused by bacteria and fungi. Studies such as these provide key insights on how biofilms can form, suggesting a means to control the growth of these.

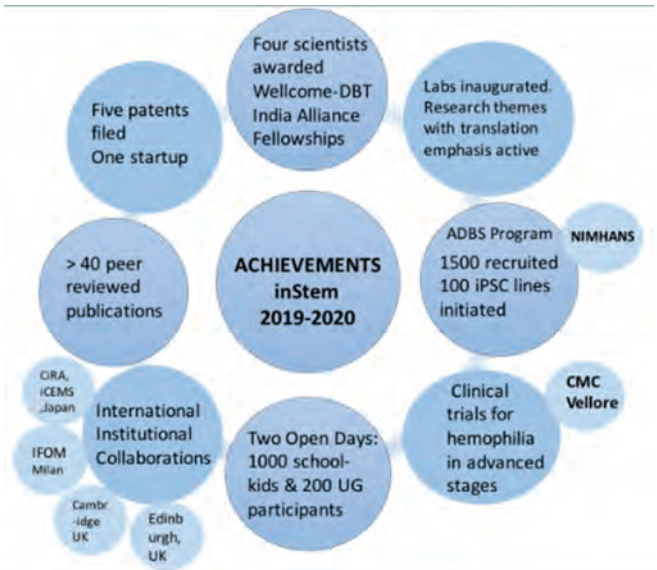


Stem Cell Exit: Translational control of differentiation : The differentiation of stem cells to form specialized tissues brings huge demands including new gene expression, changes in metabolism, remodeling of cell shape and form to name a few. Equally important, successful acquisition of a new cellular identity hinges upon the suppression or functional loss of pivotal elements of the earlier state. How might these requirements be met and maintained during cell-fate transitions? Further, are there common principles or rules that underpin these transitions? Recent work from the laboratories of Dasaradhi Palakodeti and Srikala Raghavan at inStem, in a collaboration with Ramanuj Dasgupta, A*STAR Singapore, provided significant insight into this process. Their study (**Krishna et al., EMBO Reports 2019**), which includes different experimental systems of cell-state transition, positions transfer RNA-derived small RNAs (tsRNAs) derived from 5' halves of tRNAs, as critical control element[s] in the process.

Workshops enabling advanced skill development

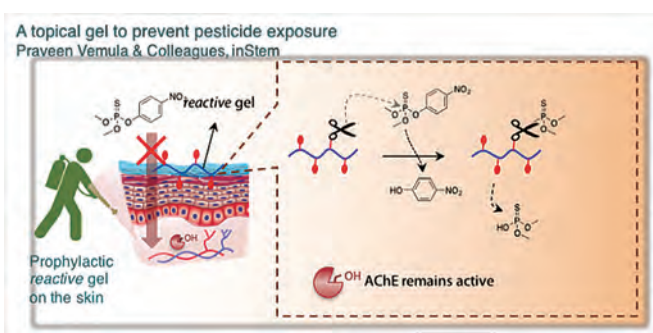
- iPSC workshops (duration of 3 weeks) saw more than 20 individuals from across the country, receive training in the generation and manipulation of these cells. This was the third edition of these workshops in campuses at Bangalore and Vellore
- 20 students participated in a joint NCBS-inStem-IBAB workshop on Bioinformatics.
- The Mouse genome engineering facility organized a Microinjection / Crispr-Cas Workshop, and a second workshop on Basics in bio-methodologies of Laboratory Mice and Rats in 2019

Awards & Recognition: **inStem** scientists bagged several prestigious awards and fellowships such as Gandhian Young Technological Innovation Award – 2019, the Wellcome Trust-DBT, India Alliance Senior, Intermediate and early Career Fellowships etc.



Societal impact:

A startup emerged, which primarily focuses on the development of on-demand, bio-responsive deliverables to reduce pathologies associated with chronic inflammation. The product under development minimizes exposure to toxic pesticides through skin contact and inhalation, during the spraying of pesticides. This is of relevance to the farming community. This effort was also recognized by the Gandhian Young Technological Innovation Award – 2019, BIRAC-SRISTI



inStem Science Outreach & Communication Efforts (inSOurCE)

- Two Open Days were organized by students and postdocs at inStem, which saw participation from 1000 school children from in and areas around Bangalore and more than 200 undergraduate college students.
- BLiSC Science Cafe effort brings scientists to the public in informal settings/ social venues in the city. Four such events involved investigators from inStem.
- InStem and NCBS have co-hosted a Science Exhibition - Lab Culture I & II – which was visited by more than 700 students in July-Aug 2019 and 1500 students in Oct-Nov 2019.

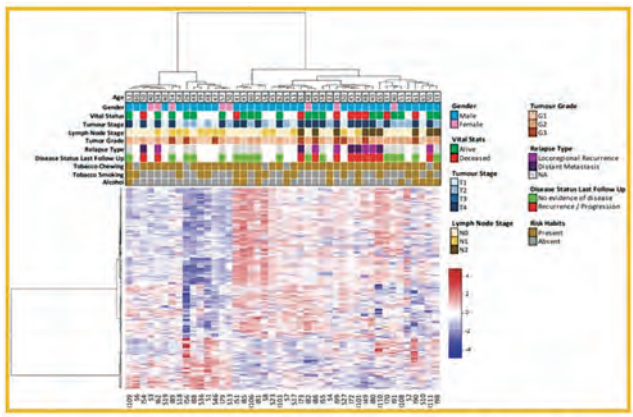
NATIONAL INSTITUTE OF BIOMEDICAL GENOMICS (NIBMG), KALYANI, WEST BENGAL

NIBMG has completed a decade of its existence. The Institute is now recognized, both nationally and internationally as a leader in research areas that apply genomics to understand human health and disease. During the last year, NIBMG expanded its research in new directions, in addition to existing ones, and scaled up its technology initiatives. The research outputs continued to receive substantial recognition, both in scientific filed and in the public. Some key achievements of the Institute in the last year are as follows:

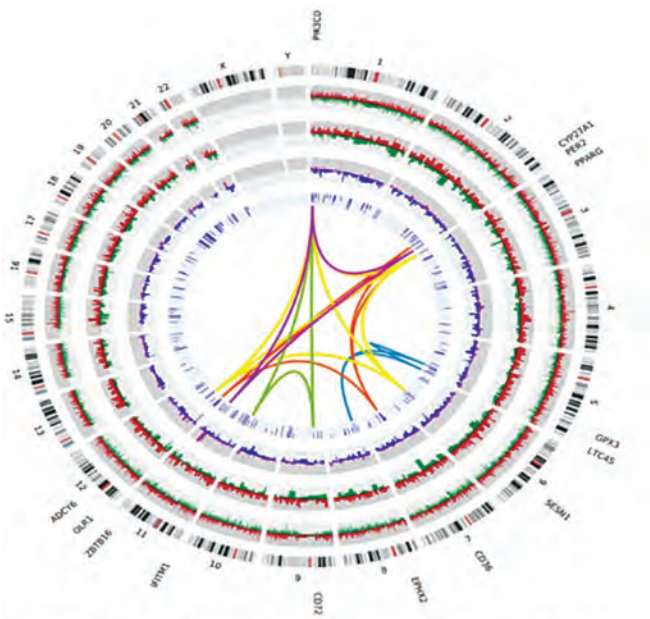
1. Epigenomic dysregulation-mediated alterations of key biological pathways and tumor immune evasion are hallmarks of gingivo-buccal oral cancer

Gingivo-buccal oral squamous cell carcinoma (OSCC-GB) is the most common cancer among men in India and is associated with high mortality. Although OSCC-GB is known to be quite different from tongue cancer in its genomic presentation and its clinical behavior, it is treated identically as tongue cancer. Predictive markers of prognosis and therapy that are specific to OSCC-GB are, therefore, required. Although genomic drivers of OSCC-GB have been identified by whole exome and whole genome sequencing, no epigenome-wide study has been conducted in OSCC-GB; our study has filled this gap, and has discovered and validated epigenomic hallmarks of gingivobuccal oral cancer. **NIBMG** carried out integrative analysis of epigenomic (n = 87) and transcriptomic (n = 72) profiles of paired tumor-normal tissues collected from OSCC-GB patients from India. Genome-wide DNA methylation assays and RNA-sequencing were performed on high-throughput platforms (Illumina) using a half-sample of randomly selected patients to discover significantly differentially methylated probes (DMPs), which were validated on the remaining half-sample of patients.

About 200 genes showed significant inverse correlation between promoter methylation and expression, of which the most significant genes included genes that act as transcription factors and genes associated with other cancer types. Novel findings of this study include identification of (a) potential immunosuppressive effect in OSCC-GB due to significant promoter hypomethylation driven upregulation of *CD274* and *CD80*, (b) significant dysregulation by epigenetic modification of *DNMT3B* (upregulation) and *TET1* (downregulation); and (c) known drugs that can reverse the direction of dysregulation of gene expression caused by promoter methylation. In OSCC-GB patients, there are significant alterations in expression of key genes that (a) regulate normal cell division by maintenance of balanced DNA methylation and transcription process, (b) maintain normal physiological signaling (PPAR, B cell receptor) and metabolism (arachidonic acid) pathways, and (c) provide immune protection against antigens, including tumor cells. These findings indicate novel therapeutic targets, including immunotherapeutic ones for treatment of OSCC-GB.



Integrated unsupervised hierarchical clustering and heatmap using $\Delta\beta$ values of differentially methylated genes in promoter region from OSCC-GB patients depicts two major clusters of patients with distinct phenotypic features. (white box in the top panel indicates unavailability of the respective clinical information)



An integrative circos plot of epigenomic and transcriptomic alterations in OSCC-GB. The outermost track displays the human genome (hg19) ideogram by chromosome number. The second track depicts frequency distribution of epigenome-wide significantly differentially methylated CpG sites. The third track provides the distribution of coding genes, with differential methylation in their promoter regions. Hypermethylation and hypomethylation are represented by red and green colors, respectively. The fourth track presents transcriptomic profiles in autosomes—upregulated and downregulated genes are shown in purple and blue, respectively. The inner most track represents the 209 genes that showed significant inverse correlation between promoter methylation and expression. Of these 209, 36 (17.2%) genes are on chromosome 19. Heights of blue bars are proportional to the correlation coefficients. The color-coded links represent genes from the significantly dysregulated pathways ($n = 5$). Gene names from the pathways are shown outside the ideogram. (Cyan, arachidonic acid metabolism; Yellow, longevity regulating pathway; Orange, PPAR signaling pathway; Green, B cell receptor signaling pathway; Purple, acute myeloid leukemia)

Das, D., Ghosh, S., Maitra, A. et al. Clin Epigenet ***11,*** *178 (2019)*

2. Profiling of genomic alterations of mitochondrial DNA in gingivobuccal oral squamous cell carcinoma: Implications for disease progress

NIBMG has identified 164 somatic mutations in mitochondrial DNA in gingivobuccal oral cancer by deep sequencing the mitochondrial genome from paired tumor and blood DNA samples from 89 patients. NIBMG found evidence of positive selection of somatic nonsynonymous mutations. Non-synonymous mutations in mitochondrial respiratory genes were found to increase the risk of lymph node metastasis NIBMG has observed a significant reduction in mitochondrial DNA copy number in tumor DNA of these patients compared to the DNA from adjacent normal tissue samples. Analysis of transcriptome data of tumor and adjacent normal tissue revealed patients harboring mutations in mitochondrial protein-coding genes exhibited reduced expression of mitochondrial transcripts. The highlights of the findings of this study are:

- Somatic mutation signature 5'-TCN-32 / >/ 5'-TTN-32 was detected in mtDNA in OSCC-GB.
- Mitochondrial nonsynonymous somatic mutations may act as driver mutations
- mtDNA nonsynonymous somatic mutations predispose patients to lymph node metastasis.
- mtDNA copy number was down-regulated in OSCC-GB patients.
- Mutated mitochondrial genes have reduced expression in OSCC-GB tumors.

3. Establishment of Single Cell RNA sequencing technology to study tumour diversity

NIBMG has established the technology of single cell RNA sequencing based on both high throughput 3'-end counts (Chromium, 10X Genomics) and full length transcript sequencing (SMART-Seq2). Presently, work on single cell sequencing is being conducted on oral cancer.

4. Establishment of Cancer Stem Cell-Derived Gingivobuccal Oral Tumor Organoids as Novel Resource for Functional Models to Perform Preclinical Studies

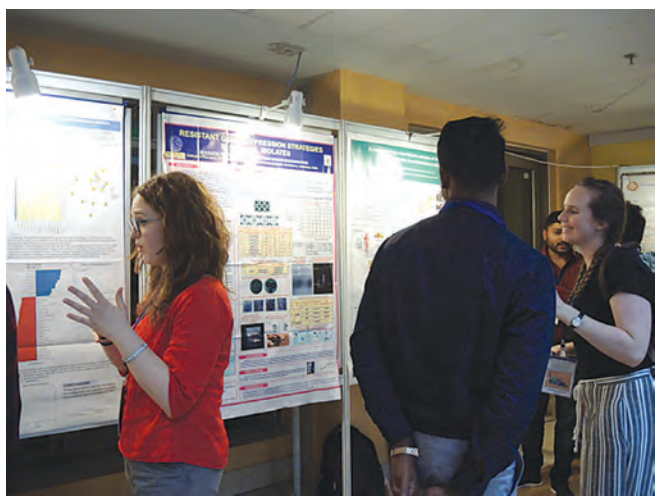
Scientists at NIBMG have been successful in developing approach to generate cancer stem cell-derived organoids from primary cultures of enzymatically-purified clusters of gingivobuccal oral tumors. Efforts are ongoing to refine the protocol for improving efficiency.

5. Population Genetics and Genetic Epidemiology

Our ongoing project with GenomeAsia 100K has resulted in its first two manuscripts. The first one has been featured in the cover page of *Nature*. Though it was published online in 2019, the printed version came out in Jan 5th 2020. We continued our exploration in excavating the history and pre-history of South and South-East Asia, with special emphasis on the Indian subcontinent. The work on population Genetics has resulted 07 publications in high impact journals.

International Symposium on Human Microbiome

An International Symposium on Human Microbiome: Resistance and Disease in NIBMG from 9-12 November, 2019 in collaboration with J. Craig Venter Institute, USA and funded by Wellcome Trust-DBT India Alliance and EMBO was organized. In this symposium, more than 20 International speakers from 10 countries shared their experience on different aspects of Metagenomics research on Human diseases. The symposium was attended by more than 50 participants from different Indian institutes as well as from other parts of the world.



Enhancing Capacity in Genomics-Driven Research in Human Health & Disease in the North-East Region : This initiative aims to empower early- and mid-career scientists working in institutions in the North-Eastern Region (NER) with state-of-the-art genetic and genomic concepts, methods and tools required for undertaking globally-competitive research on human health and disease of relevance to the NER. Under the aegis of this program, the 4th Basic Workshop and the 4th Advanced Workshop entitled "Understanding Human Disease and Improving Human Health Using Genomics-Driven Approaches" were organized.

Awards and distinctions: Scientists have been elected Fellows of the National Academy of Sciences, India and the West Bengal Academy of Science and Technology.

NATIONAL AGRI-FOOD BIOTECHNOLOGY INSTITUTE (NABI), MOHALI, PUNJAB

National Agri-Food Biotechnology Institute (NABI) was established with the objectives to promote and coordinate research of high calibre in basic and translational aspects at the interface of Agriculture, Food and Nutrition. The major areas of the institute include five core areas that deal with, improving Cereals for nutrition and processing quality; improving fruits for post-harvest quality and nutrition; basic Biology for crop improvement; diet and health, and computational biology approaches for marker and gene discovery.

Major initiatives:

- In order to provide impetus to certain research areas, NABI has hired multiple DST-Inspire faculties who will be working in identified challenging areas of Agri-Biotechnology and Food-Nutritional Biotechnology.
- NABI was recognized as a centre for pursuing Ph.D. degree in the area of Biotechnology as well as NABI scientist are now recognized as adjunct faculty of The Regional Centre for Biotechnology, Faridabad.
- A major research initiative in the form of institutional Flagship program was initiated. The Flagship program deals with the broader areas of nutritional biofortification to enhance the traits such as micronutrient, protein etc along with six other co-partners.

Salient Achievements:

- CRISPR-based editing of the *lycopene epsilon-cyclase* (*LCYå*) gene was performed in commercial banana cultivar Grand Naine (AAA). Metabolic profiling of the fruit pulp of selected edited lines showed enhanced accumulation of beta-carotene content up to 6-fold (~24 µg/g) compared with the unedited plants. The edited lines also showed either an absence or a drastic reduction in the levels of lutein and beta-carotene, suggesting metabolic reprogramming, without any significant effect on the agro-morphological parameters.
- An RNAseq approach was used to identify the candidate genes and the core pathway involved in the Fe homeostasis in wheat seedlings as submitted to NCBI with submission ID- SUB5206887 and BioProjectID-PRJNA529036. The analysis revealed that Stratgey-II mode of uptake of Fe is predominant in this crop and the biochemical role of glutathione-based responses was confirmed.
- A novel edible coating formulation based on wheat straw polysaccharide and stearic acid esterified oat bran polysaccharide has been developed for the post-harvest shelf life improvement of perishable fruit crops (Apple, Peach and Banana). The developed coating

material has the ability to extend the post-harvest quality of two major apple cultivars (*Royal Delicious* and *Rich Red*, Kinnuar) up to 30-40 days under ambient storage.The developed fruit coating material can be an alternative to animal derived shellac coating in India during transportation and storage.

- To identify the novel sources for Omega-3 Polyunsaturated Fatty Acids (PUFA), bacteria from High Altitude Lakes of Indian Himalayas were screened. Microbial community structure and the presence of genes for omega-3 long chain polyunsaturated fatty acids (ù3LC-PUFA) of microbial origin was studied in four brackish water high-altitude lakes of Indian Himalayas as well as in gastrointestinal tract of three cold freshwater trout. From this study, six novel bacterial species were also identified from the high-altitude lakes. Moreover, the six genes of PUFA synthase gene cluster from an eicosapentaenoic acid producing bacterium *Shewanella* sp. ST7T were amplified and assembled into a single gene cluster of ~20 kb size and cloned into *E. coli* for its heterologous expression.
- Previously developed high amylose wheat lines have been confirmed for their low glycemic index using *in-vivo* mice model. These lines have been developed in a good chapatti variety C306 that can be used as a genetic material for transferring into the elite cultivars of the country.

Societal impact:

- NABI has developed anthocyanin rich wheat lines. These lines were tested for their strong anti-oxidant activity. Development of different products from these wheat lines will prevent various diseases and disorders in consumers.
- The Nobel Prize Series-2019 was organized at NABI. During this occasion, more than 1700 students and teachers from different parts of Punjab participated in the inaugural day. As many as ~1000 students from different schools and colleges have visited NABI to see the Nobel Museum Exhibition at the institute.
- NABI recruited 44 trainees from various institutes and universities. The selected students were exposed to different research tools to provide them expertise in the specialized niche areas of Agri-biotechnology and Food-Nutritional Biotechnology.
- NABI hosted “Start-ups for Smart Agriculture” with the support of NITI ayog along with the National Bank for Agriculture and Rural Development (NABARD). More than 200 stakeholders, i.e., Start-ups & FPOs senior officials of concerned Ministries, State Governments, NABARD, Small Farmers Agribusiness Consortium and State Agriculture Universities of the participating northern states, i.e., Punjab, Haryana, Uttarakhand, Himachal Pradesh, Jammu and Kashmir and NCT Delhi, attended the event.

Provitamin-A rich Banana developed through genome editing

NATIONAL INSTITUTE OF ANIMAL BIOTECHNOLOGY (NIAB), HYDERABAD, TELANGANA

NIAB aims to take up research in the cutting edge area for improving animal health and productivity by integrating novel and emerging biotechnological interventions. Institute research activities are mainly focussed on animal genomics and genetics, transgenic technology, reproductive biotechnology, animal diseases, bioinformatics and nutrition enrichment. Institute has special thrust on basic research

having potential to develop novel vaccines, diagnostics and improved therapeutics for farm animals. The whole genome sequencing of Indian cattle breeds are underway as part of the major project on genomic selection for conservation of indigenous cattle breeds. In addition, institute is working on improvement of fertility of cattle through development to assays or platforms for estrous detection. Also research projects in areas of infectious diseases such as brucellosis, leptospirosis, staphylococcosis, Newcastle disease, Theileriosis, Toxoplasmosis are under process. Host pathogen interactions, virulence mechanisms, and molecular pathogenesis are being studied with ultimate objective of technology and product innovation for development of efficient diagnostic tools and novel vaccines. NIAB has initiated a program to understand the existence and spread of AMR in microbes associated with poultry birds.

Major initiatives: Institute has taken up a major Indo-UK collaborative program on "Drivers of antimicrobial resistance in poultry in India". The project is co-funded by DBT and Economic and Social Research Council (ESRC), UK. The intent is to understand AMR and design intervention strategies through multi-disciplinary approach encompassing social science, anthropology, microbiology, nutrition, economics and risk assessment.

Salient Achievements:

Livestock Genomics: The project aims to use genomics based approaches for identification of pure animals and estimation of genetic mixing in graded cattle. For achieving these objective we are using cutting edge genomics methods such as NGS and array based genotyping. Sequencing data obtained from this study will be used for extraction of SNPs and development of HD chip. The HD chip will be used for genotyping of 43 registered indigenous cattle breeds. HD chip together with developed machine learning tool will help further to identify the pure line of a breed or evaluate the level of cross breeding in an individual. The DNA samples of five milch breeds Gir, Sahiwal, Tharparkar, Red Sindhi and Kankarej have been sent for whole genome sequencing. Sequencing is done and analysis is underway. We envisage to make the chip within few months.

Transgenesis and Animal reproduction:

Testicular transgenesis in farm animals to use them as bioreactor for producing therapeutic protein in milk has been initiated at NIAB. The institute has started virosome mediated direct transgene delivery in mammary gland. Perfusion of such virosomes through teat canal in female rabbit at advanced stage of pregnancy (before 4-6 days of delivery) has helped us to target insertion of genes in mammary luminal epithelial cells. We are planning to further scale up the process for in vivo gene delivery in udder gland of goats. NIAB also initiated work to express bone morphogenetic protein 2 in milk. Another project aiming to perform transgenesis in PIG has been initiated in collaboration with ICAR Research complex for NEH region, Barapani. NIAB initiated a research activity aiming to prolong the ovarian life by finding novel primordial follicle apoptosis check points. These proteins will be targeted for modulation of its expression to prevent death of primordial follicles. A study has also been initiated to develop aptamer based point-of-care diagnostic for the detection of estrous in buffalo to assess the right time for insemination. In this aspect more than hundred aptamers against progesterone have been selected and they are being tested for specific binding characteristics. At the same time for the use of these aptamers to develop apatamer based lateral flow assay, protocols are being optimised.

Animal Diseases:

Mastitis is an important disease of milch animals. Staphylococci are the major cause of subclinical and chronic mastitis. Molecular epidemiology and genomics of bovine mastitis-associated Staphylococci are being carried out to help better devise control and intervention strategies for mastitis besides contributing to a repository of characterized strains. Work is in progress for development of diagnostics for health monitoring of laboratory animals.

Toxoplasma gondii is a parasite of medical and veterinary importance. The research carried out at NIAB has shown that antibodies to *T. gondii* are widely prevalent in small ruminants, which may cause public health problems. Current research is focussed on identification and characterization of cell cycle

regulators and immunodominant antigens of this parasite. The research aims at identifying potential drug targets and creating a robust diagnostic tool for mass screening of samples in the field.

Brucellosis accounts for huge loss to the livestock sector and poses a serious threat to public health. The available therapeutic/preventive strategies and diagnostic assays are inadequate to control brucellosis. Timely and accurate diagnosis is essential for controlling the disease in animals and humans. Several immunodominant protein antigens of *Brucella* have been identified with aim to develop improved diagnostic assays and vaccines for brucellosis. Using a high throughput siRNA screening, many host proteins have been identified, which are required for the survival of *Brucella* in macrophages. Studies are in progress to understand the role of these host proteins in the invasion and intracellular replication of *Brucella* in macrophages. A BM5 protein based ELISA based assay having DIVA capability has been developed and its validation in field samples in being carried out.

Newcastle disease is an economically important poultry disease across the globe caused by Newcastle disease virus (NDV). It is a highly contagious respiratory, neurological and/or enteric disease in chicken. In India, NDV is endemic and episodes of outbreaks despite strict vaccinations are common. Work is ongoing to develop reverse genetics system which is a valuable tool to study viral molecular biology, host-virus interactions and to establish viral vectors for developing effective multivalent vaccines. Further work is ongoing in collaboration with a chemist, Prof. Elango from Gandhigram Rural Institute, which involves screening compounds by viral plaque reduction assay in order to identify potent antiviral agent(s) against NDV.

Leptospirosis is a zoonotic and emerging infectious disease in India. It is of significant importance as India has a fast growing livestock sector and is becoming self-sufficient in production of animal products. Current vaccines provide limited protection and are unable to prevent the shedding of bacteria in urine. There is also urgent need to develop early and rapid diagnostic kit. Several surface proteins have been identified that are involved in evasion through host innate immune response (evasion through complement system and recognition through Toll like receptors). These proteins are potential candidates for developing vaccine and rapid diagnostics. Further work on immunological characterization of Leptospira LPS which is immunodominant antigen is in progress with the aim to develop LPS based conjugate vaccine. To develop novel and potent adjuvants for veterinary vaccines, work is in progress for identifying novel immunomodulators that can enhance the duration and efficacy of various vaccines used in livestock.

Point-of-care diagnostics and biosensors:

Milk and animal products are major source for the spread of antimicrobial resistance due to inadvertent use of antibiotics in livestock and poultry for better health and production. We are working towards development of aptamer based diagnostics for detection of antibiotics in milk. A novel aptamer based lateral flow assay has been developed that can detect the presence of tetracycline in milk within 5 minutes. NIAB also initiated working towards development of biosensors for detection of pesticides in animal feeds.

44 research scholars are undertaking doctoral research in the institution. More than 20 research papers have been published.

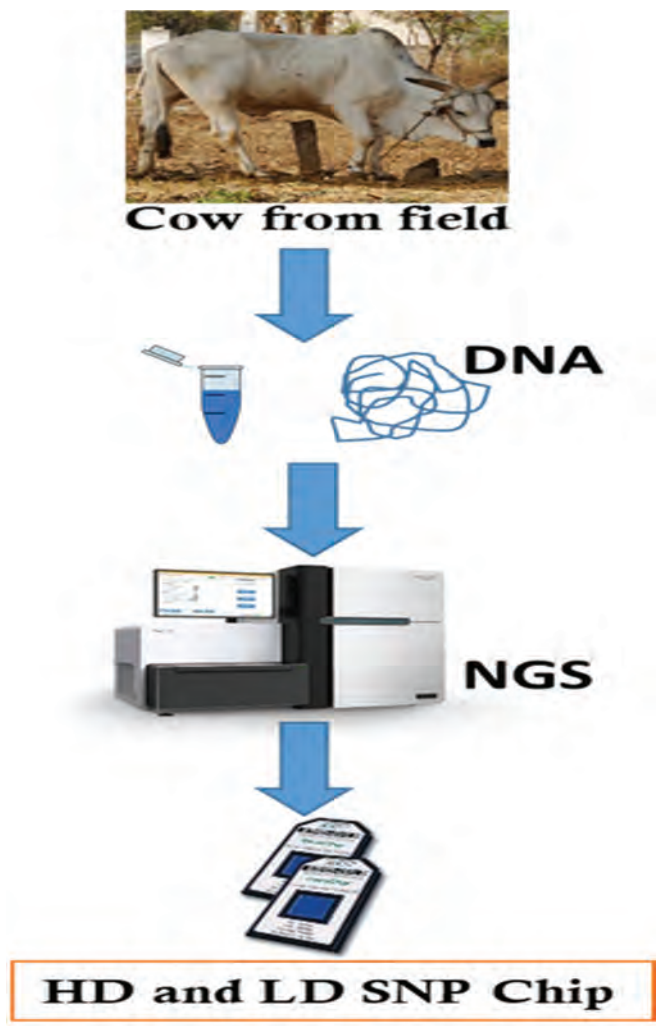
Societal impact

Bridge program: Bridge program was initiated in order to connect NIAB scientists with national educational needs of the school and colleges. The aim was to generate excitement towards science in young minds. Lectures and practicals were conducted in various higher secondary schools and colleges. Several lectures have been delivered by NIAB scientists during this period. In addition to this, several school and college students visit to the NIAB campus was organised and an Open day was also observed to facilitate visit to common people to the NIAB facilities.

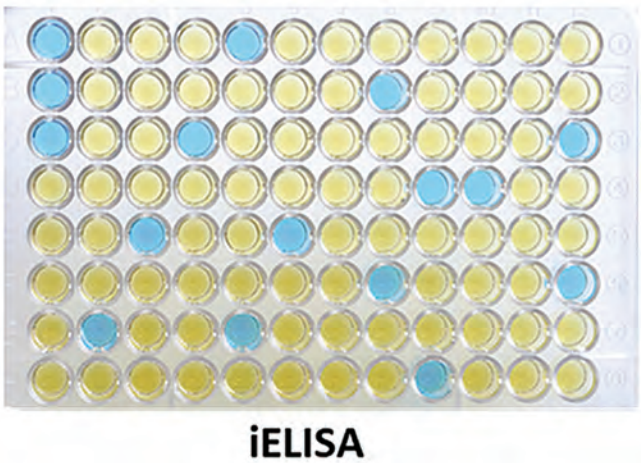
Interaction meeting with State Officials, Farming community and Experts at Yadgir-an Aspirational district in Karnataka (June 20-21, 2019)

Interaction with the scheduled tribes of Telangana to understand the ethno veterinary practices being followed for improvement of livestock health and productivity

Interaction with Munnanur and Amrabad schedule tribes and veterinarians



Steps for making the HD and LD SNP chip to know the purity of breeds of indigenous cattle.



Development of BM5 protein based Indirect ELISA to detect brucellosis in livestock with DIVA capability

CENTRE OF INNOVATIVE AND APPLIED BIOPROCESSING (CIAB), MOHALI, PUNJAB

Center of Innovative and Applied Bioprocessing (CIAB) is working in four mandate areas of research. Area-A: Value Addition to Primary Processing Residues or Wastes for Edible Products Area-B: Valorization of Crop Wastes for Specialty Products and Chemicals Area-C: Nutritionals, Nutraceuticals, and Upgradation of Value or Use of Primary Processing Bioproducts Area-D: Biosynthetic Technology/Synthetic Biology for Low Volume-High Value Products and Industrial Enzymes.

Vision: To be a nodal research and innovation organization linking leads of bioprocess and bioproduct R&D system knowledge, technology with production system, and serve as incubatorial platform for agri-process and agri-food–product related entrepreneurship along with a frontal role in translation, innovation, optimization and upscaling of approaches and technologies for bioprocessing products to catalyze agro-industrial growth through progressive functional linkages and networking/ collaborations with institutions and industries nationally and globally.

Major initiatives:

CIAB has initiated a DBT, GoI sponsored flagship programme on utilization of rice residues for value added product development. In this programme, INST, Mohali is partner institute. A very important initiative of CIAB institute is an Indo-Sweden project on development and validation of technology for production of high energy density biocoal from rice straw and other agri-biomasses with the support of PSA, GoI. CIAB has also started working on a research project entitled selective transformation of biomass-derived glycolaldehyde to C4-sugars using chemocatalysis, funded by Haldor Topsoe, Denmark.

Salient Achievements:

CIAB has licensed two technologies i) processes for development of tomato based seasoning/spice-mix and beverage and ii) iron fortified or iron added turmeric as a value added product for improving iron nutrition to M/s Aamztofaamz Technosolutions Pvt. Ltd, Mohali. Also, an agreement on a process for biotransformation of banana pseudo-stem extract into a functional juice containing non-digestible and prebiotic oligosaccharides, and nearly calorie free functional monosaccharide, and uses thereof has been signed with a startup. A patent on fragrance improvement of citronella essential oil by its enrichment with rose oxide (application no. 201611009275) has been granted by Indian patent office to CIAB.

Ultrasonication assisted salt-spices impregnation in black carrot has been found to provide protection to the anthocyanins degradation as well as retention of other quality parameters on processing like hot-air convective drying. A comparative study has been conducted to see the effect of intermittent microwave, ultrasound and conventional heating on extraction of pectin from black carrot pomace. Microwave processing integrated with conventional heating was resulted in rapid extraction and higher yield of pectin without impacting its functionality. Further, a process has been developed for the extracellular production of high purity C-Phycocyanin from Spirulina platensis for various industrial application. An improved upstream processing has been optimized for detoxification and recovery of xylitol from corncob. Also, an ethanol tolerant bacterium Acetobacter pasteurianus SKYAA25 has been identified for acetic acid production from apple pomace. Production of xylose, levulinic acid, and lignin has been demonstrated from spent aromatic biomass with a recyclable Brønsted acid synthesized from d-limonene as renewable feedstock from citrus waste. CIAB has developed lignin stabilized bimetallic and zinc oxide nanocomplexes for use as antioxidant, UV protectant, and potential antimicrobial agents. A D-Allulose 3-epimerase gene from

the metagenome of a thermal aquatic habitat has been identified and explored for D-Allulose production by Bacillus subtilis as a whole-cell catalysis. Similarly, an amylosucrase gene has been characterized from the metagenome of a thermal aquatic habitat, and its use has been shown in turanose production from sucrose biomass.

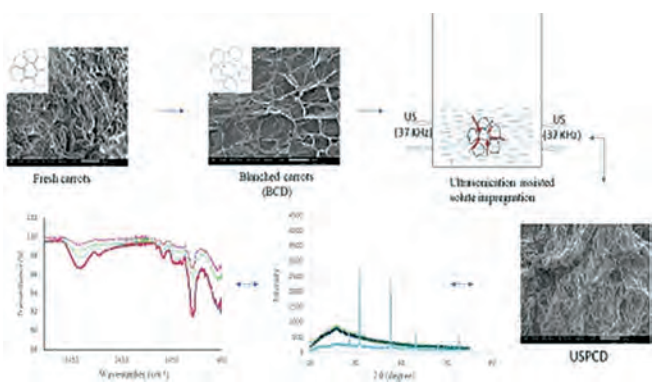
CIAB has signed MoU with CSIR-IHBT, Palampur to undertake joint academics and research in the areas of mutual interest for institutions. Institutions have agreed to collaborate their research and development areas in the field of Biotechnology, Agricultural sciences, Bioprocessing, Food and nutrition sciences. CIAB has also singed MoU with M/s Baijnath Pharmaceutical Pvt. Ltd. (BPPL), Kangra, HP singed MoU for license and sale of processes or technologies for products being developed by CIAB. CIAB and BPPL also agreed to collaborate on research projects of mutual interest. During current year, CIAB organized two major events. A three day National Conference on "Innovations in Bioprocess Technology (IBT 2019)" has been organized by CIAB. Padma Shri Dr. V. Prakash, Former Director, CFTRI, Mysore was the Chief Guest and delivered Inaugural lecture on the topic "The Science of Biotechnology in India's Food Chain – Farm to Folk to GUT". Dr. Chindi Vasudevappa, Vice Chancellor, NIFTEM was the Chief Guest during the Valedictory function. There were 40 invited talks, 100 poster presentation and 10 oral presentations. A workshop on 'Secondary Agriculture & Bioprocessing' (CIAB-SAB-2019) was also organized during 13-16 October, 2019. Workshop included talks by renowned experts in the subject area detailing importance of secondary agriculture and bioprocessing research. Hands-on training was provided on bioprocessing of biomass and characterization of value added products with equipment available at the dedicated state-of-the-art infrastructure facility of CIAB.

Societal impact

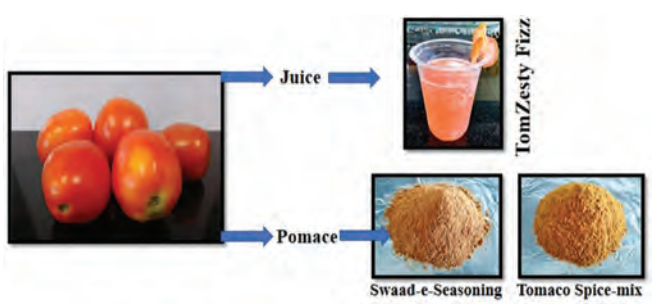
Center of Innovative and Applied Bioprocessing (CIAB) is the only institute in the country which works mainly on Secondary Agriculture and development of value added commercial products from different types of bio-resources. It also become more relevant in present context when Indian Agriculture is going on complete transformation with limited land resources and increasing input costs. In India, large amount of fruit and vegetable waste is produced on farm and at processing sites. Similarly, after having the primary produce of agriculture, secondary produce is mostly treated as waste. Such wastes are responsible for environmental pollutions. This year, three technologies developed by CIAB has been transferred to the industries for their commercialization. Institute has filed ten patents during this year and published thirty research papers in quality peer-reviewed journals. More than seventy young research scholars are working, documenting the continuous contribution of the institute on skilled professional development. Technology on processes for development of tomato based products has strong impact on the industrial revolution and societal health at large. Tomato being rich in fiber, antioxidant activity, and minerals shows potential for the development of quality nutritional carbonated beverage and spice-mix/seasonings. Technology on rare sugars like D-allulose, D-tagatose and prebiotic oligosachharides production through biological approach has strong impact on the industrial revolution and societal health at large. These rare sugars have no or very less calories and therefore of high value. These can be used in wide range of products like beverages, yogurt, ice cream, bakery products, candies, cereals and salad dressings etc.

The wide applications of functional sugars would have direct positive impact on the health of people. During current year, two very important activities were conducted i) a National Conference on Innovations in Bioprocess Technology (IBT-2019) and workshop on Secondary Agriculture and Bioprocessing (CIAB-SAB). These events have provided opportunities to the young researchers to interact with leading scientists in the field and create interest in these research areas. Also, these events have created opportunities of research collaborations. Many industries attended these events and one of the industry M/s Baijnath Pharmaceuticals Pvt. Ltd signed a MoU with CIAB on the valedictory function of the conference. Institute has conducted brainstorm meetings to evolve research program on nutraceuticals, considering the need of such initiative for the societal benefit. In addition to primary thrust of technology development, CIAB is giving equal opportunities to young students of school and colleges to see advanced translational research set up and to get familiarized with the research of international level that is being conducted at the institute.

CIAB conducted a national conference on Innovations in Bioprocess Technology (IBT-2019) during 11-13 December, 2019



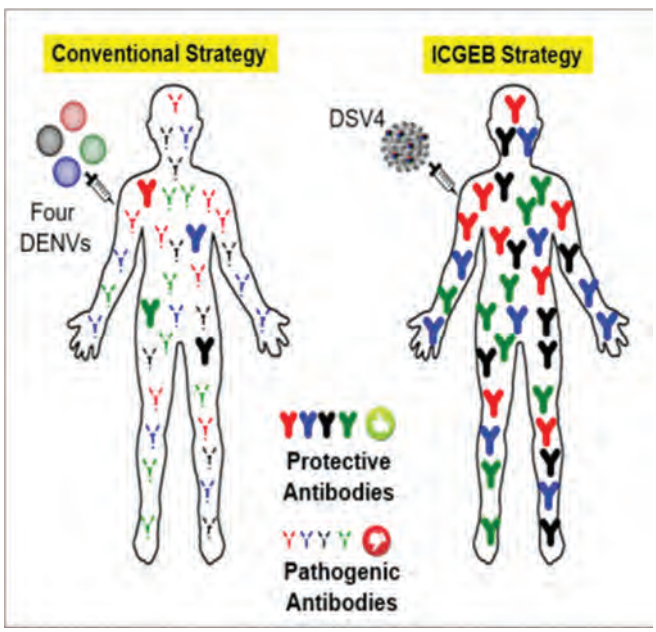
Ultrasonication assisted salt-spices impregnation in black carrots to attain anthocyanins stability, quality retention and antimicrobial efficacy on hot-air convective drying



Tomato based seasoning/spice-mix and beverage

INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY

ICGEB New Delhi component reinforced its mandate to support world class research in genetic engineering and biotechnology focusing towards issues related to developing world during the year. The year witnessed remarkable advancement in all three core domains of research; Molecular Medicine, Plant Biology and Integrative Biology and enthusiastic public and private collaborations. The year remained highly significant for ICGEB as our scientists bagged several prestigious awards such as Shanti Swarup Bhatnagar award, Young Scientist award, INSA fellowship and NASI fellowship etc; also our two projects got selected for financial support under National Bio-Pharma Mission. Our scientists were able to raise 5.16 million USD through competitive external project funding and also published 100 publications in peer-reviewed journals. Institute has filed five national and one international Patent in 2019. It is a matter of pride that one national and one US patent were also granted in this year to ICGEB.



Molecular Medicine: In the year 2019, considerable progress on ICGEB's Dengue vaccine project has been made. The project has also got financial support under the National Biopharma Misson. A US patent for this work has been recently granted to ICGEB. Patents in several countries have also been extended. The pre-clinical toxicity batch for dengue

vaccine is going on and soon the toxicology studies will be initiated. In the field of Dengue research, ICGEB-Emory vaccine is also taking strides now. The focus is studying the basic biology of dengue at a single cell level, and also mining for panels of human monoclonals from antibody secreting B cells ex-vivo from dengue patients.

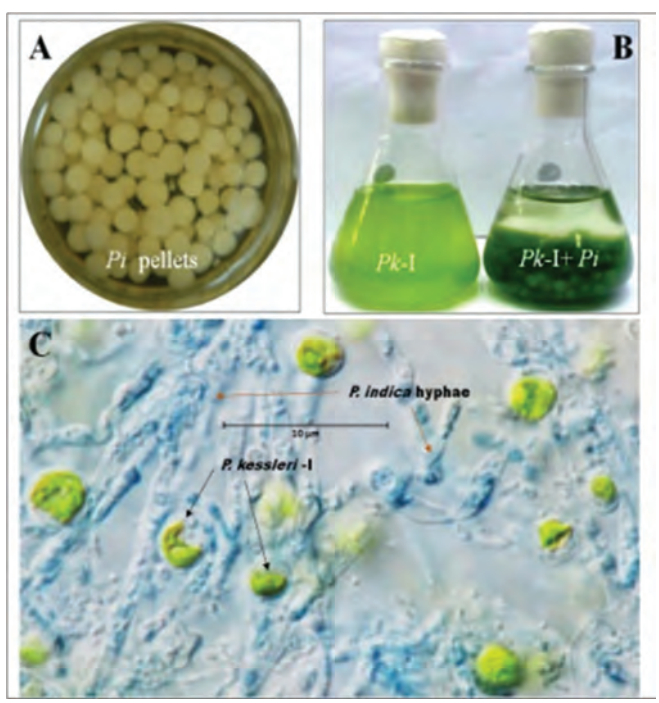
Our Malaria researchers had earlier reported identification of inhibitors for falcipain-2 enzyme and heme-detoxification protein and their higher parsidicidal activity than the artemisinin. Progressing further in this direction, it is recently found that Quninoline triazole hybrids inhibit falcipain-2 and arrest the development of Plasmodium falciparum at trophozoite stage. Malaria Biology Group is also working towards developing an effective malaria vaccine. Recently group has initiated a novel approach by screening phage display human antibody library against intact *P. falciparum* merozoite surface and 6 His tagged recombinant Merozoite Surface Proteins (MSP)-119C and 3N. The goal is to identify antibodies that can bind and block the merozoite invasion of human RBCs. In another study new leads for drug repurposing against malaria were obtained. Growth inhibition data for P. falciparum and *P. berghei* were analysed in the context of 189 and 37 drugs (total of 226), respectively. Of these, the analyses revealed 18 currently used drugs that would be suitable for further development as potential antimalarials.

The tuberculosis group has done a comparative quantitative sputum proteomics study to identify biomarkers for tuberculosis and to understand the perturbed patho-physiology in lungs of drug naïve freshly diagnosed active and non-tuberculosis patients. A biosignature consisting of 5 host sputum proteins that could differentiate drug naive active tuberculosis and non-tuberculosis cases with modest accuracy was identified. The results revealed hitherto unobserved and unexpected shift in Vitamin D binding protein (DBP) and major antimicrobial peptides (AMP) axis in lungs of tuberculosis patient, a process that is likely to favor the bacteria in surviving within the host while having a negative impact on the host.

Integrative Biology: The role played by the amino- terminal RNA recognition motif (RRM1) of PfSR1 from the solution structure of its complex with ACAUCA RNA hexamer was examined to understand how its mechanism of RNA recognition compares to human orthologs and to the C-terminal RRM. It is found that RNA binding by RRM1 is mediated through specific recognition of a cytosine base situated 5' of one or more pyrimidine bases by a conserved tyrosine residue on beta 1 and a glutamate residue on the beta4 strand. Using calorimetry and mapping of NMR chemical shift perturbations findings show conclusive evidence of complementary RNA sequence recognition by the two RRMs, which may potentially aid Pf SR1 in binding RNA with a high sequence specificity.

World-wide; the research on Biofuels focuses towards availability of cheaper feedstock and cost effective commercial production. In this direction, for Algal biofuels, studies were done on Parachlorella kessleri-I grown in standard the f/2 culture medium and the optimal flocculant concentration and pH for six inorganic, one organic and integrated flocculation processes using chemo-magnetic nanoparticle (Che-MNP) and chitosan-magnetic nanoparticle (CS-MNP) composites. This study shows that the integrated harvesting processes using Che-MNP and CS-MNP offer an effective, sustainable and rapid harvesting of P. kessleri-I for sustainable biofuel production or others potential biotechnological needs.

In another study, co-culturing of alga (*Parachlorella kessleri-I*) with endophytic fungal strains (Piriformospora indica) was done. Results showed that growing alga in association with



an endophytic fungus, enhanced the algal biomass from 471.6 to 704 mg/L, and the fatty acid methyl ester (FAME) profile of P. kessleri-I also increased substantially. The metabolites like glutamate and succinate that usually belong to the GABA (gama-Aminobutyric Acid) shunt pathway were observed to be upregulated. The study established importance of this commensal association between the endophytic fungus and autotrophic marine alga for achieving sustainability of algal biofuel industries.

Plant Biology

Understanding that edaphic factors such as salinity, sodicity, and drought may occur in combination in nature, a study was done to generate rice with tolerance to sodicity in conjunction with tolerance to salinity and drought. Using a fusion gene from *E. coli* coding for trehalose-6-phosphate synthase/ phosphatase (TPSP) under the control of an ABA-inducible promoter, marker-free, high-yielding transgenic rice (in the IR64 background) was generated that can tolerate high pH (~9.9), high EC (~10.0 dS m−1), and severe drought (30–35% soil moisture content). The transgenic plants retained higher relative water content (RWC), chlorophyll content, K+/ Na+ ratio, stomatal conductance, and photosynthetic efficiency compared to the wild-type under these stresses. Positive correlations between trehalose overproduction and high-yield parameters were observed under drought, saline, and sodic conditions. These findings revealed a novel potential technological solution to tackle multiple stresses under changing climatic conditions.

Our scientists have developed phoA overexpressing transgenic rice that minimizes the phosphate loss and contributes to weed management in the agriculture. The phoA rice lines showed improved root, shoot length and total biomass production under phosphite conditions. The results indicated that phosphate analog (phoA) alone or in combination with other Phosphite (Phi) metabolizing gene(s) can possibly be used as an effective ameliorating system for improving crop plants for phi-based fertilization and weed management strategy in the agriculture.

Societal Impact: ICGEB New Delhi has conducted three workshops in component on "Development of enzyme and microbial technologies for clean energy"; "Plant stress biology and food security"; "Florescence microscopy" respectively. These workshops were attended by almost 60 national and international participants. Beside, about 18 international personnel (including Ph.D. students) have undergone research training in various laboratories at New Delhi Component during the year. ICGEB New Delhi has also actively participated in IISF, 2019 and made enthusiastic contribution in DBT's effort to celebrate science in the country. Several schools and colleges have visited ICGEB under its outreach program and got familiarized by excellent work being carried out in one of the best scientific institution in the country. Two delegations led by Ministry of external affairs, GOI with 25-30 international delegates each were also hosted by the institute in 2019.

PUBLIC SECTOR UNDERTAKINGS

BIOTECHNOLOGY INDUSTRY RESEARCH ASSISTANCE COUNCIL (BIRAC)

Biotechnology Industry Research Assitant Council (BIRAC) is a Section 8 "Not-for-profit Company" set up by Department of Biotechnology, under Ministry of Science & Technology, Government of India, as an interface agency to promote Industry-Academia interface. BIRAC supports an enabling environment to the Indian Biotechnology Industry by promoting research & development in the field and improving capacity building across the country. BIRAC has contributed immensely to nurture the Biotech Innovation Ecosystem across India. BIRAC, through sustained handholding, has nurtured this biotech startup ecosystem over last 7 years infusing funding, technical, IP, business mentoring; connecting Angels, VCs bringing national and international strategic partnerships, policy level interventions and others.

BIRAC has so far supported 1000+ Startups, Entrepreneurs & SMEs creating Intellectual wealth (185+ IP filed) and a robust pipeline of 130+ commercialized products and technologies across the country. BIRAC's BioNEST program has supported 45 Bio-incubators creating a total space of 4,85,000+ sq. ft that is expected to grow to 50 by Mar 2020. BIRAC has created 4 Regional Centres as extended arms to implement BIRAC's mandate in the country; BIRAC Regional Innovation Centre (BRIC) at IKP Knowledge Park, Hyderabad, BIRAC Regional Entrepreneurship Centre (BREC) at C-CAMP, Bengaluru, BIRAC Regional Bio-innovation Centre (BRBC) at Venture Centre, Pune and BIRAC Regional Techno-Entrepreneurship Centre for East & North East Region (BRTC-

E&NE) at KIIT-TBI, Bhubaneswar. The ecosystem is now enriched with 2500+ Biotech Startups in the country. These Startups are in one way or the other being benefitted through various programmes of BIRAC like BIG, IIPME, SPARSH, GCI, UICs, SBIRI, BIPP, SRISTI, WInER awards etc.

BIRAC's Impact: BIRAC supports affordable product development by empowering and enabling Indian biotech innovation ecosystem. The funding schemes cover all aspects of the innovation pipeline. Following are the details of support and facilitation provided by BIRAC to startups, entrepreneurs, SMEs, academia and industry for undertaking innovative research & development activities in biotechnology sector:

Neurotouch

Smart Scope

Mobile X-ray

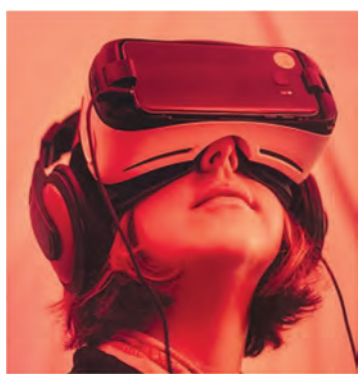
SPLAT

MushD+

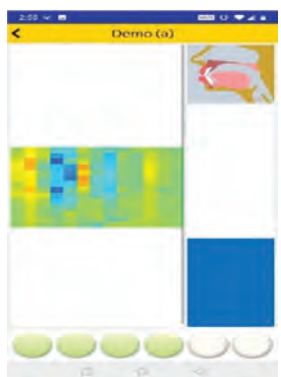
Sanmitra Hand Cranked Defibrillator

Oral nutraceutical

Paratuberculosis Point of biofilms Care Diagnostics



Virtual Reality Goggles



SeeSound App

New Products commercialized during this year

Investment schemes:

BIG (Biotechnology Ignition Grant): BIG is the flagship early stage funding program of BIRAC which has motivated and ignited more than 500 ideas over last 7 years of its operationalization. BIG has facilitated creation of more than 110 new start-ups, supported more than 90 entrepreneurs and generated more than 800 high skilled workforces. More than 125 IPs have been filed by the BIG grantees during the course of their projects. Another major highlight of the success of this programme is the ability of BIG grantees to secure follow-on flow of funds through other sources including

government and private funds. More than 60 grantees have been able to mobilize a sum of more than Rs. 250 Cr through other sources.

Small Business Innovation Research Initiative (SBIRI): SBIRI is India's first Biotech funding scheme launched by DBT in 2005 to promote Public Private Partnership. The scheme facilitates early stage research undertaken by industry/start-ups/LLPs either alone, or in collaboration with academia in the field of biotechnology for developing a product or a technology. So far, 293 projects involving 224 sole companies and 69 collaborative projects have been supported under the scheme. 50 products/ technologies have been developed/ validated through the scheme. Between January 2019 and December 2019, 3 call for proposals were announced in which a total of 183 proposals were received and 21 proposals were recommended/supported. A challenge based call for proposals was announced in October 2019. 48 proposals that were received under this call are at an advanced stage of evaluation.

Biotechnology Industry Partnership Programme (BIPP): BIPP is an advanced technology scheme which supports high risk, high innovation accelerated technology development and encourages collaborations and partnerships, between industry academia and industry-industry. So far, 210 projects involving 147 sole companies and 63 collaborative projects have been supported under BIPP. 49 Products/technologies have been successfully developed and 8 facilities have been created as research resources.

In the year 2019, 3 calls for proposals were announced out of which two were challenge based calls. A total of 128 projects were received in these calls, out of which 12 have been recommended for support and 7 are under consideration. In addition to this, 7 projects were recommended for financial support from the calls announced during the year 2018.

Promoting Academic Research Conversion to Enterprise (PACE- AIR and CRS): To encourage/ support academia to develop technology/product (up to PoC stage) of societal/national importance and its subsequent validation by an industrial partner, BIRAC has launched Promoting Academia Research Conversion to Enterprise (PACE) Program on 15th June, 2017. The Programme has two components as below.

Academia Innovation Research (AIR): The objective of Academia Innovation Research (AIR) programme is to promote development of Proof-of-concept (PoC) for a process/product by academia with or without the involvement of industry.

Contract Research Scheme (CRS): Contract Research Scheme (CRS) aims at validation of a process or prototype (developed by the academia) by the industrial partner. During 2019-20, three calls have been announced.

So far, 19 calls have been launched and 99 projects involving 83 unique academic institutions and 33 companies have been supported. 7 technologies/ products have been developed under the scheme and 2 IPs have been generated. In the year 2019, 3 calls for proposals were announced out of which two were challenge based calls. **SPARSH (Social Innovation programme for Products Affordable & Relevant to Societal Health):** SPARSH highlights the need of Innovative solutions to society's most pressing social problems. So far, 50 projects have been supported and 13 products/prototypes/technologies have been developed.

A total of 7 projects (out of 66 proposals received) under the 8th Call which was a theme based call (Waste to value, Livestock health and Improvement, New and improved agricultural tools, Reducing post-harvest losses and Combating environmental pollution) announced in January, 2019.

The Social Innovation Immersion Program (SIIP) of SPARSH has supported 33 social innovators who are trying to develop solutions for most pressing problems of the society in the field of 'Maternal and Child Health (MCH)', 'Ageing & Health' and 'Waste to Value'. To take this initiative forward, 14 new SPARSH Centres have been created pan India. Three more themes are included in addition to existing ones i.e., "AgriTech, Food and Nutrition and Combatting Environment pollution". TISS has been engaged as SPARSH Knowledge Partner. So far, 20 Social Innovators have been successful in raising follow-on funding.

SEED (Sustainable Entrepreneurship and Enterprise Development) Fund: The SEED Fund is aimed at providing first equity based capital assistance to start-ups with new

and meritorious ideas innovations and technologies. The SEED support of INR upto 30 Lakhs/startup is aimed to cover the first valley of death for potential Startups reaching TLR 3 or more. SEED fund is meant to make their Startups investible by acting as a bridge between promoters' investment and Venture/Angel investment. BIRAC operationalized the SEED fund in 2016 and implements it through BioNEST incubators. Till now 6 round of SEED Fund have been completed under which 16 incubators have been supported and 40+ startups have been supported creating a valuation of INR 370+ Cr.

LEAP (Launching Entrepreneurial Driven Affordable Products) Fund: The LEAP Fund will enable potential startups to pilot/ commercialize their products/Technologies. BIRAC's LEAP fund is aimed at providing next level funding support of upto INR 1 Cr/start up against equity and equity linked instruments. This scheme is also implemented through BioNEST incubators who have experience of handling BIRAC's SEED fund. The scheme has been operationalized recently through 6 LEAP Fund Partners.

Biotechnology Innovation Fund - AcE (Accelerating Entrepreneurs) Fund of Funds: AcE Fund is being implemented by BIRAC to promote Private Equity mobilization in the Biotech Innovation Ecosystem – an area where VC and Early Stage Angel funding is limited. The AcE fund partner is mandated to invest 2X of co-investment done by BIRAC under AcE fund. The core focus of daughter funds would be able to develop domestic innovation & manufacturing capabilities. Five AcE Fund partners are now operational and 9 new partners have been identified taking the total commitment to INR 150 Cr that will effectively infuse INR 300 Cr in this space.

ENTREPRENEURSHIP DEVELOPMENT:

BioNEST (BIRAC Bio-incubation Nurturing Entrepreneurs for Scaling up Technology): Under the BioNEST programme, BIRAC has established 45 world class incubators across the country creating a total incubation space of 485000+ sq. ft. of incubation space. These specialized Bioincubation centres provide access to high end infrastructure, incubation facility, mentoring by technical, business experts, regulatory guidance, investor and industry connect to entrepreneurs and startups. Through these Bio incubator facilities, BIRAC provides both capex and operational support for the management of these incubators. A total of 767 start ups have been supported. There are 6 BioNEST incubator soft clusters that have been created comprising of 45 incubators across the country including tier 2 cities.

SITARE (Students Innovations for Advancement of Research Explorations): BIRAC has partnered with society for Research and Initiatives for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) to support grass root level innovations. Two categories of Awards BIRAC-SRISTI GYTI Awards (wherein INR 15 lakhs is given for 2 years) and BIRAC-SRISTI Appreciation Awards (wherein INR 1 lakh is given) have been constituted to support and mentor the young innovators working at universities working at universities and schools to encourage translational research development into products/ technologies. There are 64 projects under GYTI category and more than 170 students have received support under Appreciation award category. In addition, BIRAC and SRISTI run 4 Biotech Innovation-Ignition School (BIIS) workshops of 3-4 weeks for 40-50 students/ workshop every year that provides hands on training in the areas including phytochemistry, microbiology basic biotech techniques, etc. One of these workshops was conducted for female students only.

eYUVA (Encouraging Youth for Undertaking Innovative Research through Vibrant Acceleration): The University Innovation Clusters (UIC) programme of BIRAC has helped in creating pre-incubation space where innovators (students with a Master/PhD degree) with entrepreneurial ideas can perform preliminary studies and progress it towards proof-of-concept stage. There are 5 UICs that have been created providing a dedicated incubation space of about 3000 sq. ft each, 30 fellows have benefitted from UICs and 8 fellows incorporated start-ups. The scheme is now being expanded by adding more centers and extending benefits to UG level students.

Mentorship:

BRIC (BIRAC Regional Innovation Centre) at IKP Knowledge Park BioNEST, Hyderabad

BIRAC Regional Innovation Center (BRIC) has conducted an extensive Regional Innovation System (RIS) mapping of around 10 clusters spread over Southern as well as Central India.

BREC (BIRAC Regional Entrepreneurship Centre) at C-CAMP BioNEST, Bengaluru

The regional center at C-CAMP Bangalore has been mandated to carry out various activities with an aim to promote entrepreneurial culture in the biotech sector across the country. BREC has conducted 12 awareness workshops addressing more than 1200 students, 10 workshops impacting more than 500 startups and entrepreneurs through focused learning on topics such as Biodiversity Act, Costing-Pricing issues.

BRBC (BIRAC Regional Bio innovation Centre) at Venture Centre BioNEST, Pune: Under the mentor-mixer program, 250+ entrepreneurs have been connected with mentors, 175+ participants were provided domain knowledge, 11 incubation managers trained through Practice School Immersion program.

BRTC-E&NE (BIRAC Regional Techno-Entrepreneurship Centre for East & North East Region) at KIIT-TBI BioNEST, Bhubaneswar: BRTC regional centre was initiated in March 2019 at KIIT BioNEST with an aim to develop the biotech entrepreneurial ecosystem especially laying a foundation for development of biotech cluster in East and North East Regions including Odisha, Chhattisgarh, Jharkhand, West Bengal and Bihar and the North East (Assam, Meghalaya, Guwahati, Imphal, Manipur, and Tripura). So far, 7 roadshows and 4 workshops have been conducted and more than 800 researchers, innovators and early stage startups have been benefited in North East and East region.

IGNITE: BIRAC supports participation of 5 BIG grantees every year for last 7 years in the CfEL's (Centre for Entrepreneurial Learning Cambridge Judge Business School) mentorship and capacity building programme. The program provides the participants access to the Cambridge start up ecosystem and an opportunity to learn best practice through international mentors. So far, 34 BIG grantees have been benefitted.

Road shows and IP Management Workshops: IP & technology Management workshops have been conducted so far at IIT Indore and VIT Vellore and 1 workshop is also planned in BITS Goa. In addition to this BIRAC will also be conducting one IP Clinic to provide a solution-based approach on IP & Technology Transfer related matters by engaging the BIRAC supported entrepreneurs and Start-ups.

New Partnerships:

BIRC -TATA Trust (Social Alpha – Assistive Technologies): BIRAC, with Social Alpha (FISE) has signed MoU for Unique Public-Private partnership. New initiative BIRAC-Social Alpha Quest for Assistive Technologies – supported by Mphasis' was launched to support start-ups in the Assistive Technology innovations focused on enabling and empowering solutions for persons-with-disabilities. Program would fund startups for clinical validation, designing for manufacturing & certification support as well as towards the go to market facility and commercial deployment of their products. 14 startups have been identified to receive the support under this initiative.

PHD Chambers: For creating and promoting "Biotechnology Innovation System" in states, PHDCCI has signed a MoU to enter in strategic partnership with BIRAC.

DSTE Punjab : BIRAC and DSTE Punjab have joined hands to work jointly to promote enabling ecosystem in the State of Punjab for research, innovation, entrepreneurship, start-ups, SME's, capability enhancement, technology commercialization and IPR's in the area of Biotechnology/ Life sciences.

UNHIE (UN Health Innovation Exchange) – BIRAC Partnership implement by Social Alpha: A unique programme for health innovations has been jointly announced in Nov 2019 by United Nation's Health Innovation Exchange (UNHIE), Biotechnology Industry Research Assistance Council (BIRAC) which will be implemented through Social Alpha. This unique India Accelerator Platform for Healthcare Innovations aspires to unlock the potential of the Indian Medical Technologies (MedTech) and Digital Health innovations through successful adoption of 100 Indian innovations in the next five years.

The Biotech Ecosystem: Empowerment & Scale-up:

(i) **Make in India (MII) Facilitation Cell:** Make in India is a flagship program that was launched on September 25, 2014 by the Government of India which intends to facilitate investments and build best in class manufacturing infrastructure in India. DBT and BIRAC

organized **Global Bio-India 2019** from 21st – 23rd November 2019 at Aerocity, Delhi in partnership with Confederation of Indian Industry (CII), Association of Biotechnology Led Enterprises (ABLE) and Invest India. From BIRAC, Make in India Cell led this activity.

- **Product launch during Global Bio-India 2019** - 9 products/ technologies were launched namely- See Sound Live app; skin-scope; a smart irrigation system; Enject; ZeBox; SCINTIGLO; natural pectinase enzymes; High quality next generation protein made from methane; and NEURO TOUCH

- **Lab To Market 2nd Edition:** Compilation of 111 commercialised products/ technologies of BIRAC supported startups was released during Global Bio-India 2019 (www.biotech-showcase.com).

(ii) **Start-up India:** Startup India is a flagship initiative of the Government of India, intended to build a strong eco-system for nurturing innovation and Startups in the country that will drive sustainable economic growth and generate large scale employment opportunities. To further strengthen and empower the emerging biotech startup ecosystem, DBT along with BIRAC have been implementing a detailed action plan with a mandate of promoting and nurturing the innovation research ecosystem in the country with special focus on startups.

Grand Challenges India: Grand Challenges India (GCI) is the Indian arm of Global Grand Challenges, launched in 2012 and is the flagship program managed by the PMU at BIRAC and is collaboratively funded by Department of Biotechnology (DBT), Bill & Melinda Gates Foundation (BMGF). GCI is committed to providing solutions for major public health problems especially for developing countries. GCI is seeking and rewarding established researchers, young entrepreneurs, and innovators from both academia and industry. GCI aims to help innovators expand the pipeline of ideas for developing new preventive and curative therapies, piloting new technologies, and exploring new ideas. Over the years, GCI has grown both as an idea and as a partnership covering varied themes from maternal and child health to agriculture, nutrition, infectious diseases, vaccines, AMR, health systems strengthening, big data, etc. to respond to the ever-changing needs of research in public health in India.

Till now, GCI supported six open calls and nine specialized programs in the sectors mentioned above.

INDIAN VACCINES CORPORATION LIMTED: Indian Vaccines Corporation Limited was incorporated in March 1989 as a Joint Venture Company promoted by Govt. of India (Department of Biotechnology), Pasteur Merieux Serum & Vaccines (PMSV), France and Indian Petrochemicals Corporation Limited. (IPCL-a PSU) taken over by Reliance Industries Limited (RIL)(NON-PSU) with a paid up capital Rs. 18.78 cores, with the objective of manufacturing vaccines based on Vero cell Technology to be supplied by PMSV France. The company came into existence after a joint venture was signed on 1st February 1989.

The main objective of the company was to manufacture Inject able Polio Vaccines (IPV) to be incorporated in the mass immunization programme of Govt. of India. However, IPV was not approved by W.H.O. as a result the project was put on "HOLD" in February 1992. Thereafter P.M.S.V exited from the J.V in 1998 by selling its shares to DBT. IVCOL is presently being controlled by a Board of Directors, with two Directors representing GOI (DBT) and two Directors representing RIL Company has been incurring losses for the last two years Rs.996.39 lakhs for 2016-17 and Rs.1149.19 for 2017-18 and has accumulated losses of Rs.1197.13 lakhs as of 31.03.2019.

Share holding of IVCOL at percent is as under.

Government of India (DBT)	66.67%
Reliance Industries Ltd (RIL)	33.33%

The Department is in process of finding ways on to how the immovable assets of the company can be utilized in a better way for overall benefit of the society.

Bharat Immunolgicals and Biologicals Corporation Limited (BIBCOL): Bharat Immunolgicals and Biologicals Corporation Limited (BIBCOL) is a Central Public Sector Unit (PSU) in India, promoted by the Department of Biotechnology (DBT), Ministry of Science & Technology, Government of India

with primary objective of eradication of Polio from the country. With continuous support of Department of Biotechnology, BIBCOL has achieved this vision of Government of India and now Company is in diversification mode to include other vaccines and pharmaceuticals.

BIBCOL has supplied 180.46 million doses of bOPV to Ministry of Health and Family Welfare during the year 2018-19 and has turnover of Rs. 83.64 crores. However for the year 2019-20 it is expected to make supply of 183.39 million doses of bOPV and expected turnover is of Rs. 85.90 crores.

In addition to bOPV in vaccine segment, BIBCOL has been manufacturing and marketing dispersible Zinc Tablet and Diarrhea Treatment Kit in Pharmaceutical segment. BIBCOL is in process of developing a vaccine candidate like Oral Cholera Vaccine and setting up the facility for production of plasma fractionation facility for production of plasma derived medicines (PDMs). In this regard, BIBCOL has signed MOU with NII , THSTI and IVI Korea for development of vaccines and bio therapeutics.

Further, BIBCOL has started the setting up of oral cholera vaccine production facility with the financial support from DBT/ BIRAC under NBM.

BIBCOL has contributed in the vision of Government of India to eradicate the polio from the country. BIBCOL has ambitious plans not only for its long term sustainability and better growth but making significant contributions for the better health of the masses of our country. The company is in the line of completion of its milestone towards Government of India aim for Polio-free India and will soon start the production of life saving drugs for the country at very affordable prices.

09

REGULATION, INTELLECTUAL PROPERTY AND LEGISLATIONS

Regulation, Intellectual Property & Legislations

The programme aims at implementation of the Rules, 1989 of Environment (Protection) Act, 1986 for the manufacture, use, import, export and storage of hazardous microorganisms, GE organisms or cells and products thereof for research and development. The Rules, 1989 delegated the Department of Biotechnology to administer functioning of i) Institutional Biosafety Committees (IBSCs) which operate directly from the premises of the institutions and ensures on-site assessment and monitoring of adherence to the biosafety guidelines with overall oversight of the regulatory process, at the institutional level and ii) Review Committee on Genetic Manipulation (RCGM) that monitors & reviews all ongoing research projects involving high risk category and confined field experiments and ensure the compliance of biosafety rules & regulations, as well as framing and implementation of safety measures and guidelines, while conducting research on high risk group microorganisms and GE organisms.

Biosafety Research: During the year, the RCGM evaluated more than 700 applications in its 9 meetings in the areas of agriculture, healthcare and industry. The applications were for: import/exchange of high risk group microorganisms and recombinant research related materials including seeds, gene constructs, plasmids, and vectors, living modified organisms (LMOs); conduct of pre-clinical toxicity studies and evaluation of pre-clinical study data; conduct of event selection trials (ESTs)/ Biosafety Research Level 1 (BRL1) trials in confined conditions for transgenic crops under development viz. cotton, corn, rice, chickpea and pigeon pea from universities/public & private organizations for biosafety clearance. A Central Compliance Committee (CCC) teams with more than 6 experts from entomology, pathology, silkworm biology etc., along with experts from the states and members of State Agricultural University (SAU) were constituted and visited containment facilities of genetically engineered silkworm and biosafety research trial sites and interacted with the in-charges of the trials and the Directors of Research of the respective SAUs and silkworm for monitoring the compliance of biosafety rules & regulations while conducting the trials as stipulated in Biosafety Guidelines. In the pharmaceutical sector, 19 rDNA products were permitted for conducting pre-clinical toxicity studies by private/public institutions & companies. Based on the evaluation of pre-clinical study reports, 13 rDNA products developed by private/public institutions & companies were recommended by RCGM to Drug Controller General of India (DCG (I)) for appropriate phase of clinical trials. As a measure to ensure compliance of biosafety guidelines for rDNA activities by universities, public & private institutions, laboratories, and industry through their Institutional Biosafety Committees (IBSCs), 32 new IBSCs have been constituted, while 64 old IBSCs have been renewed.

Major Initiatives

i. Reduced timelines for approval process: RCGM Secretariat is in the process of streamlining the approval process of applications submitted to RCGM. In this regard, with Internal Assessment Unit supplementing the expert review of application, the timelines have been reduced from 180 days to 90 days. To further reduce the timelines, the RCGM meetings are now being conducted every 30 days instead of 45 Days. Additionally, with the Indian Biosafety Knowledge Portal (IBKP) and online application submission, reviewing and monitoring, DBT further envisages to reduce the timelines.

ii. Indian Biosafety Knowledge Portal (IBKP): In line with Government of India's easing doing business and digital India, an online web portal has been launched recently by the Department of Biotechnology. The platform provides new scientific information on biotechnology and allow online submission of forms and their tracking. IBKP also provide India's Biosafety Regulatory information for scientific community and for public as well.

iii. Simplified procedure for Import/Export and exchange of materials

With a view to have a relaxed regulatory approval process and empowered IBSC to accord approval for import, export, and exchange of lower quantities of model organism, polynucleotides, proteins, GE organisms for R&D purposes without compromising the biosafety, a revised notification on Simplified Procedures & Guidelines on Exchange, Import & Export of GE organisms & Products thereof for R&D purpose

has been issued by DBT on 17th January, 2020 in order to bring clarity to all the Stakeholders, DBT has issued the check-list for information requirements in the application/reports on pre-clinical toxicity study of similar biologics on 31st August 2018. DBT in consultation with stakeholders has prepared a **'Guidelines and standard operating procedures (SOPs) for the conduct of event selection trials (ESTs)'** and was approved by GEAC in its 134th meeting. With this, IBSC has been authorized to accord approval of any EST conducted within Institutional own premises as such trials considering Institutional safety and security mechanism shall be followed during the trial.

iv. **Seamless co-ordination between different departments/ ministries:** DBT has taken initiatives for better coordination between various Stakeholder Departments/ Ministries. DBT has standardized the process for seamless coordination between different Departments/Ministries by inclusion of members/ nominees from relevant ministries in all the decision making committees.

Foreign Trade, In-House R&D recognition and other issues: Trade plays an indispensable role and always been a decisive parameter for the growth of country's economy. The Department had fixed and communicated Input/output norms for 4 biotechnological products. Comments on export/ import of 6 restricted items were also shared with Directorate General of Foreign Trade (DGFT) to facilitate trade in biotechnology. Incentivize the core research & developmental capabilities of various public and private establishments' remains a major boost for innovation driven industrial growth in the country. Keeping in view of the technical expertise, relevancy & essentiality of the projects, resources & manpower established, intellectual property (IP) generated, and the Department had recommended 19 R&D units of biotechnology firms under in-house R&D unit scheme to Department of Scientific & Industrial Research.

Patent facilitation and Capacity Building: The Biotechnology Patent Facilitating Cell provides single window awareness-cum-Patent facilitation (examination, filing, maintenance and follow-ups) to scientists and researchers on request for filing of Patent Co-operation Treaty (PCT) and National phase applications on inventions pertaining to Life Sciences and Biotechnology through empaneled IPR firms. US Patent on *"A Method for the Control of Nematodes in Plants"* has been granted during the year.

10

ADMINISTRATION AND FINANCE

ADMINISTRATION

The Administration Division of the Department has been consistently taking up steps to provide better infrastructure, amenities and ambience to the scientists, officers and staff working in the Department. DBT being a scientific department, a large number of scientific meetings are being held almost every day with scientists, technical experts, academicians and scholars across the country and abroad. All logistics and technical support has been provided by Administration for smooth conduct of these meetings.

Swachh Bharat Abhiyan: The Swachhta Action Plan (SAP) 2019-20 in respect of the Department was finalized at an estimated amount for Rs. 1.00 crore, out of which Rs.64.00 lakh has been utilized.

Swachhta Pakhwada 2019 (1st to 15th May, 2019) and Swachhta Hi Seva (SHS) Campaign (11th Sept. to 2nd Oct., 2019) were organized in the Department during which various activities for creating awareness along with special cleanliness drive were organized. The Department has been made Single Use Plastic free.

One unisex toilet for Divyangjan has been completed and three others are nearing completion through CPWD in the HQ office premises.

e-Office: e-office is a Mission Mode Project (MMP) under the National e-Governance Programme of the Government of India. The product is developed by NIC and aims to use in more efficient, effective and transparent inter-government and intra-government transactions and processes. It is being progressively used by the Department. The leave management system has also been activated in e-Office mode.

Government e-Market Place (GeM): During the financial year 2019-2020 the Department has made most of its public procurement of goods and services for more than Rs. 1.51 crore through GeM as per Government of India instructions.

Establishment: Establishment Section in the Department is entrusted with the following functions: -

Recruitment and promotion to various posts: 21 Scientist 'C' have been appointed on direct recruitment basis after following the due procedure i.e. written examination, interview, medical examination, police verification, verification of their character and antecedents etc. Promotion cases under Modified Flexible Complementing Scheme are being carried out from time to time.

Online APAR: For the first time completion of Annual Performance Appraisal Reports (APARs) of Scientific officers for the year 2018-19 have been started on SPARROW portal of this Department designed & developed by NIC Team.

Recruitment Rules: The Department of Biotechnology Group 'C' (Non-Gazetted, Non-Ministerial) Posts Recruitment Rules, 2019 for the Non-Statutory Departmental Canteen of this Department have been notified in the Gazette of India.

Training: More than 50 employees were deputed for various training programmes conducted by the Institute of Secretariat Training & Management (ISTM), National Institute of Financial Management (NIFM), Faridabad, Indian Institute of Public Administration, New Delhi and Administrative Staff College of India, Hyderabad to enhance their skills in relevant fields.

Modified Assured Career Progression Scheme (MACP): 28 cases for grant of Modified Assured Career Progression Scheme (MACP) to the eligible employees have been processed and their pay fixation has been done accordingly.

Review under FR-56 (J): A total of 33 employees of this Department were reviewed under FR-56 (J) as per guidelines issued by Department of Personnel & Training (DOPT) from time to time.

Grant of Advances and Reimbursement: The cases of grant of various advances, medical reimbursement and other allowances were processed as per rules in a time bound manner.

Miscellaneous: 5 posts of Multi Tasking Staff have been got revived with the approval of Department of Expenditure. Proposals for cadre restructuring of Technical and EDP Cadres of this Department have been submitted to Department of Expenditure. Requisitions have been sent to Staff Selection Commission for filling up of vacant posts of Junior Technical Assistant and Multi Tasking Staff on direct recruitment basis.

Parliamentary Matters: The meeting of the Parliamentary Standing Committee on Science and Technology, Environment & Forests was held on 25.09.2019 in the Parliament House Annexe about the functioning of the Department of

Biotechnology. Replies to about 09 Parliamentary questions pertaining to the Department were duly replied within the prescribed timeframe.

Grievance Redressal: The Department has established an effective grievance redressal mechanism to deal with the public as well as staff grievance petitions. The Department regularly updates progress, disposal and pendency of public grievances on the website of Department of Administrative Reforms & Public Grievances. A total of 399 grievances were received by the Department, from 01.01.2019 to 17.12.2019, through the CPGRAMS portal, out of which 371 have been disposed.

Vigilance Unit: A Vigilance Cell is functioning in the Department to handle vigilance and complaint cases expeditiously. In pursuance of the instructions of the 'Central Vigilance Commission', a Vigilance Awareness Week was observed in the Department and the Autonomous Institutes(AI) and Public Sector Undertakings(PSUs) under its administration from 28th October, 2019 to 2nd November, 2019. An office-wide integrity pledge taking was organized in the Conference Room of the Department. A banner was displayed at the entrance of the Department, to facilitate focus on the theme of "**Integrity-A way of life – ईमानदारी एक जीवन शैली**" which was adopted by the Central Vigilance Commission (CVC) as theme for the year 2019.

RTI Cell: RTI Cell is functioning in the Department & quarterly reports are filed timely on the RTI portal.

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 the progressive use of Hindi in every quarter and suggests corrective measures for promoting the use of Hindi. During the year, all documents issued under Section 3(3) of the Official Languages Act, 1963 were in bilingual form and the letters received in Hindi were replied to in Hindi only.

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, PVGRC, Cash section and Library in the Department have been notified to do their 100% work in Hindi. During the year, 73 officers and employees were imparted training in Hindi workshop. Hindi fortnight was organized in the Department during 01-15th September 2019, in which 8 different competitions namely, Vaigyanik shodh par bhashan, Noting & Drafting, Hindi Typing, Antakshari, General knowledge competition in hindi and Hindi Vyavahar competition, Debate, Essay writing, Kavita Path were held. The competition for general knowledge was especially held for encouraging the multi tasking staff and speech on scientific thesis for all scientists in the department and in addition Hindi Typing test for project staff. 91 officers/employees participated in various competition, out of which 68 officials won different prizes.

Successful participants in different competitions of Hindi fortnight were awarded in a prize distribution ceremony. The first prize of Rs. 5000/-, second prize of Rs. 3500/-, third prize of Rs. 2500/- and 5 consolation prizes of Rs. 1500/- each have been awarded. Wth a view to encourage writing of original books on biotechnology related subjects in Hindi, the Department has been implementing an award scheme namely "Dr. Jagadish Chandra Bose Hindi Granth Lekhan Puraskar Yojna" since 2002. Under this scheme, first prize of Rs. 1,00,000, second prize of Rs. 50,000 third prize of Rs. 25,000 and two consolation prizes of Rs. 10,000 each is given. Only One book was awarded during the competition for the scheme of 2016, wherein an award of Rs. 10,000 was given.

FINANCE: An amount of Rs.2580.34 crore was allocated as Budget Estimate for Department of Biotechnology for financial year 2019-2020. This was, at RE stage, revised to Rs.2381.10 crore. The Financial Statement showing details of Actual Expenditure during 2018-19, B.E. and R.E for 2019-20 and B.E. 2020-21 in respect of Programmes/Schemes of the Department is given at **Annexure I.**

Status of Pending C&AG Audit Paras: The Status on Action Taken Notes (ATN) on pending C&AG Paras pertaining to the Department is at **Annexure II.**

Annexure - I

Details of Actual Expenditure during 2018-19, B.E. & R.E. for 2019-20 and B.E. 2020-21

(Rs. in crores)

SL No.	Name of the Programme/Scheme	Actual 2018-19	BE 2019-20	RE 2019-20	BE 2020-21
1	2	3	4	5	6
	REVENUE SECTION				
1	Secretariat Economic Services				
1.01	Secretariat	27.81	32.31	32.31	36.48
2.01	Biotechnology Industry Research Assistance (BIRAC)	30.30	31.00	31.00	32.00
2.02	Support to Autonomous Institutions*	747.93	761.86	771.75	815.61
3.01	Biotechnology Research and Development, Human Resource Development, Research Resources Facilities	1328.83	1474.97	1315.34	1580.00
4.01	Industrial and Entrepreneurship Development	244.23	280.20	230.70	322.67
	TOTAL (Revenue Section)	2379.10	2580.34	2381.10	2786.76

** Institutes include 16 Autonomous Bodies namely: National Institute of Immunology (NII), New Delhi; National Centre for Cell Science (NCCS), Pune; Centre for DNA Finger Printing & Diagnostics (CDFD), Hyderabad; National Brain Research Centre (NBRC), Gurgaon; National Institute for Plant Genome Research (NIPGR), New Delhi; Institute of Bioresources & Sustainable Development (IBSD), Imphal; Institute of Life Sciences (ILS), Bhuvaneswar; Translational Health Science & Technology Institute (THSTI), Faridabad; Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram; National Institute of Biomedical Genomics (NIBG), Kalyani; Regional Centre for Biotechnology (RCB), Faridabad; National Agri-Food Biotechnology Institute (NABI), Mohali; Institute for Stem Cell Research and Regenerative Medicine (InStem), Bengaluru; National Institute of Animal Biotechnology (NIAB), Hyderabad; Centre of Innovative and Applied Bioprocessing (CIAB), Mohali; and International Centre for Genetic Engineering and Biotechnology (ICEGB), New Delhi.*

Annexure-II

Position of Action Taken Notes (ATN) on C&AG Audit Paras

Sl. No	Para Number and year of Report.	Number of Paras	No of para settled during year	Present Position
1.	Para No. 4.2 of C&AG Audit Report No. 2 of 2018 (Irregular grant of Promotion & entitlement) pertaining to NCCS, Pune.	One	Nil	ATN furnished has been vetted by the Audit. The Audit sought further information. 2nd ATN was sent to C&AG on 04.09.2019. The C&AG after vetting the 2nd ATN, has sent their 3rd Report for additional information. This is being prepared in consultation with the NCCS.
2.	Para No. 4.3 of C&AG Audit Report No. 2 of 2018. (Non-utilization of land procured for construction of staff quarters) pertaining to National Institute of Immunology (NII) New Delhi.	One	Nil.	ATN furnished on 03.05.2019, was vetted by the Audit. The Audit vide their communication dated 31st July, 2019 sought further information. Accordingly, 2nd ATN has been sent to C&AG on 06.01.2020.

Abbreviations

AAU	:	Anand Agricultural University
AAV	:	Adeno Associated Virus
ACTREC	:	Advanced Centre for Treatment, Research and Education in Cancer
ADBS	:	Accelerator program for discovery in brain disorders using stem cells
ADMaC	:	Advanced Animal Diagnostic and Management Consortium
AGMC	:	Agartala Government Medical College
AIC	:	Atal Incubation Centre
AIDS	:	Acquired Immune Deficiency Syndrome
AIST	:	Advanced Institute of Science and Technology
ALEAP	:	Association of Lady Entrepreneurs of India
AMR	:	Anti Microbial Resistance
ARI	:	Aghrakar Research Institute
ASD	:	Autism Spectrum Disorder
ASHA	:	Accredited Social Health Activist
ASHD	:	Accelerating the application of stem cell technology in human disease
ATGC	:	Accelerated Translational Grant for Commercialization
ATPC	:	Advanced Technology Platform Centre
B-ACER	:	Bioenergy Awards in Cutting Edge Research
BCIL	:	Biotech Consortium India Limited
BEST	:	Biotechnology Entrepreneurship Students Team
BIBCOL	:	Bharat Immunological and Biologicals Corporation Limited
BIG	:	Biotechnology Ignition Grant
BINC	:	Bioinformatics National Certification
BioCARe	:	Biotechnology Career Advancement and Re-orientation Programme
BIPP	:	Biotechnology Industry Partnership Programme
BIRAC BioNEST	:	BIRAC–Bioincubation: Nurturing Entrepreneurs for Scaling up Technology
BIRAC	:	Biotechnology Industry Research Assistance Council
BiSEP	:	Biotechnology Skill Enhancement Program
BITP	:	Biotech Industrial Training Programme
BLiSS	:	Biotechnology Labs in Senior Secondary schools
BMGF	:	Bill and Melinda Gates Foundation

BMP	:	Bone Morphogenetic Protein
BP	:	Biofuture Platform
BRBC	:	BIRAC Regional Bio-innovation Centre
BREC	:	BIRAC Regional Entrepreneurship Centre
BRIC	:	BIRAC Regional Innovation Centre
BSC	:	Biotech Science Cluster
BSL:3	:	Biosafety Level: 3
BSU	:	Biosafety Support Unit
Bt	:	*Bacillus thuringiensis*
bTB	:	Bovine Tuberculosis
BTISNet	:	Biotechnology Information System Network
BTV	:	Bluetongue Virus
Cas9	:	CRISPR Associated Protein 9
CBD	:	Centre for Biodesign and In vitro Diagnostics
C-CAMP	:	Centre for Cellular and Molecular Platforms
CCBT	:	Centre for Chemical Biology and Therapeutics
CCMB	:	Centre for Cellular and Molecular Biology
CDA	:	Congenital Dyserythropoietic Anaemia
CDFD	:	Centre for DNA Fingerprinting and Diagnostics, Hyderabad
cDNA	:	Complementary Deoxyribonucleic acid
CDSCO	:	Central Drugs Standard Control Organization
CEIIC	:	Clean Energy International Incubation Centre
CHO	:	Chinese Hamster Ovary
CIAB	:	Centre for Innovative and Applied Biotechnology, Mohali
CIFA	:	Central Institute of Freshwater Aquaculture
CIFE	:	Central Institute of Fisheries Education
CITH	:	Centre for Inflammation and Tissue Homeostasis;
CKD	:	Chronic Kidney Disease
CMC	:	Christian Medical College
CMS	:	Cytoplasmic Male Sterility
CNS	:	Centre for Neurosynaptopathies
CoE	:	Centre of Excellence
CPV	:	Canine Parvo Virus

CRISPR	:	Clustered Regularly Interspaced Short Palindromic Repeats
CRUK	:	Cancer Research UK
CSCR	:	Centre for Stem Cell Research
CSF	:	Classical Swine Fever
CSIR	:	Council of Scientific & Industrial Research
CTEP	:	Conference, Travel, Exhibition and Popular Lectures
CTRTI	:	Central Tasar Research & Training Institute
DAC&FW	:	Department of Agriculture Cooperation and Farmers Welfare
DBT	:	Department of Biotechnology
DBT-BUILDER	:	DBT- Boost to University Interdisciplinary Departments of
DNA	:	Deoxyribonucleic Acid
DST	:	Department of Science & Technology
E. coli	:	*Escherichia coli*
EGF	:	Epidermal Growth Factor
EGFP	:	*Enhanced Green Fluorescent Protein*
ELISA	:	Enzyme: Linked Immunosorbent Assay
EMBO	:	European Molecular Biology Organization
ENM	:	Ecological Niche Modelling
Env	:	Envelope
ESC	:	Embryonic Stem Cell
ESRF	:	European Synchrotron Radiation Facility, France
eYUVA	:	Encouraging Youth for Undertaking Innovative Research through Vibrant Acceleration
FADH	:	Farmed Animal Disease and Health
FAEE	:	Fatty Acid Ethyl Ester
FDA	:	Food and Drug Administration
Fe	:	Iron
FIRST Hub	:	Facilitation of Innovation and Regulation for Start-ups and Innovators
FOA	:	Funding Opportunity Announcement
FTIR	:	Fourier Transform Infrared Spectroscopy
GADVASU	:	Guru Angad Dev Veterinary and Animal Sciences University
GCI	:	Grand Challenges India
GETIN	:	Genome Engineering / Editing Technologies Initiatives
GFAP	:	Glial Fibrillary Acidic Protein

GIFT	:	Genetically Improved Farmed Tilapia
GIST	:	Global Indian Science & Technology Stakeholder
GMP	:	Good Manufacturing Practice
GWAS	:	Genome Wide Association Studies
HC	:	Horn Cancer
HCG	:	Human chorionic gonadotropin
HEL	:	High Egg Layers
HESCO	:	Himalayan Environmental Studies and Conservation Organization
HIV	:	Human Immunodeficiency Virus
hMSCs	:	Human Mesenchymal Stem Cells
HPLC	:	High performance liquid chromatography
HPV	:	Human Papilloma Virus
HSC	:	Haematopoietic Stem Cell
HSP90B1	:	Heat Shock Protein 90 Beta Family Member 1
HVTR	:	HIV Vaccine Translational Research laboratory
HTIC	:	Health Care Technology Innovation Centre
HTL	:	Hydrothermal Liquefaction
IAA	:	Indole-3-acetic Acid
IARI	:	Indian Agricultural Research Institute
IAVI	:	International Aids Vaccine Initiative
iBEC	:	Indian Biological Engineering Competition
IBIN	:	Indian Bioresource Information Network
IBSD	:	Institute of Bioresources & Sustainable Development
ICAR	:	Indian Council of Agriculture Research
ICGEB	:	International Centre for Genetic Engineering and Biotechnology
ICMR	:	*Indian Council of Medical Research*
ICRISAT	:	The International Crops Research Institute for the Semi: Arid Tropics
ICT	:	Institute of Chemical Technology
ID	:	Intellectual Disability
IDA	:	International Depository Authority
IGEM	:	International Genetically Engineered Machine
IGR	:	Insect Growth Regulatory
IICB	:	Indian Institute of Chemical Biology

IISc	:	Indian Institute of Science
IISER	:	Indian Institutes of Science Education and Research
IISF	:	India International Science Festival 2018
IISR	:	Indian institute of Sugarcane Research
IIT	:	Indian Institute of Technology
ILS	:	Institute of Life Sciences
IMHA	:	Immune Mediated Hemolytic Anemia
inStem	:	Institute for Stem Cell Biology and Regenerative Medicine
IPM	:	Insect Pest Management
IPSc	:	Induced Pluripotent Stem Cells
IRRI	:	International Rice Research Institute
ISAP	:	Indian Society of Agribusiness Professionals
IUAC	:	Inter University Accelerator Centre
IVRI	:	Indian Veterinary Research Institute
IWGSC	:	International Wheat Genome Sequencing Consortium
IYBA	:	Innovative Young Biotechnologist Award
JNCASR	:	Jawaharlal Nehru Centre for Advanced Scientific Research
JNU	:	Jawaharlal Nehru University
KDa	:	Kilo Dalton
Kg	:	Kilogram
KIHT	:	Kalam Institute of Health Technology
KVK	:	Krishi Vigyan Kendra
LAMP	:	Loop Mediated Isothermal Amplification
LCA	:	Life Cycle Analysis
LCLs	:	Lymphoblastoid Cell Lines
LEL	:	Low Egg Layers
LFA	:	Lateral Flow Assay
LLP	:	Limited Liability Partnership
LPS	:	Lipopolysaccharide
LTBI	:	Latent TB Infection
MAB	:	Marker Assisted Breeding
MCC	:	Microbial Culture Collection
MDR	:	Multi Drug Resistant

MeitY	:	Ministry of Electronics & Information Technology
MESC	:	Mouse Embryonic Stem Cells
MI	:	Mission Innovation
mIRNA	:	Micro RNA
MOEF & CC	:	Ministry of Environment, Forest and Climate Change
MoU	:	Memorandum of Understanding
mRNA	:	Messenger RNA
MSSRF	:	M. S. Swaminathan Research Foundation
MSW	:	Municipal Solid Waste
NAARM	:	National Academy of Agricultural Research Management
NABI	:	National Agri-Biotechnology Institute, Mohali
NAFLD	:	Non-Alcoholic Fatty Liver Disease,
NAHD	:	Novel approaches to hematological disorders
NaMoR	:	National Mouse Resource Facility; iPSC: Induced pluripotent Stem Cells;
NBFGR	:	National Bureau of Fish Genetic Resources
NBPGR	:	National Bureau of Plant Genetic Resources
NBRC	:	National Brain Research Centre
NBRI	:	National Botanical Research Institute
NCBI	:	National Center for Biotechnology Information
NCBS	:	National Centre for Biological Sciences
NCCS	:	National Center for Cell Science
NCD	:	Non Communicable Disease
NCI	:	National Cancer Institute
NCMR	:	National Centre for Microbial Resource
NCR	:	National Capital Region
NCSTCP	:	National Certification System for Tissue Culture Raised Plants
NDV	:	Newcastle Disease Virus
NDVI	:	Normalized difference vegetation index
NEERI	:	National Environment Engineering Research Institute
NEI	:	National Eye Institute
NER-BPMC	:	North Eastern Biotechnology Programme Management Cell
NESC	:	North East Students Conclave
NGO	:	Non-Government Organization

NIAB	:	National Institute of Animal Biotechnology, Hyderabad
NIAID	:	National Institute of Allergy and Infectious Disease
NIB	:	National Institute of Biologicals
NIBMG	:	National Institute of Biomedical Genomics
NIH	:	National Institute of Health
NII	:	National Institute of Immunology
NIIST	:	National Institute for Interdisciplinary Science and Technology
NIMHANS	:	National Institute for Mental Health and Neuro Sciences
NIMS	:	Nizam's Institute of Medical Sciences
NIPER	:	National Institute of Pharmaceutical Education and Research
NIPGR	:	National Institute of Plant Genome Research
NLDB	:	National Liver Disease Biobank
NRCPB	:	*National Research Centre on Plant Biotechnology*
NSOIM	:	National Social Organization & Institution Meet,
NSTC	:	National Science Teachers' Congress,
OBC	:	Other Backward Class
OSMoSys	:	Online Submission and Monitoring System
PACE	:	Promoting Academic Research Conversion to Enterprise
PAS	:	Periodic Acid–Schiff
PAU	:	Punjab Agricultural University
PBMC	:	Peripheral Blood Mononuclear Cells
PCBR	:	Policy Centre for Biomedical Research
PCL	:	Poly-capro Lactone
PCR	:	Polymerase Chain Reaction
PDP	:	Process Design Package
PGGF	:	Plant Genomics and Genotyping Facility
PGPM	:	Plant Growth Promoting Microbes
POC	:	Program of Cooperation
PPP	:	Public Private Partnerships
PSCST	:	Punjab State Council for Science &Technology
PTB	:	Pre term Birth
QTL	:	Quantitative Trait locus
R&D	:	Research and Development

RBC	:	Rural Bio-resource Complex
RBPT	:	Research Based Pedagogical Tools
RCB	:	Regional Centre for Biotechnology, Faridabad
RGCB	:	Rajiv Gandhi Centre for Biotechnology
RNAi	:	RNA Interference
RRSPF	:	Research Facility and Resources Technology Platform
SAEN	:	Secondary Agriculture Entrepreneurial Network
SAVI	:	Soil-adjusted Vegetation Index
SBIRI	:	Small Business Innovation Research Initiative
SCT	:	stem cell transplantation
SDG	:	Sustainable Development Goal
SIB	:	School of International Biodesign
SITARE	:	Students Innovations for Advancement of Research Explorations
SLE	:	Systemic Lupus Erythematosus
SMEs	:	Small and Medium Size Enterprises
SNP	:	Single Nucleotide Polymorphism
SPARSH	:	Social Innovation programme for Products Affordable & Relevant to Societal Health
SPF	:	specific Pathogen-Free
SPV	:	Special Purpose Vehicle
SyMeC	:	Systems Medicine Cluster
TAG	:	Technical Advisory Group
TANUVAS	:	Tamil Nadu Veterinary and Animal Sciences University
TB	:	Tuberculosis
TCN	:	Total Cell Number
TEM	:	Transmission electron microscopy
TERI	:	The Energy and Resources Institute
THSTI	:	Translational Health Science and Technology Institute
TME	:	Turbo Methanolic Extract
TNAU	:	Tamil Nadu Agricultural University
TRAC	:	Translational Research Advancement Committee
TWAS	:	The World Academy of Sciences
UAS	:	University of Agricultural Sciences
UDSC	:	University of Delhi South Campus

ULBs	:	Urban Local Bodies
UTI	:	Urinary Tract Infection
VAP	:	Vaccine Action Program
VGCP	:	Vaccine Grand Challenge Programme
VNCI	:	Virtual National Cancer Institute
VRP	:	Visiting Research Professorship
WBSU	:	West Bengal State University
WFCC	:	World Federation for Culture Collections
WHO	:	World Health Organization
WWTT	:	Waste Water Treatment Technology
Zn	:	Zinc
ZnF	:	Zinc Finger

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Designed & Printed by : Indu Cards & Graphics, Chawri Bazar, Delhi-06 M. 9811419531