सत्यमेव जयते

Department of Biotechnology

Ministry of Science & Technology
Government of India

Annual Report

January 2018-March 2019

"Attaining new heights in biotechnology research, shaping biotechnology into a premier precision tool of the future for creation of wealth and ensuring social justice – specially for the welfare of the poor"

Composition of the Committee for compilation of Annual Report 2018-19

1. Dr. Alka Sharma, Scientist G – Chairperson
2. Dr. Sandhya Shenoy, Scientist E – Member
3. Dr. Sangita Kasture, Scientist E – Member
4. Dr. Manoj Singh Rohilla, Scientist E – Member
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8. Shri. J. K. Dora, US(A) – Member
9. Dr. Nitin Kumar Jain, Scientist E – Member Secretary

ANNUAL REPORT

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01

OVERVIEW

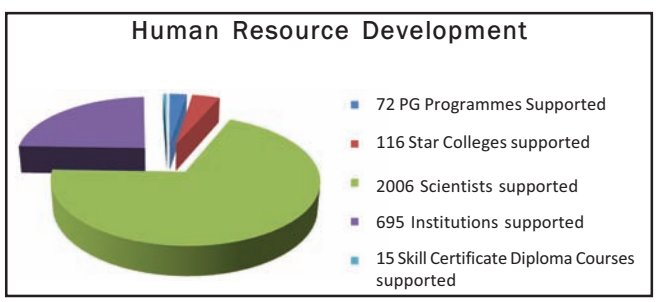
The Department of Biotechnology (DBT), under the Ministry of Science and Technology setup in 1986 has laid emphasis on promotion of excellence and innovation for discovery, early and late stage translational research in the areas of agriculture, affordable healthcare & medical technology, food & nutritional security, animal biotechnology, environmental safety, clean energy & bio-fuel, bio-manufacturing, etc. Innovation driven research in biotechnology and modern biology is being facilitated and supported by the Department through its various schemes across the country. Building capacity in cutting edge areas of research, developing right kind of infrastructure, building new national and international partnerships, development of products and their commercialization for a robust bio-economy and establishment of India as a world-class bio-manufacturing hub for developing and developed markets are the major thrust of the Department.

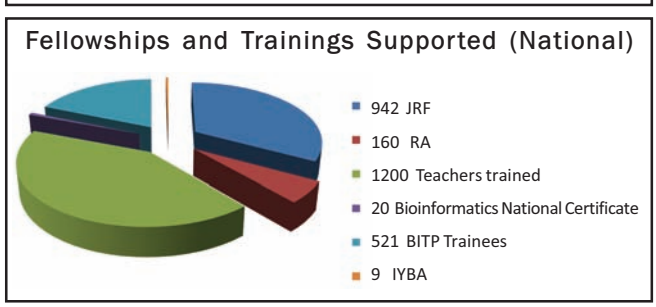
To infuse momentum in the growth of biotechnology sector in the country, DBT has formulated the National Biotechnology Development Strategy in consultation with the stakeholders including scientists, educators, policy makers, leaders of industry and civil society, voluntary and non-governmental organisations, regulators and international experts. The strategy emphasizes the need for building a skilled workforce and leadership through specialized training programs for professionals to facilitate technology competence, creating new career options for students aimed at motivating young minds towards biotechnology, arranging faculty improvement program for continuous improvement and attracting skills for imbibing scientists and post docs. Establishing core facilities and instrumentation, creating specialized centres in and around existing institutes, strengthening core capacities in the existing institutes and also establish new theme based institutes, data centres and repositories are also the key components of this strategy. This also includes enhancement of research opportunities to provide sustained support to basic sciences, promote multi-disciplinary research in biology, attract non-biologists to address biological questions; encourage emerging technologies and foster global & national alliances. The focus is also on nurturing innovation & entrepreneurship to embed translational capacity in all major research centres and institutes, provide support for business incubation, technology validation and scale-up infrastructure; promote public-private partnership and setting up of bioclusters.

Building Capacities - Human Resource Development, Trainings, Workshops

The Department is implementing an Integrated Human Resource Development Programme across the country. Building a skilled workforce is the key for strong, sustainable and balanced growth of the biotechnology sector. This year, DBT has implemented 15 new skill development courses for Post Graduate Certificate/Diploma with an objective to provide high quality hands on training in tools and techniques in Medical Biotechnology, Agricultural Biotechnology and Computational Biology. With an aim to create specialized training programs for professionals, "The Bharat Boston Bioscience Beginning (B4) - Phase II" was launched with a provision for 16 postdoctoral students to undergo training in Harvard University for two years. 100 young students will also be trained in emerging technologies under this program. Ten years of Joint partnership of DBT-India Wellcome Trust Alliance was also recently celebrated.

In addition to the new programmes, 15 Scientists were selected this year for National Bioscience Award for Career Development; 9 scientists were awarded Innovative Young Biotechnologist Award; 2 scientists were supported for National Women Bio-scientist (Senior, Junior) Award for Biotech Product, Process Development and Commercialization; 2 outstanding scientists were awarded Distinguished Biotechnology Research Professorship Award and 75 scientists were selected for the Ramalingaswami re-entry fellowship. Under finishing school program for skill





enhancement of biotechnology students, 89 students were supported.

Research and Development, Demonstration and Translational activities

Agriculture and Allied Areas: Application of biotechnological tools and techniques in agriculture and allied areas including livestock and fisheries has led to various new developments this year. New Wheat variety Unnat PBW343, resistant to leaf rust and stripe rust was developed by the scientists at PAU, Ludhiana through marker assisted backcross breeding approach. This variety is an improved version of mega variety PBW343. Two bacterial blight resistant Basmati rice varieties Pusa Basmati 1728 and Pusa Basmati 1718 were developed and subsequently released by Central Variety Release Committee after testing. Of these, Pusa Basmati 1728 is a replacement of Pusa Basmati 1401 and Pusa Basmati 1718 is replacement of Pusa Basmati 1121, which are together grown on almost 1.40 million ha. area currently. This year also saw the establishment of DBT-PGGF "Plant Genotyping and Genomics Facility" (PGGF) anchored at NIPGR, New Delhi in PPP mode. This national facility is a "single-window service system" for advanced genomics technology services that could positively influence the Indian Seed industry.

Bioenergy, Bioresource & Environment: The DBT-ICT Centre for Energy Biosciences at Mumbai has announced a new project on Next Generation Waste Treatment Technology Platform, comprising three novel technologies. A 1MLD capacity sewage water processing plant would be built to showcase the Next Generation Treatment Technology in an integrated manner. Microbial Resource Repositories have been established at NIMR, Pune and IBSD, Imphal. Hippophae Germplasm centre developed at IHBT, Lahoul Spiti. Pan India network on conservation of thretened plants resulted into significant contribution on conservation. Lindane bioremediation technology and Phytoremation technology for tertiary treatement of textile industry wastewater have been developed. Initiatives taken on forest biotechnology in protected area networks.

Healthcare and Medical Technology: DBT has made concerted efforts in the area of healthcare and medical biotechnology. This year, DBT's Indo-US Vaccine Action Programme (VAP) & the Vaccine Grand Challenge Programme (VGCP) scored high with achievements like the lowest cost Rotavirus vaccine which became part of the universal immunization programme & major strides towards vaccine for diseases like malaria & dengue. Vaccine for falciparum malaria is under toxicology assessment (JAIVAC 2) and vaccine for vivax malaria has completed phase I trial (JAIVAC1).

A comprehensive program for prevention and control of sickle cell anemia and thalassemia has also been initiated in phased manner starting with four districts of Odisha, namely Khorda, Sambalpur, Balasore and Koraput (Aspirational district). A comprehensive study in India titled "Dementia Science Programme: Incidence/ Prevalence/ Risk/ Intervention analysis of dementia and basic research thereof" was launched with an aim to provide reliable data regarding incidence, prevalence, biomarkers and risk and protective factors associated with the pathology of dementia.

Devices, Implants, Make-in-India, Start-up India, Bioincubators (in collaboration with BIRAC): In order to promote Startup India initiative, the Department alongwith BIRAC has launched various schemes and programmes. BIRAC has supported additional 4 number of new Bio-incubators during 2018 through BioNEST scheme. As per one of the recommendations of the inter-ministerial meetings at NITI Aayog, DBT has set up a facilitation cell (FIRST HUB) with the Secretariat at BIRAC to address the queries of the start-ups and innovators by the representatives of CDCSO, NIB, DBT, BIRAC, etc. With an aim to promote Make in India, BIRAC & KIHT (Kalam Institute of Health Technology) have collaborated to facilitate start-ups, entrepreneurs, researchers, academicians, incubation centres & SMEs in the area of Testing & Standardization of Medical Devices.

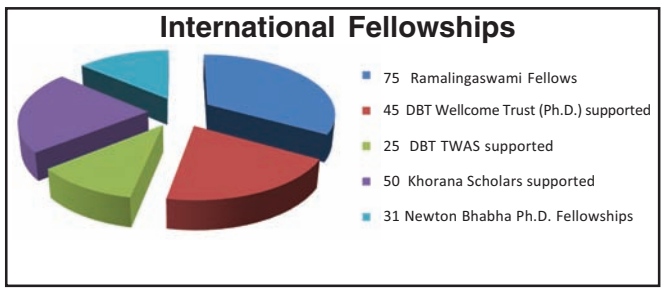
Societal Development Program: The emphasis of DBT is on promotion of use of biotechnological processes and tools for the benefit of the society comprising rural, SC/ST and women community. More than 12900 rural, SC/ST and women population have benefited through the implementation of various projects during the year. To cater to aspirational districts programme of Government of India, DBT has launched a new programme on "Rural Bioresource Complex". In the first phase, 9 proposals were awarded funding to address some of the pertinent issues related to health & nutrition and agriculture & allied areas using

biotechnological tools, techniques and processes for bringing aspirational districts in the mainstream.

Biotech Science Clusters: Recognising the need for creating an enabling ecosystem for connecting university and academic researchers, national laboratories, incubators, technology management units, industries SMEs, start-ups and entrepreneurs, the concept of setting-up of Bioclusters across the country was developed as part of the National Biotechnology Development Strategy. Accordingly, four Bioclusters have been established at Faridabad, Bangalore, Kalyani and Pune. Some of the significant achievements under the bioclusters established so far include: establishment of a national structural biology facility with electron cryo-microscope and other instruments, an Advanced Technology Platform Centre (ATPC) that would act as a catalyst for multidisciplinary basic and translational research, an incubator facility that will facilitate prototype to product conversion for devices and implants, study of large data analysis on problems ranging from plant pathogen interactions to understanding neuronal circuits, and establishment of SyMeC: a platform - both intellectual and logistical for generating required biological and medical evidence to accelerate systems medicine.

International Partnerships

DBT is successfully running international collaborative programmes with a number of countries and philanthropic organisations in different areas of Biotechnology. This year, DBT has signed a Programme of Cooperation (PoC) with Swedish Governmental Agency for Innovation Systems (Vinnova), Sweden. Broad subject areas of cooperation under the programme are Bio-based economy, Biomaterials, Health and lifesciences, biomedical devices, start-ups, incubators, test beds and bio clusters. Joint call for proposal under Horizon 2020 (Indo - EU Research and Innovation programme) has also been announced with the goal to ensure free flow of knowledge, expertise and enable public as well as private sector to work together towards delivering solutions to big challenges being faced by our society. Under Indo-Philippines collaboration on training of women farmers, 35 women farmers from 7 States attended training programme on "Advances in Rice Production for Women Farmers" In the Phase II of the programme, 8 women farmers have undergone advanced training at Los Banos, Philippines. The Department in collaboration with European Union (EU) announced the EU-India call on "*Next Generation Influenza Vaccine to protect citizens worldwide*" in July, 2018. Both the European Commission and DBT have committed equal contribution of EUR 15 million under the programme.

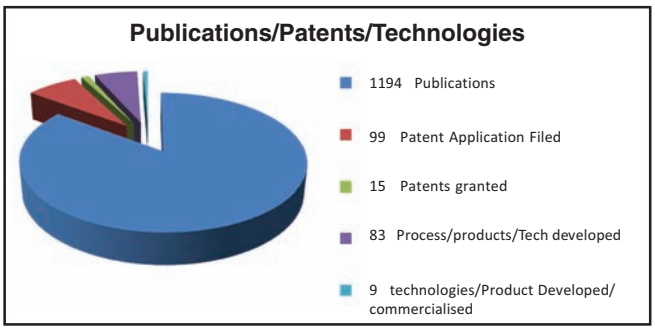


Highlights of the year are as follows :

- A major Mission program on Antimicrobial Rxesistance (AMR) was launched in October, 2018 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.
- Initiated discussion with all the stakeholders to plan for a mission program on Artificial Intelligence for affordable and accessible healthcare- Big Data and Genomics.
- Accelerated Translational Grant for Commercialization (ATGC) was launched to encourage technological innovation by providing funding opportunities for fundamental research that is explicitly aimed towards application development.
- Indo-US collaboration on Genome Engineering/ Editing was launched to provide opportunity to brightest Indian students and scientists to gain exposure and access to world class research facilities in leading U.S. institutions through student's internship, overseas fellowship and visiting professorship programmes.
- Secondary Agriculture Entrepreneurial Network (SAEN) was launched in 2018 which is led by The Punjab State Council & Technology (PSCST) and other partners, such as, National Agri Food Biotechnology Institution (NABI),

Centre for Innovative and Applied Bioprocessing (CIAB) and BIRAC's BioNEST - Panjab University (BioNEST-PU). The project aims to promote new enterprises and to support existing industry in the secondary agriculture sector.

- Cattle Genomics programme was launched to improve the germplasm of Indian Cattle breeds. The aim of this programme is to identify elite animal at an early stage and also to reduce the cost and time interval of breeding programme in future.
- A new regional center, BIRAC Regional Bio-innovation Centre (BRBC) was established at Venture Centre, Pune. BRBC is mandated to be a high quality national resource center for regulatory guidance to startups, training of Incubator managers, etc. and to support and promote Entrepreneurship in Life Sciences.
- India-UK Cancer Research Initiative launched in collaboration with Cancer Research UK (CRUK) focussing on affordability of cancer prevention and care, and the potential to make significant progress against cancer consequences. Both CRUK and the DBT will invest £5m (~47 Crores INR) each in this initiative.
- Ten years of successful joint partnership of DBT-India Wellcome Trust Alliance for three-tier fellowship programme on Biomedical Research at post-doctoral level was celebrated.
- First Clean Energy International Incubator has been set up under Mission Innovation. Under this program, start ups from 23 participating EU countries can potentially come & incubate in India and likewise start ups from this incubator can go to the partnering countries, thus facilitating access to global opportunities



Overview of the major achievements during the year in terms of publications, patents and technologies has been depicted in the figure:

Autonomous Institutions

The Department has also established 16 theme based institutions across the country. These institutions are pursuing basic, discovery and translational research in line with the National Missions in the areas of agriculture biotechnology, animal biotechnology, medical biotechnology, clean energy and bioresourse development, secondary agriculture, etc. The institutions also have mandate of human resource development and societal outreach. During the period, all the autonomous institutes of DBT have initiated flagship programme based on their core competence in the respective areas. Steps were taken to harmonize Recruitment Rules (RRs) of all autonomous Institutions. Department signed MoU with all DBT Autonomous Institutions. New positions have been created at THSTI, Faridabad and InStem, Bangalore.

Some of the achievements of these institutes during the year are summarized below:

- Center for DNA Fingerprinting and Diagnostics, (CDFD) Hyderabad, is providing patient services for genetice disorders at the Nizam's Institute of Medical Sciences (NIMS), Hyderabad, through an MoU. CDFD has developed a bio-control strategy for bacterial leaf blight (BLB), a serious disease of rice caused by the bacterium *Xanthomonas oryzae.*
- National Center for Cell Science (NCCS), Pune identified a novel mechanism to rejuvenate aged stem cells from older donors, which could lead to improvement of outcome of Stem Cell Transplantation (SCT)-based therapeutic approaches for disorders like leukemia, lymphoma, and aplastic anaemia. NCCS is also Serving as a national repository of animal cell culture, and supplied 8086 cell lines to research/academic organizations.
- Institute of Life Sciences (ILS), Bhubaneshwar has developed many useful plant expression vectors coupled to recombinant promoters for boosting agricultural production under stress conditions. A recombinant construct was also developed as a whole cell biosensor for the detection of arsenic in drinking water.
- National Agri-Food Biotechnology Institute (NABI), Mohali has demonstrated proof of concept in banana for the

feasibility of carrying out CRISPR based genome editing. This technology is being exploited to develop traits in banana as well as in crops like wheat, rice and lathyrus. NABI has also developed oligosaccharides-based natural fruit coating that enhances the shelf-life of fruits and vegetables.

- The knowledge gained at National Institute of Plant Genome Research (NIPGR), from genomic studies of chickpea was employed to develop a high yielding variety through molecular breeding approach. A molecular marker was also identified for large seed size in chickpea which was used to transfer large seeded characteristic from an Ethiopian variety of chickpea into a commercially important Indian variety (called ICCV 93954) that has high seed number but small seed size. The newly developed chickpea lines exhibited overall 13-20% enhancement of yield as well as 15% increase in protein content as compared to the parent line ICCV 93954.
- Centre of Innovative and Applied Bioprocessing (CIAB), has developed a scale up process for production of rose oxide value added citronella oil and a titania-based catalyst for large-scale isomerization of glucose to fructose.
- Insect Resources Group at Institute of Bioresources and Sustainable Development (IBSD), has identified plant-derived compound having insecticidal properties that is less toxic to animals including human beings. Its unique properties offer an inherently eco-friendly alternative to current fumigants.
- Under MILAN (Meeting of Indian Livestock Farmers and Agriculturists with the scientists from NIAB) programme, NIAB Hyderabad scientists have reached-out to 18 States to address problems in goat rearing.
- National CryoEM Facility was inaugurated in Institute for Stem Cell Science & Regenerative Medicine (inStem), Bangalore. The facility is equipped with a 300 kV Transmission Electron Microscope (TEM) that is capable of high-resolution structure determination of macromolecules in solution as well as *in situ* in cells by tomography.
- Regional Centre for Biotechnology (RCB), Faridabad) through partnership with European Synchroton Radiation Facility (ESRF) in France has imparted training to 200 researchers on advanced beamline for research purpose.
- National Institute of Immunology (NII), Delhi has identified novel cellular factors affecting the replication of HIV within cells and a novel DNAase from *Streptococcus pneumonia* crucial for bacterial survival. Phase II clinical trials of a dendritic cell-based vaccine targeting SPAG9 are currently underway in patients of cervical cancer, in collaboration with the Cancer Institute, Chennai.
- Translational Health Science and Technology Institute (THSTI), Faridabad started collaborative project with Bioneeds India Private Ltd. and NCCS, Pune for developing method of treatment of HIV infection and another collaborative project with Premium Serum for the development of aptamer based TB diagnostics.
- National Brain Research Centre (NBRC), Manesar has identified receptors (host protein) in neurons, which facilitates the entry of Japanese Encephalitis Virus into cells. NBRC also studied the importance of inflammatory pathways in neurodegeneration which follows infection of the brain by the Chandipura virus and role of an ubiquitin ligase, Rnf2, that regulates synapse maturation via non-degradative function of protein ubiquitination that is linked to a neuro-developmental disorder known as Angelman Syndrome.
- Rajiv Gandhi Centre for Biotechnology (RGCB), Trivandrum published the use of a single dose of HPV vaccine to prevent cervical cancer instead of the regular three doses showed role of metformin in regression of vascular disease in patients with type 2 diabetes and demonstrated enhancement of cardiac mitochondrial functions in hypertrophy by Amalaki rasayana a traditional Indian Ayurvedic product. RGCB Bio-Nest provided incubation facility for young entrepreneurs and has state-of-the-art equipment to facilitate research and development.
- National Institute of Biomedical Genomics (NIBMG), Kalyani launched doctoral program on Biostatistics and Bioinformatics, jointly with Regional Centre for

Biotechnology (RCB) and GlaxoSmithKline Private limited (GSK). NIBMG has taken genomic laboratories and genetic testing to the doorsteps of clinicians by establishing a unit in the largest tertiary care government hospital in Kolkata, the SSKM Hospital. About 800 patients have benefitted by getting genetic tests done for various disorders.

- International Center for Genetic Engineering and Biotechnology (ICGEB), Delhi, has developed high yielding rice through silencing of one of the specific cytokinin oxidase, making it possible to obtain "More grains per plant". Another breakthrough achieved lately is the development of multiple abiotic and biotic stress tolerant rice, through the manipulation of glyoxalase pathway, which show minimum yield penalty under stress conditions.

Public Sector Undertakings

Bharat Immunological and Biologicals Corporation Limited: One of the the public sector units, Bharat Immunological and Biologicals Corporation Limited (BIBCOL) was entrusted with manufacture of Oral Polio Vaccines and with continued support from the Department, played a significant role in polio eradication in our country. BIBCOL is also manufacturing and marketing zinc dispersible tablets and Diarrhoea treatment kits. It has now launched ready-to-use Therapeutic Food BIBPOSHAN and table top sweetener BIBSWEET.

Biotechnology Industry Research Assistance Council: In order to promote Public-Private Partnership (PPP) to nurture the emerging biotech enterprises in the country, Biotechnology Industry Research Assistance Council (BIRAC) was set up by DBT as its public sector undertaking organization with the mandate BIRAC promotes start ups and SMEs to undertake strategic research and innovation addressing the country specific needs. This started as a PPP model where innovation risks are shared both by the innovator company and the Government.

Following its inception in 2012, it has launched several schemes to steam up the start up ecosystem for affordable product development in our country. BIG, SBIRI, BIPP, PACE-AIR & CRS, BIRAC-BioNext, SPARSH are to name a few of these. It has initiated several mentorship programes for capacity building. Hubs have been created for capacity building and mentorship at BRIC, Hyderabad; BREC, C-CAMP; IGNITE Boot Camp. Besides, it has actively promoted the newly launched schemes of the Government such as Make in India, Start-up India, SWACHH Bharat. Several initiatives were taken to give impetus to overall Government mandate within each of these. In addition, BIRAC has forged key National-International linkages with Bill Melinda Gates foundation, with Meity, SAEN, TiE Delhi NCR and several others in an effort to further boost the Research Innovation Ecosystem.

Highlights of the year:

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- A major Mission program on Antimicrobial Resistance (AMR) was launched in October, 2018 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.
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Legislations

The DNA Technology (Use and Application) Regulation Bill: The Lok Sabha has Passed "The DNA Technology (Use and Application) Regulation Bill" in January 2019. The Bill has been formulated for the regulation of the use and application of DNA technology with the aim to establish the identity of certain category of persons including the victims, offenders, suspects, under trials, missing persons and unknown deceased persons and provides provision for establishment of a DNA Regulatory Board (DRB).

National Guidelines for Stem Cell Research: The DBT jointly with ICMR has formulated and revised National Guidelines for Stem Cell Research. As per the recommendation of the inter-ministerial meeting, "National Guidelines for Stem Cell Therapy" is also being formulated jointly with ICMR and other stakeholders.

Administration and Finance

The administrative section is responsible for ensuring smooth functioning of the Department by providing amenities, infrastructure and ambience to the scientists, officers and staff working in the Department. This year, the Swachhta Pakhwada Programme was organized to re-intensify the *Jan Andolan* to realize the vision of Clean India. Also, the administration section provided all the logistics and technical support for organizing India International Science Festival 2018. The establishment section of DBT has efficiently handled reimbursement matters, recruitment and promotion of staff.

02

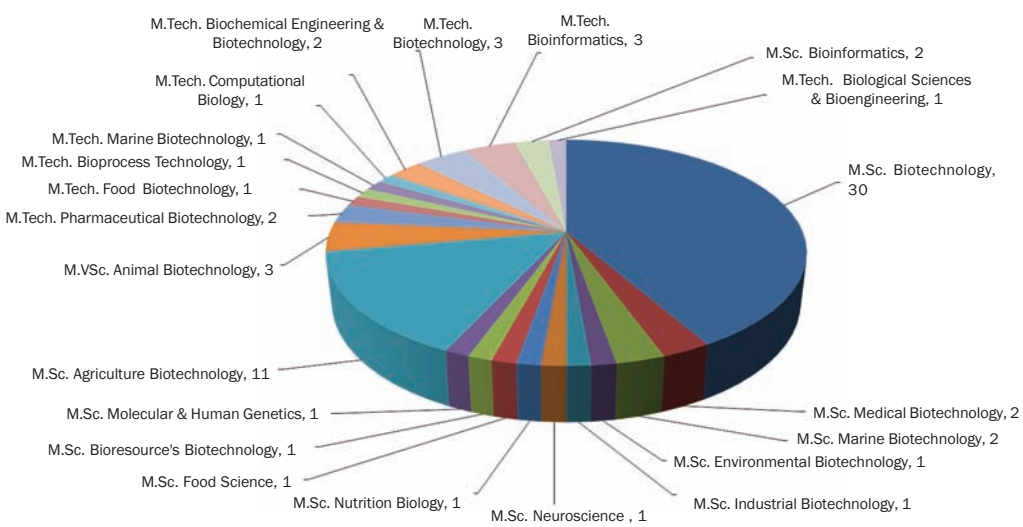
BUILDING CAPACITIES : HUMAN RESOURCE DEVELOPMENT, TRAININGS AND WORKSHOPS

Human Resource Development Programme

The Department has major emphasis on human resource development and implemented an Integrated Human Resource Development Programme in Biotechnology comprising of post graduate teaching programme, industrial training of students, skill development programme, fellowship for doctoral and post-doctoral research training in frontier areas of life sciences and biotechnology, short term training courses for upgradation of skills of mid-career scientists and faculty engaged in life science and biotechnology teaching and R&D. Department is also supporting finishing school program for skill enhancement of biotechnology students and meetings for young investigators and students. Department is generating critical mass of trained and skilled manpower required for overall development of biotechnology sector in the country. Steps have been initiated to start Skill Vigyan programme in partnership with State govt. and Union Territories for imparting skill training for entry level students. There are a number of international partnerships to build capacity in cutting edge technology and priority areas.

TEACHING PROGRAMMES

(i) **Postgraduate Teaching Programmes (M.Sc./ M.Tech./M.VSc.):** Department initiated post-graduate teaching programmes in 1985-86 to ensure high standard of teaching and to generate critical mass of trained manpower in country. These programmes were 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 etc. These programmes have been expanded in general biotechnology as well in niche area such as medical, agricultural, marine, veterinary, industrial biotechnology, bioprocess technology computational biology, food science, bioinformatics and nutrition biology. A total of 72 courses are being offered under this programme. The location of universities/ institutes offering M.Sc./ M.Tech/M.VSc. teaching programmes in biotechnology in country with DBT support is depicted in Map. DBT supported postgraduate teaching programme in biotechnology continues to selecting best students and impart quality education with intensive hands on training. To ensure admission of quality students, selection is made through an All India Common Entrance Test conducted by JNU, Joint Entrance Test conducted by IIT and national test conducted by other universities. All selected candidates are offered studentships. During the year 2018-19, five new PG proposals were considered by DBT-HRD Task Force. One PG teaching proposal in area Medical Biotechnology was recommended for support. Department reviewed the progress of ongoing postgraduate teaching programs and based on the performance accorded ranking to 68 programs.



Area wise number of universities/institutes conducting DBT supported PG teaching programmes.

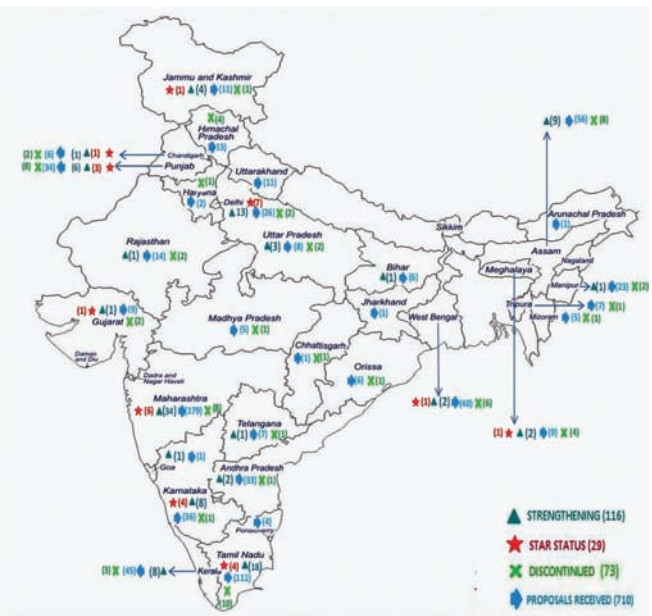
Location of universities/ institutes offering DBT supported Postgraduate Teaching Courses in biotechnology in country

(ii) **Skill Development Programme in Biotechnology:** The Department has implemented new skill development programme to provide high quality hands-on-training in tools and techniques in the areas of Medical Biotechnology, Agriculture biotechnology and Computational Biology. The objective of skill development program is to generate trained manpower for enhancing job opportunities in industries, hospitals, medical colleges, R&D laboratories, diagnostic laboratories. During the year 2018-19, a total 15 Certificate/Diploma courses have been implemented in institutions located in various parts of country. Department has also initiated the Skill Vigyan Program in partnership with States govt. and Union territories through hub & spoke model. This program 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. Expert committee on skill Vigyan recommended the proposals of six states for support. Department has approved the proposal of five States in 2018-19.

(iii) **Star College Scheme:** Star College Scheme was initiated by DBT to support UG colleges and university departments offering undergraduate education to improve science teaching. This scheme aims to improve the skills of teachers by organizing faculty training, improved curriculum and emphasis on practical training to students by providing access to specialized infrastructure and consumables. Star college scheme has been divided in two categories *i.e.* strengthening of support for undergraduate education and Star college status. Criteria for selection as a "Star College" are very stringent and budget provision is double for colleges accorded star college status. At present, 20 colleges under Rural category and 96 under Urban category have been supported under this Scheme. So far Department has received 710 proposal and supported 189 colleges under Star College Scheme since 2008-2018 and state wise distribution of proposal received/ supported in different states in country depicted in Map. DBT conducted workshop titled "Brainstorming meeting on Star College Scheme" in Patna, Bihar to increase the outreach and to popularize the Star College Scheme and thereby creating the awareness among the colleges for applying to this scheme. Further, such workshops are proposed in the upcoming financial year to increase the outreach to the Rural category colleges.

To augment the capabilities of undergraduate teachers, Department has also funded a project at IISER, Pune for conducting "Multi-level Workshop on Research-based Pedagogical Tools to Improve Undergraduate Science Education in Indian Colleges and Universities". Multi-level workshops organized under this program will help in training of approximately 900 Star College teachers across all over India. The workshops would be designed to train teachers to use Research based Pedagogical Tools (RBPT) in the classrooms to augment critical thinking and research skills. These workshops will help disseminate locally developed innovative methods in pedagogy and would be drivers for improving the quality of undergraduate science education by reaching a large number of teachers across the country. For the resource person, British Council will invite applications from organizations engaged in science education in the UK to conduct these workshops. There will also be trainers from UK. Indian invitees will include

senior teachers and experts on education from the Government and Academia for the regional workshops teachers who have undergone level 2 workshops will be the trainers. These workshops will be supported via funding from DBT and Newton Bhabha Fund of the British Council. Task Force meeting was conducted in the month of January to evaluate new proposals for support under the Urban Category, in which 60 colleges proposals were evaluated out of which 35 have been recommended for the support. Rs. 12.76 Cr under Non –recurring and recurring head have been disbursed to these colleges. DBT conducted a **"Brainstorming meeting on Star College Scheme"** workshop in **Udai Pratap College, Varanasi (UP)** in the month of February in which around 65 colleges participated.



State wise colleges supported under Star College Scheme by DBT

(iv) **Biotechnology Finishing School Programme:** The Department jointly with Department of IT, BT and S&T Government of Karnataka is supporting "Biotech Finishing School program" has now been renamed as "Biotechnology Skill Enhancement Program (BiSEP)". Karnataka Innovation and Technology Society (K-Tech) selected 18 host institutes in Karnataka State for support and for imparting skill training. K-Tech has signed MoU with Life Sciences Sector Skill Development Council (LSSSDC), New Delhi for development of national occupational Standards for training modules as well certification of training program. During the year, 473 applications were received and 432 candidates appeared in entrance exam and finally 89 candidates selected for admission in BiSEP program under DBT support. Selection process is very stringent and all selected students are paid fellowship of Rs. 10,000/month.

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 in the country. The programme is being coordinated by BCIL, New Delhi. Students are selected through online Biotechnology Eligibility Test (BET) conducted across country. The programme has provision to select **Category-I** JRF who are eligible to avail fellowship under DBT-JRF at any university/institute in India once they are registered for PhD and **Category-II** who are eligible to join any DBT sponsored project after following selection process of host institute. They can avail fellowship equivalent to NET qualification from the extramural R&D project funds. During the year, a total 7385 applications were received, 6217 students appeared for the online exam and 293 students selected under category- I and 116 students in Category-II. A total of 829 ongoing students and 113 newly joined students are availing Fellowship under DBT-JRF program in 2018-19.

(ii) **DBT Research Associateship (DBT- RA) Programme:** DBT Research Associateship program was started in year 2001 for post-doctoral research in frontier areas of Biotechnology and Life sciences 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 2018-19, in response to two advertisements, a total 864 applications were received and 98 candidates were selected for award of DBT-RA fellowship. A total number of 157 RAs are being supported during 2018-19.

(iii) **Bioinformatics National Certification (BINC) Exam:** The Department is supporting Bioinformatics

National Certification (BINC) since 2005 to certify bioinformatics professionals to improve their job placement opportunities. Top ten candidates also received the cash award. The successful post-graduate candidates are eligible for availing JRF/SRF for pursuing Ph.D. in Indian Institutions/Universities. This programme is equivalent to UGC-CSIR-NET, DBT-JRF and all other such programs. This year, 1037 applications have been received and total 600 students appeared in exam for Paper I. 28 students have qualified the Paper I and appeared in Paper II and Paper III. The BINC exam was conducted at 12 places in the country and 17 students could qualify the BINC 2018. The total number of ongoing students is 20.

PROGRAMMES FOR NORTH EASTERN STATES (NER)

Department has made special provision in HRD scheme during 2010 for providing the support to students/ Research Fellow 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:** The Programme is being coordinated by Indian Institute of Science, Bengaluru. During the year, a total 62 applications were received and 15 candidates selected for award of DBT-RA Fellowship.

(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. The programme is being coordinated by Biotech Consortium India Ltd., New Delhi. There is a provision for placement of 100 candidates in industries for training under BITP-NER. During the year, a total 172 applications were received and 136 candidates appeared for interview and finally 98 candidates selected for six months training. Total of 53 candidates have been placed for training in industries under BITP-NER.

BUILDING CRITICAL MASS OF SCIENCE LEADERS

(i) **Ramalingaswami Re-entry Fellowship:** The Ramalingaswami Re-entry Fellowship was conceived in the year 2006-07 with the idea of encouraging scientists (Indian Nationals) working outside the country, and would like to come back to the home country to pursue their research interests in life sciences, biotechnology and other related areas. The principal objective of the scheme is to improve (the country's) India's human resource capacity in life sciences and biotechnology research - both in terms of development, translation and diffusion by means of attracting scientists (Indian nationals) settled abroad. The number of fellowships have now been increased from 50 to 75 fellowships per year from 2017-18 onwards. So far, 322 fellows have taken up positions in various Indian Laboratories, out of which, 223 fellows have already been able to seek permanent faculty positions. More people want to relocate themselves to Indian Institutes/National R&D Laboratories as these institutes are now providing excellent research facilities to do high quality research. Fellows have published their research work in peer received 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:

- Hydrogel based drug delivery was developed to prevent organ rejection (animal model trials done in both small (rats) and large animals (pigs) Further, clinical trials are under way. With this technology, transplanted organs will be protected without any side effects.

Hydrogel based drugs

- Green roof substrates were developed using local materials (vermiculite, sand, crushed brick, perlite, coco-peat, seaweeds, etc.) available in India. Also, a light weight green roof system was developed and successfully operated under pilot and real conditions. The green roof system comprises of light weight medium (locally prepared), light weight drainage board and plants (local species). The advantage of the developed green roof technology is that it can be

installed on existing rooftops without structural alterations.

A B

(A) Green roof substrate (B) Green roof system developed with lightweight materials

- Completely biodegradable packaging boxes (food and non-food) were developed using agricultural wastes. Partition boards and false ceilings from rice straw and sugarcane bagasse; disposable and low cost cups and containers for food applications, biodegradable diapers and sorbent materials from agricultural wastes were also developed.

A B C D

(A) Packaging boxes (B) False Ceiling tiles

(C) Boxes for food or non-food

(D) Disposable cups.A)

- Antimalarial drug artemisinin was over expressed using tobacco plants as bio-factories. The concept was validated and proven effective using whole plant material as compared to pure artemisinin.
- A non-invasive method for cancer detection was developed using pulse induction magnetic nanoparticle detector (PIMNP). Preclinical validation is currently in progress.
- Technology was developed for pesticide detection in food and produce by mass spectrophotometry. Field tested on 20 acre land. This technology enables to analyze 500-1000 samples per day compared to currently used imported technology (50 samples per day). This technology/IP was sub-licensed for commercialization to a spinoff company; Barefeet Analytics Pvt. Ltd.

(ii) **DBT- Wellcome Trust Fellowship: Biomedical Research Career Programme:** The Biomedical Research Career Programme is operationalized through India Alliance, a special purpose vehicle (SPV). The Programme is an equally funded partnership between The Wellcome Trust (UK) and the Department of Biotechnology, Government of India. It aims to improve the biomedical research landscape in India through mechanisms that support exceptional researchers at Indian institutions, and facilitate the recruitment of highly trained and qualified scientists from overseas. This is done through (1) Fellowship Programme with three types of fellowships (early, intermediate and senior), (2) Culture of transparency, international quality and timeliness to grants management, and (3) effective engagement to develop the next generation of research (and policy) leadership.

"The Governent of India has approved the continuation of the Biomedical Research Career Programme (BRCP), and Wellcome Trust (WT) /DBT India Alliance (India Alliance) beyond its initial 10-year term (2008-09 to 2018-29) to a new five year phase (2019-20 to 2023-24) with Department of Biotechnology (DBT) increasing its commitment to two times that of WT in Union Cabinet's meeting held on ***27th March, 2019. This would further strengthen our*** *focus on building strong, world-class, biomedical research human resources in India at a scale where the country can make a global impact."*

- During 2018, 45 Fellowships were awarded to scientists at 33 different institutions in 21 Indian cities. Fellows also received prestigious national and international awards and recognitions during 2018. These include Infosys Prize for Life Sciences; Shanti Swarup Bhatnagar Award; EMBO Young Investigator Award; Swarnajayanti Fellowship; NASI-SCOPUS Young Scientist Award; Fellow of the Royal Society of Physicians (London); Emerging Leader Award 2018 from Royal Society of Tropical Medicine and Hygiene; Fellow of the Indian National Science Academy and many others. Fellows published 116 publications in high-ranking international journals that attributed to India Alliance funding on Europe Pubmed Central in 2018.

- In 2018, India Alliance organized three Science Communication workshops that trained more than 300 Masters and PhD students and Postdocs from across the country. It also organized two EMBO Research Leadership courses that trained 32 Assistant and Associate professors in critical leadership and management skills. India Alliance organized two Developing Indian Physician Scientists (DIPS) workshops which were attended by more than 60 MD and MBBS students to the excitement of research and to research methodology. Through India EMBO Symposia funding scheme, seven meetings have been funded in India with the aim to address discovery and innovation in life sciences through interdisciplinary approach. India Alliance also supported various Public Engagement projects:
  - Actors and Doctors: Staging Public Health matters used theatre arts to initiate a two-way learning process between social and scientific enquiry and to make health research more accessible to the public.
  - Life of Science: chronicling the lives of women scientists in India to highlighted the work & challenges faced by women scientists and showcased them as role models for young girls
  - Arting Health for Impact: A three-nation programme, explored the use of street art forms to spread awareness about health
  - Superheroes against Superbug: This program partnered with schoolchildren to sensitize the public about rising antibiotic resistance in India.

  In 2018, 12 researchers attained faculty placements in various academic and research institutions. They were awarded fellowships in earlier years under this programme.

(iii) **India Alliance Celebrates 10 Years of Enabling Biomedical Research in India:** The Biomedical Research Career Programme celebrated a decade of enabling biomedical research in India by hosting a three-day event (12-14 November 2018), which was inaugurated by the Hon'ble President of India, Shri Ram Nath Kovind, in the presence of the Union Minister for Science and Technology and Earth Sciences, Dr. Harsh Vardhan at Vigyan Bhawan, New Delhi, on 12 November 2018 To commemorate its tenth-year, India Alliance launched - The Explorer Series - a public science talk series about 500 college students attended the first set of talks. An array of curated science talks and panel discussion on cutting-edge research and research needs in India were hosted. This platform also hosted a science image competition/exhibition called Stories of Science.

Public at Art & Science program, New Delhi

Children participating in the Superheroes against Superbug campaign, Hyderabad

The Biomedical Research Career Programme Team with Shri Ram Nath Kovind, the Hon'ble President of India; Dr. Harsh Vardhan, Hon'ble Union Minister for Science and Technology and Earth Science; Prof. K. VijayRaghavan, Principal Scientific Advisor to Govt. of India; Dr. Renu Swarup, Secretary, DBT; and Prof. Jeremy Ferrar, Director of Wellcome trust

INTERNATIONAL FELLOWSHIP

(i) **DBT-TWAS Fellowship:** The Department 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 Laboratories/ Institutes in India. The fellowships are tenable in Institutes in India and are provided under three categories: a) Full-Time Postgraduate Fellowship to pursue a PhD research programme in India, b) Sandwich Postgraduate Fellowship to pursue a PhD research programme in India, and c) DBT-TWAS Postdoctoral Fellowship to pursue a postdoctoral research programme in India. Few achievements of the scheme are: 75 Pre doctoral and 36 Post doctoral fellows have availed this scheme. Currently 25 fellows are availing this fellowship. This year, 25 fellows were selected and will be joining their respective host institutes in next financial year.

(ii) **DBT - Energy Biosciences Overseas Fellowships:** DBT "Energy Biosciences Overseas Fellowships" is a flagship scheme of DBT for bringing back the scientists of Indian origin who are working outside the country in the field of Energy Biosciences. Energy Biosciences Chairs are for the senior scientists who are desirous of pursuing, complementing and enhancing quality of R&D in energy related biosciences in Indian institutions. Currently four overseas fellows and two chairs have been working at various host institutions. Several processes in different areas of biofuels, enzymes, bioenergy at various Indian institutions are being developed by fellows enriching the R&D in the bioenergy field. Cumulatively around 40 papers were published in international peer reviewed journals. During 2018-19 four overseas fellows have availed this fellowship.

(iii) **Indo-U.S. Genome Engineering/Editing Technologies Initiative (GETin) Overseas Fellowship:** The department started this Fellowship Program for steering collaborative research projects between Indian institutes and premier U.S. Universities for students and young faculty in areas of Genome Engineering/Editing Technology. The program is being managed by Indo-U.S. Science & Technology Forum (IUSSTF). The objective of program is to provide 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. Indian students currently pursuing a Ph.D. on a full-time basis in various forefront disciplines of Biotechnology are eligible for Student Internships for 6 months. Indian citizens having Ph.D. in Life Science, Biotechnology, Engineering or Technology holding a regular position in public funded R&D Lab/ S&T Institution / recognized Universities/ Colleges in India are eligible for Overseas Fellowships for 5 weeks to 12 months. U.S. Faculty or Foreign Post Docs presently working in U.S. (for at least two years) in a field having an interface with Genome Engineering /Editing Technologies are eligible for Visiting Fellowships for a period of 2 to 3 months to undertake collaborative research in Indian Lab. The department has provision to provide support to 5 individuals in each category. During the year 2017-18, 5 Indian students and 5 Scientists have successfully completed the fellowships and during the current year, 5 Student Internships, 5 Overseas Fellowships and 3 Visiting Fellowships have been awarded.

(iv) **Newton Bhabha PhD Placement Programme:** For the fourth consecutive year, DBT in partnership with British Council India provided funding opportunities to support short-term PhD placements between UK and Indian institutions. Under the scheme 31 Indian PhD scholars have been selected to spend short term (2 to 4 months) in UK's higher education institutions in pursuance of their research work of PhD.

(v) **Khorana Programme for Scholars:** The Department is collaborating with University of Wisconsin (UW) Madison, USA and the Indo-US Science and Technology Forum (IUSSTF) to nurture contacts between students of biotechnology and biomedical sciences from India and the US, through a joint training programme in biotechnology and allied areas. The programme acts as a key catalyst to encourage post-graduate students to take up research as a career. In

the year 2018-19, 50 Indian scholars were supported under the scheme.

(vi) **Building Bharat-Boston Biosciences (B4) Programme:** The Department has supported a program -"Building Bharat-Boston Biosciences (B4) Program", in June, 2018 with the aim 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. The program is being implemented by Institute of Bioinformatics and Applied Biotechnology, Bangalore and The Lakshmi Mittal and Family South Asia Institute, Harvard University (Mittal Institute), USA. During the year, Phase-II program implemented. Further, a two week hands-on workshop in "Synthetic Biology" was organized for imparting training to young students and researchers.

(vii) **DBT-Heidelberg Graduate Program on Big Data Research:** Department has implemented joint graduate programme on Big Data Research with Heidelberg University, Germany for human resources development. The programme is designed toward a joint doctoral research training from Heidelberg University and one of the Indian partner institutions. Initially, six Indian institutions *viz*., IIT, Madras, IIT, Guwahati, IIT, Kanpur, Jawaharlal Nehru University (JNU), New Delhi, Allahabad University, Allahabad and Delhi University, Delhi have been selected. The programme has three components (i) 2-3 months short term summer training for 20 master students per year (ii) Joint PhD support for 10 students per year (ii) Associate young Researcher Visiting program for 4 scholars per year.

TRAINING PROGRAMMES

(i) **Short Term Training Programme for Mid-career Scientists and UG & PG Teachers:** Department is supporting short term training program of 2-3 weeks duration for 20-25 participants for hands on exposure in emerging areas for mid career scientists and UG & PG teachers involved in Life Science and Biotechnology education and research. During the year, 7 programmes were selected by Department for support.

(ii) **Biotech Industrial Training Programme:** 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 programme is being coordinated by Biotech Consortium India Ltd., New Delhi. The programme is mutually beneficial to the students as well as industry as it not only provides industrial exposure to the students but also an opportunity to industry to select suitable manpower for their requirement. During the year, total 2211 applications were received, out of which 1726 candidates appeared in online test, 1135 candidates were shortlisted for second round of interview. Based on interview of 1135 candidates, 521 candidates were finally selected for industrial training. Total 114 companies were selected for imparting training. Total 362 candidates have placed in industries for training in 2018-19. Department is providing stipend of Rs.10,000/month to all selected candidates for six months period and bench fee of Rs. 50,000 to trainer companies. Department has developed online feedback system for obtaining monthly feedback from trainees and trainer companies.

WORKSHOPS

(i) **India Bioscience-Young Investigator meetings and students workshops:** Department has supported young investigator meeting and workshops for young investigators (Teachers and Scientists), Post-Doctoral Fellows and PhD students with the objective to promote and disseminate information about R&D environment and opportunities in Biotechnology sector in country. During the year, NCBS, Bengaluru organized Young Investigator Meeting (YIM), 2018 at Thiruvananthapuram and one Regional YIM at Hyderabad. A total of 142 participants attended YIM at Thiruvananthapuram and 110 participants attended Regional YIM at Hyderabad. The meetings organized so far have provided great mentoring and networking opportunities to the life science researchers, not just among themselves but also with folks from industries, education space, science communicators etc. The

website (www.indiabioscience.org) and the discussion forum (www.discuss.indiabioscience. org/) have been developed for science communicators, young investigators or educators for networking among life science professionals across India.

(ii) **European Molecular Biology Organization (EMBO):** The Government of India, EMBO and the EMBC signed a Cooperation Agreement to strengthen scientific interaction and collaborative research between India and Europe. As a result of this, India became an EMBC Associate Member State in January 2016. Consequently, researchers working in India are eligible to participate in all EMBO Programmes and activities. Indian scientists can apply for funding through EMBO Programmes, such as EMBO Long-Term Fellowships for postdoctoral researchers, EMBO Short-Term Fellowships, EMBO Courses & Workshops, as well as EMBO Young Investigator Programme membership. Since 2016, 2 applications have been awarded Young investigators, 3 long term fellowships, 40 short term fellowships, 6 for organizing courses and workshops, 161 travel grants and 9 applications for conducting lectures.

Human Resource Development through International Programmes

S. N.	International Programmes	Nos.
1	Khorana Program for Scholars	55
2	Newton-Bhabha PhD Placements Programme	31
3	The Wellcome Trust/ DBT India Alliance	44
4	Partnership with EMBO	
	a. EMBO Young Investigators:	1
	b. EMBO Fellowships:	
	i. EMBO Long-Term Fellowships:	2
	ii. EMBO Short-Term Fellowships:	24
	c. EMBO Courses & Workshops:	
	i. Workshops or conferences funded by EMBO:	2
	ii. Courses funded by EMBO:	2
	iii. India-EMBO Symposia funded by EMBO:	1
	d. Indian Scientists attending EMBO Courses & Workshops:	664
	e. Travel stipends for Scientists from India to attend EMBO Courses and Workshops	103
5	No. of fellowships provided to students/ under various exchange programs	929

(iii) **Foldscope-Microscopy for all:** The Department organised a two-day DBT-PrakashLab Orientation Workshop on the use of Foldscope at International Centre for Genetic Engineering and Biotechnology, (ICGEB), New Delhi on 16th-17th April 2018. During this workshop, 400 school and college teachers from across the country were trained in the use of Foldscopes, for further imparting training to students in these schools and colleges. These government schools and colleges were also supported with micro-grants. At the India International Science Festival, 2018 in Lucknow, workshops on Foldscope training were conducted by Dr. Manu Prakash, inventor of the Foldscope and Assistant Professor of Bioengineering, Stanford University, USA and his team. Over 2000 students and 300 teachers were provided with Foldscopes and were trained.

Workshop at ICGEB: Teachers from 400 schools and colleges from across India.

Schools and colleges spread in the states of India

(iv) **Innovations in Rice Farming Technologies: DBT-IRRI Initiative:** In an endeavour to empower women farmers, the backbone of Indian agriculture, the Department in partnership with International Rice Research Institute (IRRI), Philippine, under the International Component of the Biotech-KISAN program have conducted a two phase training program on **"Advance in Rice Production for Women Farmers"**. 35 Women Farmers from 7 States attended the training program in the Phase I at Bhubaneswar, from 26th June - 1st July, 2018. In the 2nd phase of the training session, 7 women farmers along with Joint Director of Agriculture, Raichur, Karnataka underwent further training at Los Banos, Philippines from September 24-29, 2018 where advanced farming experiences and technological advancements were shared with these women farmers during five day course.

Farmers at Bhubaneswar, June 26- July 1, 2018

Dr. Renu Swarup, Secretary, DBT with the women farmers and others.

Farmers at Los Banos, Philippines, September 24 - 29, 2018

DBT AWARDS - RECOGNIZING EXCELLENCE

(i) **Tata Innovation Fellowship:** The Department initiated the TATA Innovation Fellowship scheme in 2006 to recognize and reward scientists upto 55 years with outstanding track record in biological sciences with a commitment to find innovative solutions to major problems in healthcare, agriculture and other areas related to life sciences and biotechnology. Each year upto of 5 fellowships are given. Each awardee receives a fellowship @ Rs. 25,000/- per month in addition to regular salary and a contingency grant of Rs. 6.00 lakhs 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, 57 scientists have been awarded the fellowship till March 31, 2018. Total 5 fellowship awarded during 2018-19

(ii) **Bioenergy-Awards for Cutting Edge Research (B- ACER):** The Department of Biotechnology, Govt. of India and the Indo-US Science and Technology Forum (IUSSTF) have partnered for a dynamic visitation program called The Bioenergy-Awards for Cutting Edge

Research (B- ACER) focusing on the capacity building in the frontier area of Biofuel and Bioenergy. The B-ACER Program has successfully completed one year and currently the second batch of 2017 B-ACER Awarded Interns and Fellows have commenced their Internships/ Fellowships at respective U.S. Universities. So far 17 Interns and 13 Fellows have been benefited from this Program including training for 7 Interns and 3 Fellows during 2019.

(iii) **Indian Biological Engineering Competition (iBEC) PRE- iGEM Competition:** Indian Biological Engineering Competition (iBEC) PRE- iGEM Competition: National Competition Indian Biological Engineering Competition (iBEC) was launched in 2016 by Department in order to select and support best Indian student teams to participate in international contest iGEM competition (International Genetic Engineered Machine) which is held every year in Boston, USA. iBEC, the Pre-iGEM competition provide opportunity to UG and PG students, researchers to work in teams and solve real-world challenges by building genetically engineered biological systems. The teams manage their own projects, advocates for their research, and secures funding with a mentor. Teams are also challenged to actively consider and address the safety, security and environmental implication of their work. So far, Department has supported 5 team (25) team from various institute like IITs, IISER, IISc and Public/Private Colleges/Universities. In February, 2018, Pre-iGEM (iBEC) competition was announced by Department and in response, a total of 19 proposals were received and 5 teams of total 25 students were selected for consumable, registration and travel of INR 10 lakhs/ team to travel to Boston, USA to participate in iGEM 2018 held in October, 2018.

(iv) **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 physically challenged. Scientists on a soft positions are also eligible to apply. The award carries a fellowship of Rs.1.00 Lakh/annum for candidates who are in 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. In the last five years, DBT has awarded fifty two young scientists under this scheme. During the year, 9 candidates were selected for the award.

Details of selected 'Innovative Young Biotechnologist Awardees' (IYBA)-2018

S. No.	Name of Awardees	Affiliation	R&D Activity Selected for Award
1.	 Dr. Amar Pal Singh	National Institute of Plant Genome Research (NIPGR), New Delhi.	Hormonal Regulation of Root Development in Response to nutrient availability.
2.	 Dr. Aparna Dixit	Dr. B.R. Ambedkar Center for Biomedical Research (ACBR), University of Delhi.	Molecular mechanisms underlying epileptogenesis and/ or drug-resistance in patients with drug-resistant epilepsy (DRE)

3.	 Dr. Harsha Bajaj	NIIST Industrial Estate, Thiruvananthapuram	Transport of small molecules like antibiotics, sugars across bacterial membrane proteins
4.	 Dr. Nagarjun Vijay	Indian Institute of Science Education and Research (IISER) Bhopal.	Research using genomic tools to study the process of speciation in multiple vertebrate species
5.	 Dr. Naresh L. Selokar	Central Institute for Research on Buffaloes, Hisar, Haryana	Work on different using assisted reproductive technologies in buffalo to improve its productivity
6.	 Dr. Parul Mishra	School of Life Sciences, University of Hyderabad.	Unraveling the function of Heat Shock Proteins (hsp90).
7.	 Dr. Vikram Saini	All India Institute of Medical Sciences (AIIMS), New Delhi	Genomics analysis of Mycobacterium indicus pranii (MIP), an immunotherapeutic and vaccine for individuals with leprosy.
8.	 Dr. Umakanta Subudhi	CSIR-Institute of Minerals & Materials Technology, Bhubaneswar	Self-assembled DNA nanostructures for switching gene expression

8.	 Dr.Rajanish Giri	Indian Institute of Technology, Mandi, Himachal Pradesh	Unravelling the implications of disordered regions in Zika virus Capsid folding and function

(v) 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 and trophy along with project research grant of Rs 15.00 lakhs (Rs.5.00 lakhs/year) for a period of 3 years. During 2017-18 & 2018-19 a total of 15 awardees were selected.

Details of selected National Bioscience awardees for Career Development 2017 & 2018

S. No.	Name of Awardees	Affiliation	R&D Activity Selected for Award
1.	 Dr. Manas Kumar Santra	National Centre for Cell Science (NCCS), Pune University Pune.	Studying the underlying mechanism that could help increase the efficacy of cancer therapy
2.	 Dr. Dipyaman Ganguly	CSIR-Indian Institute of Chemical Biology (IICB), Kolkata	Research work focusing on allergic asthma and cancer immunology
3.	 Dr. Subhadeep Chatterjee	Centre for DNA Fingerprinting and Diagnostics (CDFD), Telangana	Novel insights to understand the role of quorum sensing in *Xanthomonas* and *Pseudomonas*

4.	 Dr. Soumen Basak	National Institute of Immunology (NII), New Delhi	Understanding the molecular mechanisms that control replication of Chandipura virus.
5.	 Dr. Manoj Majee	National Institute of Plant Genome Research (NIPGR), New Delhi.	Contributions in dissecting the molecular and biochemical mechanisms that are involved in the maintenance of seed vigor and viability for prolonged periods of time
6.	 Dr. Arun Kumar Shukla	Indian Institute of Technology (IIT), Kanpur	Understanding the structure and function of G-Protein Coupled Receptors (GPCRs) and leveraging this information for designing better therapeutics for a range of human disorders
7.	 Dr. Amit Singh	Indian Institute of Science (IISc), Bengaluru.	Understanding the mechanism of mycobacterial persistence and drug tolerance
8.	 Dr.Beena Ramakrishnan Pillai	CSIR- Institute of Genomics and Integrative biology (IGIB), New Delhi	Understanding the fundamentals of non-coding RNA biology with a focus on vertebrate brain development.
9.	 Dr. Mohammad Zahid Ashraf	Jamia Millia Islamia, Delhi	High altitude thrombosis, (blood clotting on exposure to hypoxia at high altitudes) and mechanisms associated with its pathology

10.	 Dr. Ranjith Padinhateeri	Indian Institute of Technology (IIT), Bombay	Developing a computational model to investigate kinetics of nucleosomes along DNA and also trying to study nuclear organization and understand how cells make decisions
11.	 Dr. Rayala Suresh Kumar	Indian Institute of Technology (IIT), Chennai.	Understanding the role of P21-activated kinase 1 (Pak1) signaling in cancer cells with clinical relevance
12.	 Dr. Prabhu B. Patil	CSIR- Institute of Microbial Technology (IMTECH), Chandigarh	Understanding evolution of clones, strains, species, communities and population in the bacterial world
13.	 Dr. Pritam Deb	Tezpur University, Assam	Developing new class of secondary magnetic nanostructures and development of smart molecular imaging probes for potential applications
14.	 Dr. Maddika Subba Reddy	Centre for DNA Fingerprinting and Diagnostics, Hyderabad	Deciphering the molecular mechanisms of various cellular signaling pathways and their contribution to human diseases specifically cancer
15.	 Dr. Aswani Kumar	CSIR- Institute of Microbial Technology, Chandigarh	Understanding the mechanisms used by *Mycobacterium tuberculosis* to display phenotypic drug resistance.

(vi) **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 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 has 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. Two scientists under senior category and four scientists under junior category were selected for 2017-18 & 2018-19).

Details of selected National Women Bioscientist Awardees- 2017 &2018

S. No.	Name of Awardees	Affiliation	R&D Activity Selected for Award
Awardee under Young Category			
1.	 Mahak Sharma	Indian Institute of Science Education and Research (IISER) Mohali.	Studying the molecular mechanisms regulating membrane trafficking towards lysosomes and how pathogens manipulate the endolysosomal pathway for their growth and survival.
2.	 Dr. Oishee Chakrabarti	Saha Institute of Nuclear Physics (SINP), Kolkata	Understanding Calcium homeostasis, ubiquitin mediated proteasomal degradation and basic cellular regulatory processes.
3.	 Dr. Ruchi Anand	Indian Institute of Technology (IIT) Bombay, Mumbai	Unearthing enzyme systems as new therapeutic targets and structure-guided development of biosensors for aromatic pollutants
3.	 Dr. Shailja Singh	Jawaharlal Nehru University, Delhi	Understanding of the functional roles of key parasite proteins that mediate erythrocyte invasion and egress by malaria parasites

Awardee under Senior Category			
1.	 Dr. Jaya Sivaswami Tyagi	All India Institute of Medical Science (AIIMS), New Delhi & Translational Health Science and Technology Institute (THSTI), Faridabad	Discovery of DevR-DevS dormancy/ persistence signaling system in M. tuberculosis and developing diagnostic kits suitable for national TB programme
2.	 Dr. Poonam Salotra	National Institute of Pathology (ICMR), New Delhi	Establishing molecular tests for non-invasive diagnosis and assessment of cure of Visceral Leishmaniasis and Post Kala-azar Dermal Leishmaniasis

(vii) **Biotech Product, Process Development and Commercialization Award:** The aim of this 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. Upto 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 category as well as under institutional category. During the year, three awards with a cash prize of Rs.2.00 lakhs each were conferred on Technology Day i.e., on 11th May, 2018 by Hon'ble Minister of Science & Technology and Earth Sciences, Dr. Harsh Vardhan.

(viii) **Biotechnology Social Development Awards-2017-18:** Biotechnology as an emerging area has immense potential to improve the lives of people especially the socially and economically weaker sections of the society. There are many dedicated organizations and individuals who have brought a positive change in the lives of the community in the areas of livelihood generation, healthcare & hygiene improvement, education & advocacy, skill development & growth of regional entrepreneurs. In an attempt to recognize these organizations/individuals, Department of Biotechnology invited applications for 'Biotechnology Social Development Awards' from Government/Non-Government Organizations/Individuals. The Department has conferred Biotechnology Social Development Award for 2017-18 to M.S. Swaminathan Research Foundation (MSSRF), Chennai in organisation catogory for the landmark achievement of MSSRF in implementation of programmes and projects in 10 villages in Wayanad district of Kerala since 1997 which has now spread in more than 80 villages benefitting more then 2200 families.

In Individual catogory two awards given. One award given to Dr. Partha Pratim Chakrabarti RRC - CIFA, Kalyani, West Bengal. The Award was given for the landmark achievement in the Sunderban deltaic area for sustainable agricultural and rural development through integrated fish farming with duck and other poultry species, among the tribal and rural communities of Bali Island in Sunderbans and also for his contribution for spreading integrated fish farming in North-Eastern states covering more than 100 villages encompassing more than 1000 families.

Second award in Individual category was given to Ms. Sangeeta Atul Kulkarni, Jnana Prabodhini Navnagar Vidyalaya, Pune, for her instrumental role in providing

training of more than 1500 school students on various aspects of biotechnology by inculcating innovative attitude to take active interest in developing solutions to the current environmental problems through adoption of various viable interventions in bamboo and medicinal plants, including micro-propagation, promoting research and extension activities in various multifarious areas including livelihood generation.

(ix) **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 2 positions are filled under the said scheme and selection procedure for 3 vacant positions is underway.

(x) **Young Entrepreneur Scheme-India (Yes-India) Programme:** ABLE organizes the Biotechnology Entrepreneurship Students Team (BEST); an annual flagship program supported by the Department of Biotechnology. The mandate and goal of the program is to encourage the budding entrepreneurship talents of college students. The program creates quality human resource by nurturing innovation & entrepreneurship among young researchers and training in techno managerial issues. During the 9th edition of the programme held in 2018, 20 college teams, consisting of 100 students were trained over 3 days on various aspects of entrepreneurship. In 2018 two companies were also registered by BEST alumni (KBCols Sciences Pvt Ltd and Farmgulp).

POPULARIZATION & PROMOTION OF BIOTECHNOLOGY:

(i) **DBT-CTEP Program:** To popularize Biotechnology activities in India, the Department provides financial assistance towards organizing Conference, Seminar, Symposium, Workshop and Travel support to the researchers for presenting their papers in the conferences which are being organised outside the country. It also extends support for organising DBT stalls in international and national exhibitions. Financial support is also provided for organising Popular Lectures. The collective term for these four activities is CTEP (Conference, Travel, Exhibition and Popular Lectures). DBT has introduced a web portal i.e., Online Submission and Monitoring System (OSMoSys) which act as a single window for the submission, processing and settlement of grants. This portal not only ease the assistance process but also provides timely deliverables. During current financial year DBT has supported a total number of 293 proposals.

(ii) **India International Science Festival 2018 (IISF 2018):** The Department in association with Department of Science & Technology and Ministry of Earth Sciences organized India International Science Festival from 5th to 8th October, 2018 at Lucknow, Uttar Pradesh. The 4th India International Science Festival 2018 was inaugurated by the Hon'ble president of India President of India, Shri Ram Nath Kovind at a function held at Indira Gandhi Pratishthan, Lucknow. It was an international event and scientists/researchers/ students delegates attended the event not only from India but also from various other countries. Global Indian Science & Technology Stakeholder (GIST), Industry Academia Meet, National Social Organization & Institutions Meet (NSOIM), National Science Teachers' Congress (NSTC), North East Students Conclave (NESC), Women Scientist Entrepreneur Conclave, Students Science Village, International Science Film & Literature Festival, Green Good Deeds, Agriculture Conclave, etc. were some of the major highlights of the IISF 2018. Total participation was around 21425 including delegates, students, researchers, scientists etc. 1130 farmers also participated in the event. Further, this year 02 Guinness World Records were also made.

Inaugural ceremony of IISF, 2018 (From Left to Right) 1) Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology, Earth Sciences and Environment Forest & Climate Change, 2) Shri Ram Naik, Hon'ble Governor, Uttar Pradesh, 4) Shri Ram Nath Kovind, Hon'ble President of India, 4) Shri Yogi Adityanath, Hon'ble CM, Uttar Pradesh, 5) Shri Dinesh Shrama, Deputy CM, Uttar Pradesh. During Inauguration of IISF -2018 at Indira Gandhi Pratishthan, Lucknow.

School Students created Guinness World Record for 'the maximum number of people conducting DNA Isolation experiment' during IISF-2018 at Lucknow.

(iii) **Participation in BIO International Convention 2018:** The participation of Team India at BIO 2018 in Boston was supported by the Ministry of Science & Technology through the Department of Biotechnology. The Indian team had about 90 members and included officials and scientists from Central and the State Government departments and agencies. Besides the DBT and BIRAC, CSIR participated for the first time. Andhra Pradesh and Karnataka states also put up their stalls. 18 start-ups and 2 companies exhibited. 2017-18 & 2018-19). The India Pavilion was inaugurated by Shri C P Goyal, Joint Secretary, DBT, and Ms. Kiran Majumdar Shaw Managing Director, Biocon.

Inauguration of the India Pavilion during Bio International Convention 2018

03

RESEARCH AND DEVELOPMENT, DEMONSTRATION AND TRANSLATION ACTIVITIES

Agriculture And Allied Areas

This section details application of biotechnology tools and techniques in agriculture and allied areas including crops, livestock and fisheries. In general, the advanced molecular biological techniques, omics, genomic based selection and / or development of molecular markers for selection of improved breeds for different traits, genetic engineering are employed. The department provides support for various schemes such as R&D, translational research, product development and its validation and demonstration in collaboration with universities, research institutions and non-profit research organization as well as private sector. Collaboration with ICAR, ICMR, CSIR, DST and DoD and their institutions is integral part of implementation. Further, it is ensured that all projects follow stringent biosafety and other institutional and ethical regulations in animal experimentation. Various products arising out of these efforts include development of pre-breeding materials for improved crop varieties, genomic information for markers and development of vaccines and diagnostics. The various achievements in biotechnology of crops, livestock and fisheries are detailed below.

AGRICULTURE BIOTECHNOLOGY

The mandate of Agriculture Biotechnology program is knowledge generation, technology and product development for productivity gains, enhanced nutrition and ensuring quality, resistance to drought salinity, high temperature, resistance to pests and diseases, input use efficiency, climate resilience and bio-safety. The nature and types of programs include product oriented basic research, translational R&D projects, national networks, autonomous institutions, grand challenge program, centers of excellence, international collaboration, public-private partnership etc.

During the priod, the mandate of Agriculture Biotechnology programme was broadened with dovetailing of Basic Plant Biotechnology, Agriculture and Frontier areas programme. The focus is now on future readiness in sync with climate, natural resource use efficiency and tackling carbon foot print. Programme is fine tuned to nation requirements, farmers, consumers preferences and international markets for developing varieties/technologies. Further, the mandate is to promote directed basic research aimed at addressing problems of future.

During the period major initiatives include implementation of Network project on pulses with 13 partnering institutions entitled "Genetic Enhancement on minor pulses: Characterization, Evaluation, Genetic Enhancement and generation of Genomic Resources for Accelerated utilization and improvement of minor pulses" under the Mission programme on Genetic Enhancement of Pulses; QTL to variety Phase II targeted at introgressing abiotic stress traits and mega varieties of rice; Plant Genomics and Genotyping Facility(PGGF) anchored at NIPGR and projects targeted at understanding host-pathogen interactions.

Genetic Enhancement of Pulses: - A Mision Programme

Improvement of legumes is one of the priority areas of Department. Department has initiated a mission program on "Genetic Enhancement on Pulses". NITI Aayog has directed to take necessary scientific interventions in a targeted and mission mode approach in this direction. Department through this "**Mission programme on Genetic Enhancement of Pulses**" is targeting complex biological system of pulses which has been neglected. Programme envisages providing farmers with improved and productive varieties, disease and climate resilience. Under the programme Department has funded a first network project entitled "Genetic Enhancement of Minor Pulses: Characterization, Evaluation, Genetic Enhancement and Generation of Genomic Resources for Accelerated Utilization and Improvement of Minor Pulses" with ILS, Bhubaneswar as coordinating centre. Project has thirteen participating Institutions across the country. Pulses targeted under the project are Green gram (*Vigna radiata*, mung bean), Moth bean (*Vigna aconitifolia*), Black Gram/ Urad Bean (*Vigna mungo*), Cow pea (*Vigna unguiculata*), Horse gram (*Macrotyloma uniflorum*, Kulthi) and Rice Bean (*Vigna umbellata*).

Plant Genomics and Genotyping Facility (Phase I)

In order to the use of genomic technology to increase crop yield and farm productivity, Department has funded for establishment of "Plant Genotyping and Genomics Facility" (PGGF) anchored at NIPGR, New Delhi. Facility is a "single-window service system" for advanced genomics technology services and will influence the Indian seed industry at national

level. Proposed facility will facilitate genotyping services with private service providers and then advance these, in a focused way, to meet the specific objectives for plant genotyping. The "Facility" will have potential to evolve into a "leading edge" genotyping service provider and a consulting facility that would have impact not only on agriculture in India, but could serve as a model on a global basis. Facility would be a Genomics Service and a State of art Bioinformatics facility which will accelerate the new trait development efforts in the country by the public and private sector.

The areas focused are: Genome wide association studies, Genomic selection, maker assisted foreground selection and background selection, diversity analysis, tracking line purity. Genotype detection for every test points for purity testing / finger-printing besides consultancy/advice for analysis of generated data whether in house or external. It will come with pipeline of solutions and advice for accelerating genomics based breeding and thus will aid to accomplish goal of food and nutritional security and reduced dependence on imported seed. It will also help to overcome legal hurdles in Material Transfer, IPR protection, etc. as well as will prevent bio-piracy.

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

Cereals

Rice: Department is financially supporting four major network projects and eighteen other projects on rice. In the current year seven improved rice varieties were developed and released.

Indian Agricultural Research Institute, New Delhi has developed two bacterial blight resistant Basmati rice varieties, Pusa Basmati 1728 and Pusa Basmati 1718. These varieties were released by the Central Variety Release committee.

Tamil Nadu Agricultural University, Coimbatore has developed a drought tolerant and heat resistant variety of locally cultivated rice, "Improved White Ponni" through marker assisted introgression of Quantitative Trait Locis (QTL) controlling high temperature tolerance from a heat tolerant Nagina 22(qHTSF1.1& qHTSF4.1) and Quantitative Trait Loci (QTL) controlling drought tolerance (qDTY2.1and qDTY3.1) from an upland indica genotype APO.

Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir has developed a blast resistant variety of local cultivar *MushkBudji* by pyramiding *Pi54+Pita* genes. This variety was released for cultivation in Jammu & Kashmir through Saginaw Valley Rehabilitation Center.

Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur has successfully developed blast and bacterial leaf blight resistant improved variety 'HPR2143' through marker assisted back cross breeding.

DRR Dhan -50 a two-in-one flood and drought tolerant rice variety was developed by National Research Centre on Plant Biotechnology, New Delhi and ICAR-Indian Institute of Rice Research. This variety was released and notified by Central Variety Release Committee in 2018. It is a near-isogenic line of highly popular rice variety Samba Mahsuri (BPT 5204) developed using marker-assisted breeding to combine submergence tolerance (SUB1A gene) with two Quantitative Trait Loci (QTL) for drought tolerance (DTY2.1 and DTY3.1).

National Centre for Biological Sciences, Bangalore has unraveled that multiple yield-related traits associated with indica rice domestication are linked to miRNA397-mediated regulation. miR397 targeted mRNAs encoding laccases that decayed and induced robust secondary cascade silencing in wild species requires RNA-dependent RNA polymerase 6. In wild species of rice, reduced expression of laccases resulted in low lignification. A patent "Method to improve rice yield and de-domestication" has been filed.

Wheat: Department is supporting two major networks and seven other projects on Wheat. In current year,one improved variety of Wheat was developed and released.

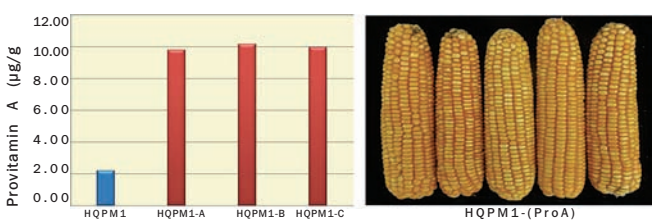
The Department has partnered in the "International Wheat Genome Sequencing Consortium (IWGSC)" and supported the Indian

researchers to achieve the most challenging task of decoding of complex wheat genome. The genome of bread wheat variety 'Chinese Spring' was published in the international journal Science. An insurmountable task of deciphering Bread wheat genome which is heaxaploid and five times larger than the human genome and 40 times larger than rice was released.

Department has supported development of Unnat PBW343 by PAU, Ludhiana through marker assisted backcross breeding by pyramiding two leaf rust and two stripe rust resistance genes *Lr76-Yr70/Lr37-Yr17*. This variety is resistant to leaf rust and stripe rust and has been released for cultivation.

Draft genome of *Tilletia indica*, an economically important quarantine fungal pathogen of wheat was deciphered and annotated by research group at Govind Ballabh Pant University of Agriculture & Technology, Pantnagar. Functional annotation of Karnal bunt pathogen genome and classification of identified effectors into protein families has been achieved. In addition, patent was granted under project "Immunological marker to assess the pathogenicity levels of *T. Indica* fungal isolates".

Maize: Indian Agricultural Research Institute, New Delhi; Punjab Agricultural University, Ludhiana and Tamil Nadu Agricultural University, Coimbatore has developed an improved maize variety HQPM1 by introgression of favorable allele of *crtRB1*and *lcyE*for enrichment of provitamin-A. Variety is rich in pro-vitamin A and is currently under trials.



Provitamin-A level of original- and improved- version of (HQPM-1-A, HQPM1-B and HQPM-C) popular hybrid, HQPM1; Grain- and ear- characteristics of provitamin-A rich version of HQPM-1 nominated to AICRP trial.

Millets: Tamil Nadu Agricultural University, Coimbatore has selected high grain yield per plant and high beta carotene content RILs from the cross between varieties PT 6029 x PT 6129. The identified two beta carotene rich lines (TNBG 0608053 & TNBG 0608207) which are agronomically superior are registered in NBPGR.Two markers, PSMP 2266 and PSMP 2087 linked with beta carotene Quantitative Trait Loci (QTL) can be used in marker assisted breeding programme to develop genotypes with enhanced beta carotene content in pearl millet. Rapid screening method for beta carotene estimation in pearl millet was also standardized.

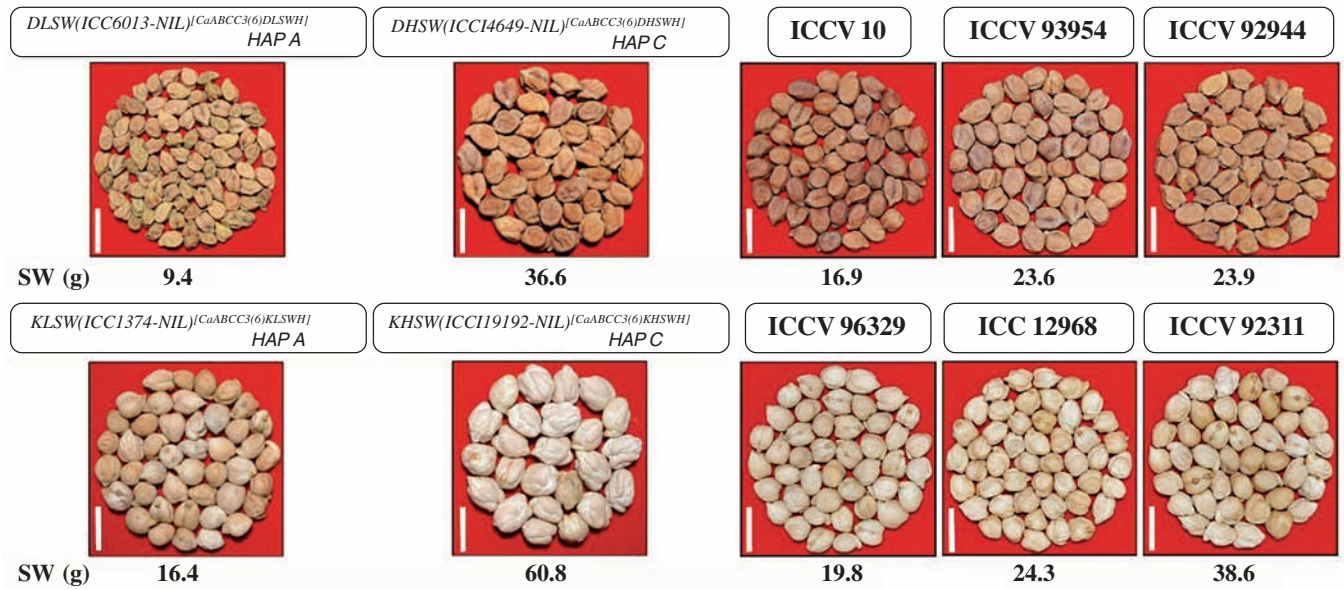
Pulses: Sher-e-Kashmir University of Agricultural Sciences and Technology-K, Jammu and Kashmir has identified two genotypes (WB-966 and WB-967) of *Phaseolus vulgaris* (Common bean) as broad spectrum resistant sources against most prevalent races of bean anthracnose (*Colletotrichum lindemuthianum*).

Field trial of different bean genotypes for seed multiplication at SKUAST-K, Shalimar campus

Tamil Nadu Agricultural University, Coimbatore has developed two soybean varieties through marker assisted back crossing with Phytophthora and Powdery mildew resistance. They are under yield evaluation along with popular checks in South and North India and will be released as new soybean variety in rainfed and irrigated area of India for the benefit of the farmers.

Indian Institute of Pulses Research, Kanpur has identified a Quantitative Trait Loci (QTL) for yield traits in lentil by using a mapping population derived from a cross (IPL 220 × ILWL118). Progenies have been phenotyped for yield and other agro-morphological traits (flower color, number of flower/cluster, plant type and flowering time).

National Institute of Plant Genom Research and Indian Agricultural Research Institute, New Delhi have identified natural alleles and haplotypes of anATP-binding cassette transporters gene, CaABCC3(6) that regulates seed weightby modulating transport of glutathione conjugates in seeds of desi and kabuli chickpea. The superior allele/haplotype of an ABCC3 transporter gene introgressed in desi and kabuli NILs and enhance seed weight, yield and productivity but also plant architecture without compromising the agronomic performance. A patent "An ABC transporter gene modulating glutathione conjugates transport and utilization thereof in enhancing seed yield and quality in chickpea" has been filed.



Picture illustrating the comparative overview of seed size/weight variation observed between low and high SW NILs as well as high-yielding Indian varieties of desiand kabuli chickpea. DLSW/KLSW: Desi/kabulilow seed weight, DHSW/KHSW: Desi/kabulihigh seed weight, LSWH/HSWH: Low/high SW haplotype and NIL: Near isogenic line.

Oil Seeds: Indian Institute of Soyabean Research, Indore has released a variety which is kunitz trypsin inhibitor free. Tamil Nadu Agricultural University, Coimbatore has successfully introgressed Quantitative Trait Loci (QTLs) for rust and LLS resistance from resistant donor GPBD 4 into released varieties viz., VRI 2, CO 7, TMV(Gn) 13, TMV 2 and ICGV 00350 and elite breeding line viz., ICGV 03128.Progenies were selected for improved foliar disease resistance and desirable pod types and are in trials.

Directorate of Groundnut Research, Junagadh has identified two major Quantitative Trait Loci (QTLs) qstga01.1 and Quantitative Trait Loci (QTL)qstga01.2 for resistance to stem rot for first time which would be useful in marker-assisted selection for improving resistance to stem rot in groundnut and in cloning of candidate resistant genes.

DBT-UDSC Partnership Centre on Genetic Manipulation of Brassicas

The overall thrust of this project is oriented towards the development of tangible products in oilseed mustard *B. juncea* through genetic improvement by both conventional and molecular breeding approaches. In the Part I (product development activities), the objectives are directly associated with development of improved varieties and/or hybrids. In the Part II (R&D activities), the objectives are mostly designed which would require more R&D work before they could be utilized for the development of any tangible products. Towards product development activities efforts on spread of hybrids have been made by providing parental lines (CMS and restorer of hybrids) to selected seed companies. Transfer of white rust resistance genes into elite verities & restorer lines and development of '00' lines through marker assisted breeding is going on. Towards objectives related to the R&D activities of the project, QTLs governing seed size and seed oil content have been discovered and candidate genes have been identified. This information would enable development of lines with improved seed size and oil content. A large number of DH lines involving diverse lines have been generated. Some of these lines have been used to develop new hybrids. This is likely to lead to identification of better combiners with improved productivity. Transgenic approach for increasing oil content and seed size are being pursued. Similarly, for *Orobanche* control, herbicide resistant mustard is being developed.

Vegetable & Horticulture Crops

The network project on Development of amaranth core collection using SSR and SNP markers and evaluation of core set for nutritional, yield traits and abiotic stress tolerance implemented by two centers: NBPGR, New Delhi and NABI, Mohali.

Punjab Agricultural University, Ludhiana has developed advanced breeding lines of high yielding tomato cultivar "Punjab Chuhhara" by introgressing genes for leaf curl virus (Ty2); late blight (Ph2 andPh3); and root knot nematode (Mi) resistance. These lines can be used either directly or can be used to develop F1hybrid(s) with disease resistance and good horticultural traits.

Kerala Agricultural University, Thrissur & Indian Institute of Horticulture Research, Bangalore has Identified 10 novel bacterial wilt resistance sources in chilly viz. IHR 3377, IHR 3447, IHR 3453, IHR 3580, IHR 3581 & IHR 3590.One variety of non-pungent, bacterial wilt resistant chilli suited for tropical regions of India is under development.

Under the project "DNA Marker assisted Mapping of anthracnose resistance in Chilli (*Capsicum annum* L.)" two RIL's (RIL 46 & 181) tolerant to anthracnose caused by pathogen *Colletotrichum capsici* coupled with high green and red fruit yield were identified by University of Agriculture Sciences, Bangalore.

Siksha 'O' Anusandhan, Bhubaneswar has characterized two onion cultivars viz. ArkaKalyan and CBTAc77 resistant to Purple Blotch (PB). Crossing of ArkaKalyan with the susceptible cultivar Agrifound Rose showed that the PB resistance is controlled by a single dominant gene designated as ApR1 and markers linked to PB resistance locus in onion have been reported for first time. Markers can be used for the introgression of ApR1 gene into susceptible onion variants for the development of high yielding PB resistant genotypes.

Scientist at University of Horticulture and Forestry Nauni has developed a cost effective in-vitro propagation of Plum cv. Santa Rosa. Tissue culture raised plants of Plum cv. Santa Rosa were transferred to the field.

National Research Centre for Grapes, Pune; Agharker Research Institute, Pune & Punjab University, Chandigarh has developed three downy mildew resistant hybrids of grapes containing Quantitative Trait Loci (QTL) region RPV3 (imparting downy mildew resistance) with commercially important traits like bold berries and loose bunches.Varieties are being taken up for large scale evaluation for their commercial use.

The crop wise list of varieties developed during 2018-19 is as below:

List of Crop Varieties developed

Crop	Varieties Developed	Traits
Rice	Pusa Basmati 1728, Pusa Basmati 1718	Bacterial blight resistant
	CARI Dhan 6 CARI Dhan 7	
	Improved White Ponni.	Drought tolerant and heat resistant
	Mushk Budji (improved)	Blast resistant variety
	HPR2143 (improved)	Blast and bacterial leaf blight resistant
	DRR Dhan -50	Two-in-one flood and drought tolerant
Wheat	Unnat PBW343	Resistance against leaf and stripe rust
Maize	HQPM1 (improved)	Pro-vitamin A rich variety
Pearl millet	TNBG 0608053 & TNBG 0608207	High grain yield and high beta carotene content
Soybean	C03 (Soybean I) & JSS 35 (Soybean M) Improved	Phytophthora and Powdery mildew resistance
	NRC127	Kunitz trypsin inhibitor free
Tomato	Punjab Chuhhara (improved)	Leaf curl virus, late blight& root knot nematode (Mi) resistance
Grape	H90.24 and H98.23	Downy mildew resistance with bold berries and loose bunches

Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) - A Mission Programme

Biotech-KISAN scheme is a farmer centric scheme for farmers, developed by and with farmers. It is a Pan-India program, following a hub-and spoke model and stimulates entrepreneurship and innovation in farmers and empowers women. The Biotech- KISAN Hubs are expected to fulfil the technology requirement to generate agriculture and bio-resource related jobs and better livelihood ensuring biotechnological benefits to small and marginal farmers. Biotech-KISAN also has unique a feature to identify and promote local farm leadership in both genders. Such leadership helps to develop science-based farming besides facilitating transfer of knowledge.

So far a total of eight Biotech-KISAN Hubs in different Agro-climatic Zones have been supported. Major highlights of the progress made in ongoing programmes are as follows:

Biotech-KISAN Hub at Himalayan Environmental Studies and Conservation Organization, Dehradun has clear objective to reach farmers' through a network and facilitation. The central hub (HESCO, Dehradun) and Sub hub (Paini, Sahiya and Simoli) have been created. Improved Agriculture, Horticulture practices, Sustainable use of Bioresource and soil and water conservation are major initiatives of the project. A village-based fruit processing unit was established at Chakarata Sub Hub. One poultry business model has been created in Chakarata Sub Hub. At initial stage a total 500 Broiler + 300 Broiler (*Gallus gallus domesticus*) chicks and feeds were provided to the farmers. For promotion of goat farming 5 goats were given at Almora Sub Hub. To promote economic use of water for irrigation, four micro sprinkler systems were installed in all the locations. Integrated model of water harvesting and its storage with multiple usage has been initiated in two locations.

Establishment of Biotech-KISAN Hub at Bihar Agricultural University, Bhagalpur established with the major mandates to popularise *lathyrus* in Tal areas of Bihar and to conduct values chain analysis and value addition of *lathyrus*. Demonstration is conducted for two varieties of lathyrus (i.e. Ratan and Prateek) in 26.33 acres areas in the field of 46 farmers.

Field Demonstration of Grass Pea (Lathyrus sativus) Var. Ratan in farmers' field (BAU, Bhagalpur)

Biotech-KISAN Hub at West Bengal University of Animal and Fishery Sciences has been started with the objective for linking available science and technology options to the farmers of Sundarban area through understanding their problems to provide a suitable and alternative solution for their better livelihood.

Biotech-KISAN Hub has been established at Foundation for Agricultural Resources Management and Environmental Remediation (FARMER), Ghaziabad. The project is being implemented by FARMER with partnering Institutes; ICAR - IARI, New Delhi, ICAR - CPRIC, Meerut, SVPUA&T, Meerut through KVKs, G. B. Nagar, Ghaziabad/Hapur in the agro climatic zone of Upper Gangetic Plains Region. Trainings have been organized for farmers on development of entrepreneurship in rural youths and women and crop residue management and bio-degradation.

Biotech-KISAN Hub has been established at Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh with the major objectives of assessment of the yield gaps in major pulses and groundnut grown in scarce rainfall and north coastal zones. As part of the project, a base line survey was conducted at selected 25 villages of Srikakulam, Visakhapatnam, Anantapuram and Kurnool districts. Based on the identified focused areas, inputs were also finalized and literature on package of practices of the crops (*Vyvasaya Panchangam*), broachers and booklets pertaining to the advanced technologies were distributed to the farmers to create awareness (Fig 6 a & b). Training programmes were organized for affective implementation of technologies in the farmers' fields. A web portal was also designed for affective dissemination of the technologies at the farmers' level.

Distribution of Inputs (Vyavasaaya Panchaangam), Blackgram Seed, Pesticides to the selected farmer at KVK, Amadalavalasa

Distribution of Inputs Black gram (PU31), Vyavasaaya panchaangam, Bio-fertilizers to selected farmers at DAATTC, Kondempudi

Sustainable enhancement of production and productivity of horticulture and fisheries sectors in the North Eastern states of Assam and Nagaland is the main objective of the Biotech-KISAN Hub established at Horticulture Research Station of Assam Agricultural University, Kahikuchi, Guwahati. The Institute of Horticulture Technology, Guwahati, ICAR, Nagaland Centre and KVK, Kahikuchi are the partner institutes in this programme. Trainings have been imparted to the farmers for establishment of quality planting material production systems of banana, turmeric and pineapple. Overwhelming response from the farmers, particularly women farmers, is an indicator of the percolation of latest sustainable technology at the grass root levels in tune with the felt needs of the farmers of North East Region.

Demonstration of Quality Planting Material in Horticultural Crops at IHT Mandira, Assam under Biotech-KISAN project

A Tinkering Lab has been established under Biotech-KISAN Hub at Indian Society of Agribusiness Professionals (ISAP), Gulbarga for water and soil anlaysis. So far, soil and water samples of 210 farmers and KVK have been analyzed along with 75 soil samples of selected farmers. Demonstration has been carried out in farmers' field for promotion of new red gram variety GRG-811, which is high yielding and resistant to wilt and sterility mosaic along with micronutrient application, space planting, dibbling, transplanting and thinning / pruning. Pulse wonder technologies were also demonstrated at farmer's level. The red gram yield has been almost double with the adoption of these technologies. Under protective irrigation, the yield has touched even more than 2 tons per hectare.

Demonstration of improved Agro-technologies in Red gram

A Biotech-KISAN Hub has been recently established at Chandra Shekhar Azad University of Agriculture & Technology, Kanpur with an aim of agricultural diversification for income enhancement through Horticulture, Scientific Beekeeping, Scientific Goat Rearing, Entrepreneurship Development for Rural Youth and Conservation Agriculture to conserve natural recourses and increase the productivity as well as income with low cost.

R&D collaborative programs through international partnership

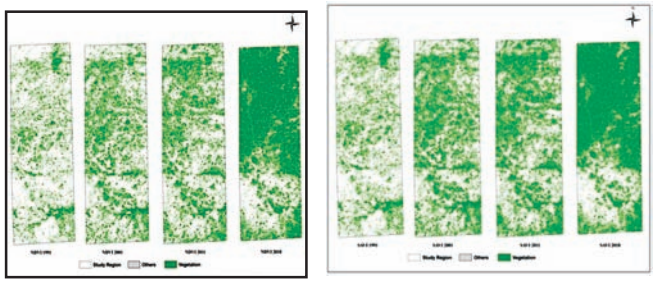
The Department is implementing various international collaborative programmes in area of agriculture biotechnology. The highlights of the achievements are as follows:

Farmer Zone

The Department is positioning itself to take the lead to develop a commercial model for the Indian farmer and their farming needs in what we call a "FarmerZone", a cloud-service with curated data catering to all needs of the farmer from dealing with climate change, weather predictions to problems faced by the farmer on matters of land, soil, disease, pest, water, planting material and marketing. This would be a multi-purpose window for solutions and will be available for farmers anywhere in India and probably the world. Solutions will be provided at the farm, similar to that done by e-commerce companies at the doorstep. The farmer can access the service directly or through an intermediate structure such as local co-operatives. The FarmerZone will include a MarketZone where farmers can directly sell their produce which can be picked up directly from the farm.

As an outcome of an international conclave organized by DBT on August 30-31, 2017, the first sentinel site of FarmerZone on potato crop has been approved for funding. The first sentinel site for potato farmers have been initiated with the support of government of UK through RCUK. DBT hopes to expand the FarmerZone to all crops and to other parts of the country other countries as a major alliance of next generation agriculture technologies for farmers under the FarmerZone.

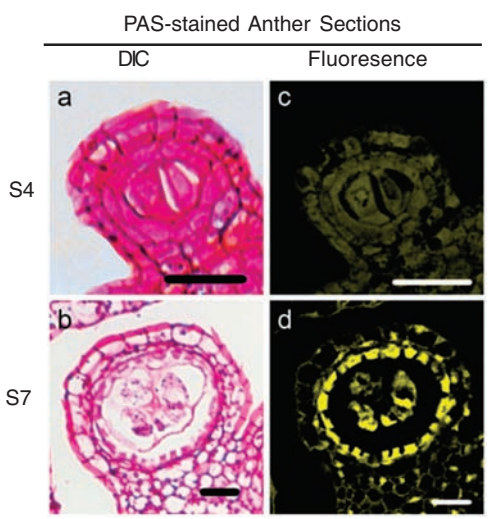
The network project on "the Rural-Urban interface of Bangalore was supported at UAS, Bangalore and other partners in collaboration with University of Kassel, Germany under DBT-DFG cooperation to study the transition process in agriculture and society, triggered by urbanization, keeping Bangalore as an example. Important leads achieved so far, includes vegetation changes over a period of 1991 to 2018 (1991, 2001, 2001-TM sensors, 2018 OLI TIR sensor) in northern transect of Bangalore.



Comparison of the Normalized difference vegetation index (NDVI) and Soil-adjusted Vegetation Index (SAVI) comparison using Landsat imagery.

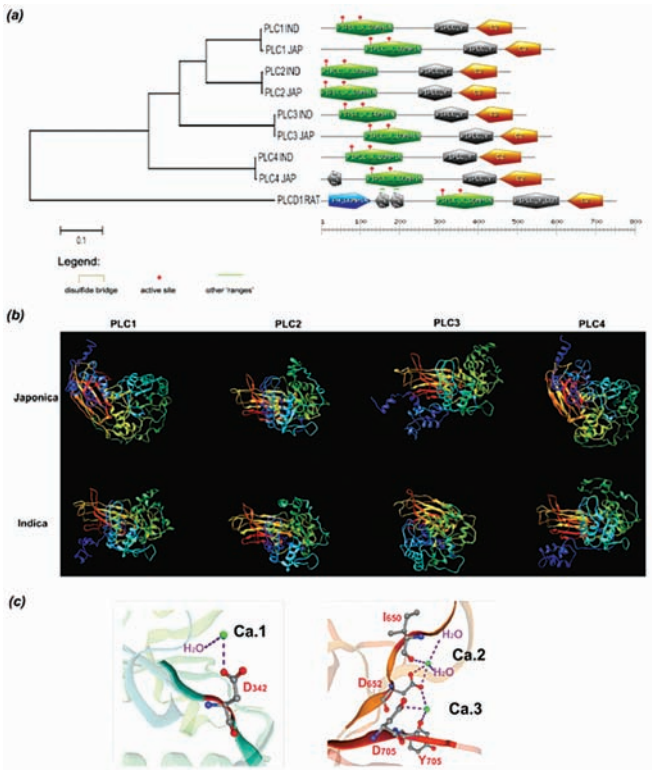
A process for utilization of pea peel and production of microalga biomass enriched with omega 3, protein, carotenoids (lutein) was developed by investigators at GBPUA&T, Pantnagar in collaboration with University of Helsinki, Finland. Medium formulation and cultivation conditions for high cell density have also been optimized.

Investigators of Univ. of Delhi (south campus) and Radboud University, Netherlands revealed that one of the ways that heat tolerant plants achieve tolerance to heat is to hasten their pollen developmental process and minimize the exposure to adverse conditions.



Development of a novel periodic acid-Schiff (PAS) staining technique that distinguishes tapetum at premeiotic (a & c) and post-meiotic (b & d) stages of anther development.

Investigators at Bose Institute, Kolkata in collaboration with Netherlands (University of Amsterdam) investigators have identified, isolated and characterized four PI-PLCs from *Oryza sativa var. indica*. The relative quantification of *O. sativa. var indica* PLC gene expression under different abiotic stress showed up regulation of all the four genes, especially PLC1and PLC3 under salt and drought stress suggesting salt/ drought stress responsive cis-acting elements in the promoter sequences.



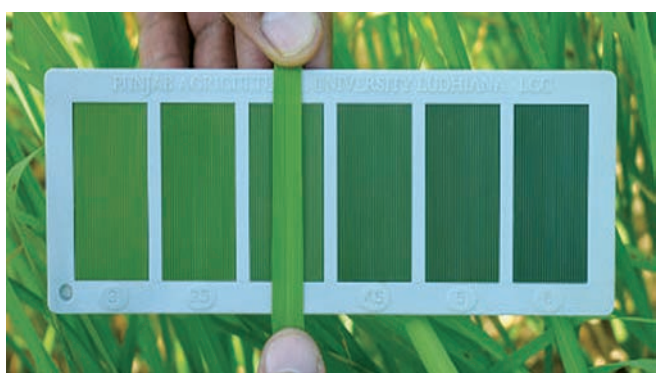
Protein structures of O.sativa. japonica and O.sativa. indica PLCs. (a) Comparison of motif structures of rice PLC and that of rat PLC-ä. (b) PLCs models as predicted by I-TASSER. The homology modelling was compared using UCSF Chimera. (c) Calcium ion binding sites for 1DJI:Chain A. Ca.1, Ca.2 and Ca.3 refer to the first, second and third calcium ion. Dotted lines represent the protein-ligand interactions as well as interactions with water molecule.

Investigators at Jay Research and Biotech India private limited (JRABIPL), Pune in association with Dadelos S.L., Valencia, Spain developed novel microorganisms and bio-stimulants products for complete tomato and soybean Insect Pest Management (IPM). This IPM kit outperformed existing package of farmers practice.

Research supported at IARI-New Delhi and SEIPASA, Valencia, Spain has resulted in the development of plant protection formulations using chilli oleoresin, karanjin, sesame oil and garlic oil. These formulations and their combinations showed insect growth regulatory (IGR) activity against S. *litura*. Garlic oil and chilli formulation showed highest mortality of *B. tabaci* followed by karanjin and sesame oil in lab conditions and showed promising activity in field conditions.

The DBT-BBSRC supported virtual joint nitrogen centre "Indo-UK Centre for the improvement of Nitrogen use Efficiency in Wheat (INEW)" coordinated at IIWBR-Karnal; 406 Wheat germplasm lines comprising 199 Indian and 207 UK lines were screened for nitrogen use efficiency (NUE) and adaptation of UK lines to North Indian environments under field conditions as well as precision nutrients. Another centre "Cambridge-India Network for Translational Research in Nitrogen (CITRIN)" coordinated at ICRISAT, Hyderabad in collaboration with University of Cambridge, UK has established.

Leaf Colour Charts (LCCs) developed for wheat, rice and maize and cotton, and successfully deployed in 1 village in Punjab, which resulted in substantial savings in N fertilizer with no penalties on yield.



Leaf Colour Charts

ANIMAL BIOTECHNOLOGY

Overall objective of Animal Biotechnology program is to enhance livestock production and productivity and improve animal health through biotechnological approaches. The broad areas of research are cattle genomics, reproduction, transgenics, cloning, animal nutrition, animal by-products, animal vaccines diagnostics and therapeutics.

ANIMAL PRODUCTION

Livestock sector plays an important role in our economy. The department continued its efforts towards enhancing animal production and productivity through biotechnological interventions. New programmes have been initiated in the area of cattle genomics, estrus detection in buffalo, early pregnancy diagnostics in bovines, development of transgenic chicken for the production of biopharmaceuticals, prediction of reproductive efficiency of buffalo etc.

Beside organizing Task Force and Technical Evaluation Committee meetings to review the progress and achievements of ongoing and completed projects respectively, several brainstorming meetings viz. In-vitro meat production, enhancing farmer's income through animal husbandry using biotechnological tools, somatic cell derived bovine gametes/ embryos, bovine sexed semen technology were also organized to identify priority areas of research. Some of the achievements of the programme are as follows:

Livestock Genetics & Genomics: Genetic improvement of livestock through traditional selection for increasing livestock productivity has major limitations. The department has therefore initiated a major programme on genome sequencing of indigenous cattle breeds and developing high density SNP chip representing SNPs from all registered cattle breeds of India. Initially, phenotypic data and whole genome sequencing of five milch breeds is being carried out. The study will help in deciphering the genetic makeup of indigenous cattle breeds, identifying elite animal at an early stage.

Molecular and bioinformatics analysis of *DMá (Dystrophia myotonica)* and *DMâ* genes of major histocompatibility complex (MHC) of buffalo *(Bubalus bubalis),* was carried out at Jamia Milia Islamia University, New Delhi to understand their role in health status of animal and to develop possible therapeutic strategies.

Molecular analysis of high incidence of horn cancer (HC) in Kankrej Bull is being carried out at AAU, Anand. Transcriptome data analysis of HC and HN samples were carried out and utilized for SNPs detection and eight uniquely present SNPs related to coding portion of genes in all HC samples were found to be associated with squamous cell carcinoma in humans.

Comparative transcriptional profiling of mammary gland of local Kashmiri cattle and its Jersey cross was carried out to understand molecular basis underlying the milk production at SKUAST, Srinagar. A total 71 putative long non coding RNAs (lncRNA) transcripts were found during various stages of lactation, 8 lncRNAs were specifically found in Jersey cattle targeting milk quality and yield related genes whereas only one lncRNA was reported in Kashmiri cattle.

Genetic analysis of various field strains and vaccine strain of *Theileria annulata* showed high degree of allelic diversity and multiplicity of infection in a study carried out at NIAB, Hyderabad. The presence of multiple genotypes determined by microsatellite markers genotyping and *tams1* gene polymorphism confirmed panmictic population of parasite in the country. These findings will help in understanding the evolution and diversity of the *T. annulata* population and in designing strategies to control disease.

Livestock Reproduction and Cloning: Assessment of early pregnancy in dairy animal by analyzing neutrophil dynamics and gene expression profile was carried out at NDRI, Karnal. In pregnant cows, maternal immune system successfully down-regulates the number and phagocytic activity of blood neutrophils during peri-implantation period. There was an up-regulation of interferon stimulated genes in pregnant cows only which indicates their role in implantation. Sudden increase in the activity of neutrophils causes loss of pregnancy while up-regulation of neutrophils and cytokines are indicators of early pregnancy in cattle.

Work on isolation of sex specific spermatozoa of bovines is being carried out through integrated proteomic and genomic approach in a multicentric project. Aptamer based approach was utilized to detect the presence of three dimensional surfaces and structural differences across X- or Y-spermatozoa. The efficiency and specificity of the binding to sex specific spermatozoa is being assessed.

The development competence of cloned embryos produced from various types of somatic cells were analyzed at NDRI, Karnal and found to be varied in terms of cleavage and blastocyst rate and their quality in terms of total cell number (TCN) and apoptotic index. A feeder-free *in vitro* culture system was developed, which enabled long-term culture of trophoectoderm (TE) cells derived from both IVF and SCNT buffalo embryos.

Animal Nutrition: Effect of plant bioactive compounds on functional attributes of mutton is being investigated at CSWRI, Avikanagar. The study suggest that strategic two hour grazing of stall fed finisher lambs modulated higher *Butyrivibrio fibrisolvens* population in rumen and high expression of Δ-9 desaturase resulting in higher proportion of PUFA in LD muscle and MUFA and DFA in adipose tissue. Incorporation of straw of *Foeniculum vulgare* (Saunf) and *Fenugreek* (Methi) in the diet of goats resulted in improved carcass traits and fatty acid in LD muscle and adipose tissue with higher level of CLA and higher fatty acids.

In another study, supplementation of Omega 3 Polyunsaturated Fatty Acids in the diet of goats resulted in its enhanced reproductive activities. The number of ovarian follicles was increased and ovulation rate was recorded 40% higher with enhanced embryo survival and kidding rate up to 25%. The supplementation also enhanced follicular maturation, increased the litter weight at birth and resumed follicular activity immediately post kidding.

Bacterial and fungal isolates, having potential of production of extracellular enzymes were characterized and technique for enzyme production was scaled up upto 160 kg in single batch for *Aspergillus niger* (CMCase), *Rhizopus oryzae* (Fpase and Amylase), *Phanerochaete chrysosporium* (Xylanase, Laccase, LiP) and *Pluerotus sajar caju* (MnP) at AAU, Anand and GV, Gandhinagar. *In vitro* study of feed with cocktail of enzymes showed better digestibility in comparison to individual enzyme. *In vivo* study conducted on growing calves improved growth rate, digestibility of nutrients, decreased daily methane emission with 8 % reduction in feed cost per kg body gain. The study revealed the potential of SSF in utilization of crop residues as quality feed.

Poultry: Ovarian transcriptome variability between High Egg Layers (HEL) and Low Egg Layers (LEL) of Chara duck, a popular duck breed, was carried out to understand its role in egg production at Central University, Kerala. A total of 16,602 unique genes were identified, out of which 493 genes showed differential expression between HEL and LEL. Besides these, 265 genes exclusively expressed in HEL while 125 genes exclusively expressed in LEL. Further analysis to undermine the role of these differentially expressed genes in egg production is being carried out.

At PDP, Hyderabad, work on transgenic chicken was initiated for the production of human interferon alpha 2b protein. Transgenic vector incorporating chicken ovalbumin gene promoter and non-coding sequence of histone 2A gene has been prepared. The 582 bp whole open reading frame of chicken interferon alpha 2b gene has been amplified and cloned in vector. The functionality of transgenic vector will be examined in the chicken oviductal cells.

In vitro meat production: The department has initiated a pilot study to standardize in vitro meat production technology using cell culture / stem cell technology and outlined different aspects of its production and challenges associated with the process of its production in March, 2019. Various factors responsible for cell growth will be investigated and efforts will be made to standardize technology and also alternatives of fetal calf serum would be tested.

ANIMAL HEALTH

The main aim of the program is to establish collaborative research for the development of affordable new generation vaccines and diagnostics against major diseases of livestock, dogs and poultry. The emphasis of the Animal Health program is on the collaborative translational research, consolidation of existing projects with potential leads and generation of network programmes around major animal diseases.

During the period 10 products were developed, 1 patent was granted, 5 patents application were filed and a total of 24 research papers were published with an average impact factor of 2 in the area of Animal Health research. About 120 manpower were trained in R&D projects of Animal Health programme during 2018-19. The division has also organized several brainstorming meetings to identify priority areas of research for the development of Network program on Anthrax and network program on pathogen genomics of zoonotic and animal pathogens, respectively.

List of products developed

S.N.	Products developed	Use
1.	Low passage High titer CPV-2b vaccine	Parvo virus Vaccine for dogs
2.	Attenuated Theileria vaccine	Therileriosis vaccine for bovines
3.	Evan Syndrome Flow cytometry staining kit	Diagnostic kit for Evan syndrome for dogs
4.	Strip test to detect immune mediated hemolytic anemia	Diagnostic kit to detect anemia in dogs
5.	Canine Leptospira ELISA Ab Diagnostic Kit	Diagnostic kit to detect leptospirosis in dogs
6.	*Brucella* Canis ELISA Ab Diagnostic Kit	Diagnostic kit to detect brucellosis in dogs
7.	Canine Leptospira RDT Ab Diagnostic Kit	Diagnostic kit to detect leptospirosis in dogs
8.	*Brucella* Canis RDT Ab Diagnostic Kit	Diagnostic kit to detect brucellosis in dogs
9.	Canine Parvo RDT Ab Diagnostic Kit (Fig. 2e)	Diagnostic kit to detect parvo virus disease in dogs
10.	Enteric coated polymer probiotic beads	Probiotic for poultry

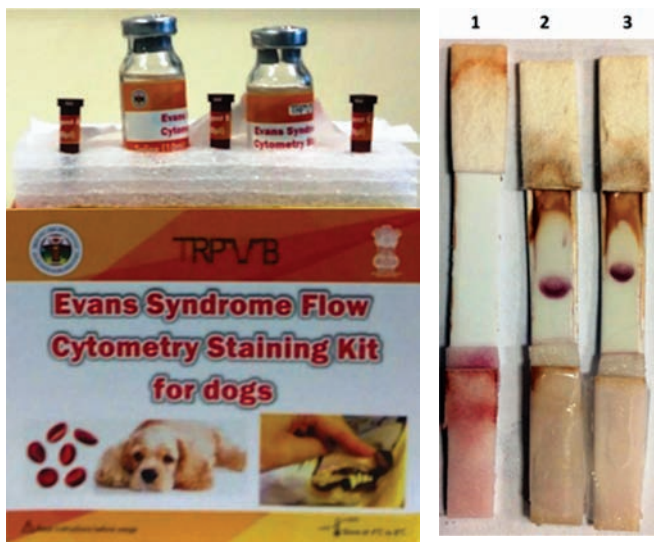
Major Initiatives

Program on Bovine Tuberculosis (bTB): The division after several rounds of brainstorming meetings has formulated a Bovine Tuberculosis Network program in collaboration with the Bill and Melinda Gates Foundation and Penn State University. The network program includes several specific components focusing on bTB surveillance for bTB prevalence, bTB control program through BCG vaccination, establishment of repository, and training of young scientists. The program has been implemented at 8 academic and national institutes involving nearly 80 PIs, Co-PIs and research scholars.

Program on Canine health: In order to implement PAN India program on Canine Health Research, the department has initiated a program involving investigators from Universities and institutions to address major problems of canine upkeep and maintenance in terms of health, nutrition and therapy etc. to prevent zoonotic infection through integration of human and veterinary medicine interface for addressing One Health concept in canine. Under this program two Canine Research centers were established at Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) and Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), respectively. Six networks have been formulated and 42 projects have been supported addressing several issues of dogs at more than 15 state veterinary colleges, national research institutes, national centers and private industries.

Salient Achievements

Development of diagnostics: Under Canine Health Network program an Evan Syndrome Flow cytometry staining kit and a strip test to detect immune mediated hemolytic anemia (IMHA) in dogs have been developed by scientists of TANUVAS, Chennai.



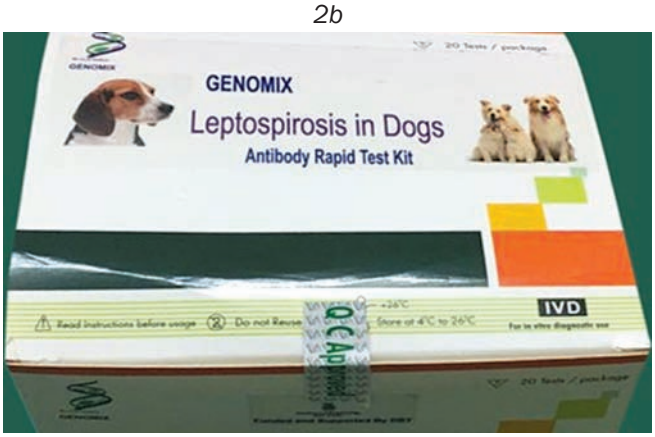
1a *1b*

Evan Syndrome Flow cytometry staining kit and Strip Test for immune IMHA diagnosis (1a) The test dot development in coated membrane is positive whereas the absence of the test dot in the coated membrane indicates negative samples. (1b)

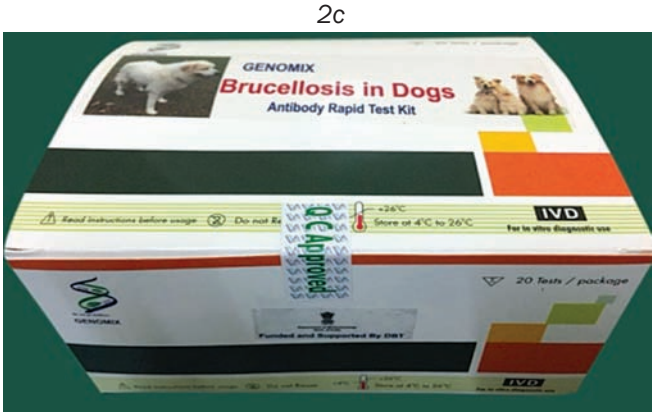
Rapid and ELISA based diagnostic kits to detect sero-surveillance for *Brucella canis*, Canine Leptospirosis, Rabies and canine Parvovirus in vaccinated pups were developed by Genomix India Pvt. Ltd under Canine Health Network program.

2a

2b



2c



2d

2e

Canine Leptospira ELISA Ab Diagnostic Kit (2a), Brucella Canis ELISA Ab Diagnostic Kit (2b), Canine Leptospira RDT Ab Diagnostic Kit (2c), Brucella Canis RDT Ab Diagnostic Kit (2d), Canine Parvo RDT Ab Diagnostic Kit (2e)

Scientists at Tamil Nadu Veterinary and Animal Sciences University have established ELISA for sero detection of Sialodacryoadenitis virus and a PCR panel for pathogen detection in laboratory rodents under a program supported for development of diagnostics for laboratory animals.

Development of Vaccines and therapeutics: Towards development of a genetically engineered vaccine against Newcastle disease and chicken infectious anaemia infection of chickens, scientists from IVRI, Izatnagar have successfully generated and characterized the gene cassette containing the altered fusion protein cleavage site of the fusion protein gene of the mesogenic Newcastle disease virus (NDV) strain R2B. This recombinant NDV has generated a robust humoral and cell mediated immune response in specific pathogen free chickens.

In a study conducted at NIAB Hyderabad, scientists have performed siRNA screening to identify host genes that support intracellular replication of *Brucella neotomae* in macrophages. The detailed characterization of one of the identified genes, FBXO22 suggests that this gene may serve as a potential target for development of novel therapeutics for brucellosis. Detailed characterization of other host proteins that affected intracellular replication of *B. neotomae* is in progress.

The efficacy of the live attenuated Classical Swine Fever (CSF) virus vaccine developed by the scientists of TANUVAS is being validated under field conditions at an organized piggery farm in Thiruvallur district and also in a commercial pig farm at Erode district of Tamil Nadu State. Good sero conversion was noticed among vaccinates under field conditions and the live CSF virus vaccine was found to be safe as well.

Flagship programme: The Department has supported a flagship programme on two major zoonotic diseases viz. Japanese encephalitis virus and Leptospirosis at NIAB, Hyderabad. The project aimed to determine important factors responsible for host pathogen interaction using omics based studies and high end bio-informatics tools.

Strategic Approach for One Health

Human health is inextricably linked to both environmental and animal health and, therefore, must be considered as one; a concept referred to as "One Health." Thus, the development of sustainable, robust human health initiatives requires consideration and effective management of zoonoses– now known to account for the majority of recognized and emerging infectious pathogens and also anthropozoonoses involving diseases transmitted from humans to animals. The Indian subcontinent has been recognized as being particularly vulnerable to zoonoses, and requires coordinated, multi institutional efforts to meet these challenges. The Department has been supporting several network programs on one health like programs on brucellosis, tuberculosis, antimicrobial resistance, anthrax etc. in collaboration with ICMR, ICAR, State Veterinary universities, and private stakeholders. Moreover, the Department is also hosting a **One Health India Symposium** in New Delhi on 18-19th February, 2019 inviting national and international experts to further understand the problems India faces, outline joint goals, key policy strategies and identify critical actions. The One Health India Symposium aims to bring together Veterinarians, Physicians, Public Health Officials, Students, NGOs and other stakeholders synergizing the Department of Health Research, Ministry of Health & Family Welfare, Department of Agricultural Research and Education , Ministry of Agriculture & Farmers Welfare, as well as other relevant stakeholder organizations at national and international level.

R&D collaborative programme through international partnership

A novel molecular diagnostic systems for various arboviruses of livestock and wildlife importance has been developed through the research supported at LUVAS, Hisar and The Pirbright Institute, UK under the joint DBT-BBSRC Call on Farmed Animal Disease and Health (FADH) Research. The efforts have also led to the isolation and identification of new bluetongue virus (BTV) serotypes including BTV-4, 5, 12 and 24 for the first time in India. Multiple exotic and reassortant strains of BTV in India including western vaccine strains of BTV-2 and BTV-10 were also identified, which may have important implications for the design of effective vaccination strategies for the sub-continent.

Mission Programmes on Livestock Health and Genomics

Large Scale Demonstration of Brucella Disease Free Villages of Livestock in States and Union Territories :

Brucellosis, a zoonotic disease caused by *Brucella*, is endemic in India and is characterized by chronic infections, abortion and sterility in livestock. The basic principles to control and eradicate brucellosis in animals are stamping out of positive animals, vaccination of animals and maintaining sanitary conditions. However, the situation in developing countries including India is otherwise because stamping out of positive animals (particularly for cattle) is not feasible due to social and economic reasons. Hence, DBT has initiated a *Brucella* Free Village programme, to establish a consortium focused on providing knowledge-based real-world solutions to accelerating the control of brucellosis in animals. The program will be implemented in a phased manner in 10 states of India. Under phase I, studies will be conducted in five states (Tamilnadu, Andhra Pradesh, Telangana, Karnataka and Gujarat) to demonstrate the concept of Brucella free village in 25 villages (five villages in each state). Likewise, under phase II, five villages each of Punjab, Haryana, Rajasthan, Uttar Pradesh and Assam will be covered under this program.

The proposed project aims to demonstrate the feasibility of *Brucella* Free Village concept on a pilot scale and in a phased manner by using diagnosis of brucellosis in both animal and human populations, vaccination programmes, initiating appropriate therapeutic interventions, animal husbandry

practices and creating public awareness about the importance of the disease. Utilising above strategies, 5 villages each from Tamil Nadu, Andhra Pradesh, Telengana, Gujarat and Karnataka have been selected and other modalities like selection of institute and nodal officers from each state, etc have been worked out.

Utilization of Genomic Technology for Genetic Upgradation of Indigenous Dairy Cattle (*Bos Indicus*) Breeds like Sahiwal, Gir, Tharparkar and others: Genetic improvement of livestock through traditional selection for increasing livestock productivity has major limitations. The department has therefore initiated a major programme on Cattle Genome sequencing in a phased manner. Cutting edge technologies such as NGS, array based genotyping etc. are being used to decipher the genetic makeup of all registered cattle breeds for conservation of indigenous cattle. In the first phase, the project envisages generating phenotypic data of five high milk yielding indigenous cattle breeds (Sahiwal, Gir, Red Singhi, Kankrej and Tharparkar), their genomic analysis, identification of SNPs and development of chips for evaluation and selection of quality animals. The main aim of the proposal is to predict breeding value of an animal using genomic information with performance record and genetic worth at an early age. The ability to select an elite animal at an early age will help in enhancing livestock productivity. So far, 170 blood samples and phenotype data from 4 milch breeds (Gir, Sahiwal, Red Sindhi and Kankrej) have been collected.

AQUACULTURE AND MARINE BIOTECHNOLOGY

Aquaculture plays a very important role in Indian agricultural economy. The programme is being implemented for enhancing aquaculture production, productivity and development of useful products and processes from marine resources. Under this programme projects are being supported to benefit the aquatic and marine sectors by addressing broad areas on fish genomics, breeding and transcriptomics, fish health and management, fish nutrition, fish production, development of diagnostics, immunostimulants and antimicrobial peptides, bio-prospecting, capacity building, development of fish cell lines through adoption of molecular tools and techniques. Project on establishment of viral repository has also been supported.

During the year, significant number of scientific leads have been obtained. Two patents applied and a total of 32 research papers have been published with an average impact factor of 2 from the projects supported in the area of Aquaculture and marine biotechnology. Training programmes were organized to disseminate the technology for Genetically Improved Farmed Tilapia (GIFT) and shrimp production and 130 farmers and stake holders have been trained in four batches for adoption of GIFT and shrimp production. Three months national training in molecular biology & biotechnology has also been supported at CIFE, Mumbai, CIFA Bhubaneswar and CMFRI, Cochin to promote molecular

S. No.	Details of scientific leads under aquaculture and marine biotechnology programme
1.	Establishsing Tachyplesin as anti-mycobacterial peptide
2.	Development of conjugation strategy for Tachyplesin-drug conjugate for anti-cancer drug delivery
3.	LAMP based kit for rapid and sensitive detection of pathogenic *V. parahaemolyticus* in direct seafood samples
4.	Colony hybridization for accurate enumeration of both total and pathogenic V. parahaemolyticus
5.	Standardized protocol for *L. rohita* muscle tissue for various pH range and obtained 657 unique protein
6.	Standardized protocol for all the 17 tissues for pH 8 sample buffer
7.	Triploidy induction in rainbow trout by heat shock
8.	Pelleted diets containing seeds and leaves of *Achyranthes aspera* have been formulated for carp and magur.
9.	Two new prototypes of column based filtration unit designed for extraction and purification of high value pigment Phycocyanin from *Spirulina platensis.*

10.	A low-cost growth medium developed for reducing the cost of biomass production
11.	A new water filtration device designed and tested for chlorine/ ozone/UV treatment free water decontamination. The water decontaminated through this device is used for *Spirulina* biomass production.
12.	New prototype of portable *Spirulina* culture unit with integrated tubular component is designed.
13.	New cell lines were developed from Mozambique tilapia and cold-water fish, *Oncorhynchus mykiss*
14.	New strain of WSSV was isolated and developed PCR protocol to differentiate old and new strains of WSSV
15.	An antiviral compound against WSSV from plant was isolated and identified
16.	LFIA kit for WSSV, *Mr* NV and IMNV
17.	Bacterial cellulose based Paper points for use in endodontics
18.	Identified the chemical structures of four novel antimalarials derived from marine organisms.

biology and biotechnology research in fisheries institutes and universities. Sixty six participants were trained on various aspect of molecular biology including aquaculture & marine biotechnology.

Major Initiatives

Fish Genomics, Breeding and Transcriptomics: Genetic enhancement *Catla catla fish* using genetic and molecular approaches has been implemented and 51 improved *Catla* full-sib families (generation-2) were produced out of which 43 full-sib families recovered and stocked in nursery ponds for further rearing. During breeding season 21.50 lakh improved catla spawn has been produced and used in a field demonstration program. The genomic organization of myostatin gene was derived through genome walking and four CRISPR/CAS constructs were also accomplished using GeneArt CRISPR Nuclease OFP Reporter.

Whole genome sequencing and development of Allied genomic research in two commercially important Fish-Rohu (*Labeo rohita)* and Magur (*Clarias batrachus)* has been implemented and 183.12 Gb (130X coverage) sequences in Rohu and 208.5 Gb (200X) sequences in Magur have been generated using five next-generation sequencing platforms. The draft genome was validated by anchoring all the scaffolds on 25 linkage groups of Rohu. A framework linkage map of Magur has been constructed using 250 informative SSR markers. Genome browser for *L. rohita* and *C. magur* has been developed. Both whole genome sequences have been submitted to NCBI genome database.

For the development of an RNA interference-based silencing approach targeting lectin(s) gene transcripts in freshwater prawn, *Macrobrachium rosenbergii* and its implications as a bio-therapeutant, a hemocyanin protein possessing lectin-like activity has been characterized and two separate lectin molecules have been identified from the hepatopancreas of *M. rosenbergii* which are also being characterized.

Fish Health and Management: *Aphanomyces invadans,* an oomycete fungus causes epizootic ulcerative syndrome (EUS) in more than 92 fish species all around the world. A project on virulence factors identification in fish disease epizootic ulcerative syndrome (EUS) has been implemented. Based on the virulence factors derived from *A. invadans*, four antigenic peptides were derived and the antibody response studies are underway against those antigenic peptides.

Structural characterization of White Spot Syndrome Viral enzymes involved in nucleotide synthesis has been implemented. Codon optimized genes coding for WSSV Thymidylate Synthase (TS) and Thymidine Kinase Thymidylate Kinase (TK-TMK) proteins in pUC57 vector were obtained from Genscript for bacterial over-expression. Crystallization screening for WSSV-TS was carried out and one of the crystals yielded 2.4 Å data was obtained. The structure has been refined and the ternary complex of this enzyme with dUMP and known TS inhibitors are being screened. The enzymatic assays for WSSV-TS are also being optimized.

Fish Nutrition: Development of pelleted diet for *Labeo*

rohita and *Clarias batrachus* using *Achyranthes aspera* and evaluation of its immunostimulatory properties in pond culture system was supported. Experimental diets have been prepared with seeds (0.5%) and leaves (0.25 and 0.5%) of *A. aspera* along with other feed ingredients which showed immune-stimulatory effect of seeds and leaves of *A. aspera*.

Fish Production: Triploid rainbow trout (*Oncorhynchus mykiss*) production for aquaculture enhancement was supported and fifteen healthy brooders were selected to get fertilized eggs which were exposed to heat shock treatment and 80% success of triploidy induction was possible with 40-46% hatching rate and 57-68% survival upto swim up fry stage. There is 9-19% better growth in triploids over the diploids in different rearing conditions at fingerlings stage.

A novel technique is being standardized to produce spermatozoa of *Clarias Magur* using biotechnological approaches. Busulfan (40 mg/kg) and warm water 38°C treatment was given to *Pangasianodon hypophthalmus* for complete gonadal degenerations with an aim to use these fishes as surrogate father for *C. magur*. The spermatogonial cells of *C. magur* were harvested and transplanted in *P. hypophthalmus* and successful transplantation was reported. This will help in production of spermatozoa in *C. magur* in captive breeding.

Technique for Genetically Improved Farmed Tilapia (GIFT) and shrimp production through Bio-Floc based farming system has been standardized. Training programmes were organized to disseminate the technology. So far, 130 farmers and stake holders have been trained in four batches for adoption of GIFT and shrimp production.

Development of Diagnostics: Work on development of novel methods for the sensitive detection and enumeration of *Vibrio parahaemolyticus* has been supported. Pathogenic strains of *Vibrio parahaemolyticus* were identified by targeting virulence genes and two sets of multiplex PCR were developed for genotypic characterization. The loop-mediated isothermal amplification (LAMP) assay was developed which could detect up to 10^2 CFU/ml of cells in direct seafood sample targeting virulence genes (*trh* & *tdh*). The specificity of the assays were 100% for all the gene tested and found to be up to 1000-fold more sensitive in comparison to PCR assay and similar in sensitivity to real-time PCR.

Antimicrobial peptides: Screening of antimicrobial peptides from marine Actinomycetes against Septicemia in Indian Carp has carried out and it has been reported that seven potent isolates of marine actinomycetes showed antibacterial activity against the septicemial pathogens *Aeromonas hydrophila* and *Pseudomonas aueroginosa*. Peptide fraction extracted from these isolates showed inhibition of the test pathogen *Aeromonas hydrophilla* isolated from the infection with a zone of inhibition equal to the crude protein.

Bio-prospecting: Bacterial cellulose (BC) production from newly isolated marine bacterium and their application has been supported to find an alternative bacterium which produces bacterial cellulose. A potent strain *Komagataeibacter rhaeticus* PG2 has been identified as an efficient producer of bacterial cellulose using glycerol as a low-cost carbon source, confirming the economic feasibility of its BC production. The structural characteristics of the BC membrane produced by glycerol were found to be suitable for various applications. The produced BC has the highest water holding capacity at pH 3.0 and the evaluation of this as a paper point for endodontics treatment is being carried out.

Purification and Chemical Characterization of Bioactive Leads from a Marine bacterium has been supported. The marine isolate (*Acenetobacter*) has also been proved to produce a novel alkaline laccase and patent of the same has been filed (Patent Application number: 01741012684).

Fractions of Turbo Methanolic Extract (TME), HxTME (Hexane fraction) and DmTME (Dichloromethane fraction) significantly inhibited receptor activator of NF-êB ligand (RANKL) induced osteoclastogenesis *in vitro*. HxTME has proved its beneficial effects on skeletal health particularly in postmenopausal osteoporosis and may be pursued as a potential candidate for treatment and management of osteoporosis. An Indian patent related to the fraction and its process has been filed (Patent application No. 201821013965).

Study of novel membrane active peptides from marine organisms and their applications in human theragnostics has been implemented at Indian Institute of Technology Delhi New Delhi. It has been reported that Tachyplesin, a membrane active peptide (MAP) was studied for its antimicrobial activity against *Mycobacterium smegmatis*, and the peptide was

found to be efficient in killing *M. smegmatis* cells. The assessment of functional aspect of the peptides is being carried out.

A process for the extraction of collagen peptides directly from raw fish bones was developed by enzymatic hydrolysis using alcalase. It is reported that collagen peptides had more proline, hydroxyproline and glycine and low histidine, serine and threonine as compared to bone collagen. Collagen peptides extracted directly from fish bones possess good biochemical characteristics in terms of their size, composition and functional properties for formulating as dietary supplements without any cytotoxic effect.

Fish Cell Lines Repository: National repository of fish cell lines has been supported in NBFGR, Lucknow with an access centre in C. Abdul Hakeem College, Vellore, Tamilnadu for research on application of cell lines in virology, toxicology and gene expression studies. It is reported that sub-culturing and cryo-preservation of 42 fish cell lines at ICAR-NBFGR and 33 cell lines at CAHC have been carried out for long term storage of cell lines. Ten new cell lines have been developed from Mozambique tilapia and cold-water fish, *Oncorhynchus mykiss* for the first time in India. Two training programmes were conducted in CAHC and 28 participants attended the training for 7 days. One training programme was also conducted in ICAR-NBFGR, Lucknow for five days and 8 participants attended the programme.

Viral Repository: Establishment of national fish viral repository for molecular screening, cell culture based isolation and characterization of finfish and shellfish viruses has been implemented at CUSAT, Cochin, CAHC, Vellore, SKUAST-Kashmir, CIFE, Mumbai and CIFA, Bhubaneswar. The group is collectively working on standardization/ development of PCR conditions for the detection of all known finfish and shellfish associated viruses. A manual on Aquatic Animal Viruses has been prepared encompassing the information on all known viruses of Molluscs, Crustaceans and fin fishes.

Bioenergy, Bioresources And Environment

ENERGY BIOSCIENCE

Department of Biotechnology has been implementing programs on RD & D for Biofuel technology development recognizing the need for clean and renewable energy for transportation. Government of India has announced new policy on Biofuels and an indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel is proposed by 2030. Department has made significant R&D efforts in this direction, major focus has been on development of 2nd Generation Biofuels. Overall aim of DBT is to make available cost effective biofuel technology by improving feedstock/developing new feedstock, improving biofuel production technologies, developing enzymes/ microorganisms for improved yield of biofuel and developing value added products from by-products etc.

During the year 2018, focus has been on demonstration of technologies to convert Waste into Energy and value added products. Based on novel technologies to convert Municipal solid waste (organic fraction) into energy, 3 demonstration plants are being commissioned at Goa, Hyderbad and Mumbai. Indigenous cellulytic enyme with good activity required for conversion of biomass to ethanol has been successfully scaled up at 5000 L fermenter. A major project for Barapullah Sewage Treatment Technology demonstration will be commissioned using Technology developed at DBT-ICT Centre for capacity of 1 Million Litres /Day.

Mission Innovation is a major global initiative launched during Paris Agreement in Nov. 2015 with the objective to accelerate innovation in Clean Energy to make it affordable and accessible for all. India is an active member of this initiative and leading many activities specifically towards eight jointly identified Innovation Challenges. Under Mission Innovation program, Funding Opportunity Announcement was made for Sustainable Biofuels Innovation Challenge (IC#4) to invite proposals in identified gap areas for R&D and Demonstration. Based on merit /novelty a total of 14 collaborative projects selected in which investigators from 9 countries will share knowledge through student & scientist exchange.

India is also an active member of Biofuture Platform, which is an action oriented program to accelerate development and deployment of Biofuels and is being coordinated by Brazil and International Energy Agency.

Energy Bioscience Division has been promoting innovative research in Biofuel area through Centre of Excellence, Extramural projects and Fellowship schemes. Capabilities developed in Systems and Synthetic Biology with demonstrated laboratory work. Technologies/ products developed at DBT-Bioenergy Centres are taken forward for scale up/ demonstration at pilot scale. Research outcomes have been published through 80 research papers and 10 patent applications have been filed. Salient Achievements during the year are summarized below:

DBT-Bioenergy Centres

Department is supporting four DBT-Bioenergy Centres with specific goals and targets in accordance with the National Biofuel Policy. Recently in September 2018, 5th Bioenergy Centre has been set up at TERI with 3 other partner institutions (IITG, IARI and Transtech Green Power Private Limited) which would focus on integrated production of advanced Biofuels and Bio-commodities. Salient achievements of established four DBT Bioenergy centres are as follows.

1. **DBT-ICT Centre for Energy Biosciences, Matunga, Mumbai:** This centre for R&D and technology translation in the area of biofuels and bio-refineries, completed 10 years of this operation. The first- of-its-kind robotic platform explorerTMG3 Workstation for High-Throughput microbial & enzymes screening and molecular biology routinesinstalled at the Centre. The facility has resulted in accelerating the development process in enzyme and microbial innovations alongside Synthetic Biology involving multiple microbial chassis for various target products.

The DBT-ICT Centre also successfully scaled up macro algal cultivation in its newly designed cost effective photo bioreactors. This technology will be helpful to derive multiple products from the on-shore marine produce.

Explorer™G3 Workstation -Advanced High Throughput Screening System

2. DBT-IOC Centre for Advanced Bioenergy, Faridabad: DBT-IOC Centre has major thrust to develop viable 2nd Generation Biofuel technologies in new areas of second and third generation biofuels, such as ligno-cellulosic ethanol and algal fuels. Major achievements of Centre during this year are:

DBT-IOC Centre successfully scaled up its enzyme technology at 5 KL fermenter at third party premises good FPU/ml activity. The whole enzyme broth material was tested at 1MT/Day 2G Ethanol pilot plant at Pune. The enzyme showed comparable hydrolysis efficiency when compared to commercial enzyme. The centre has installed world's first pilot plant based on DBT-IOC & LanzaTech technology for conversion of CO2 to high value Lipids (Omega 3 Fatty Acids). Data is being generated in the pilot plant trials (100 litre scale) to optimize the cost /economics.

The centre has installed and commissioned India's firstcontinuous Steam Explosion pilot plant & Extractor

CO2 to High Value Lipids Pilot Plant at DBT-IOC Centre, Faridabad

system. This 300 kg/day pre-treatment pilot facility shall be used for developing process technology for 2G ethanol agnostic to feedstock (cotton, mustard stalk etc.). Centre has filed 3 patents and published 5 papers.

3. DBT-ICGEB Centre for Advanced Bioenergy Research, ICGEB : DBT-ICGEB is the third Bioenergy Centre of DBT set up at International Centre for Genetic Engineering and Biotechnology, New Delhi. The research focus of this Centre is to use molecular tools to engineer microbes, cellulytic enzymes, algae for enhanced biofuel production. During year 2018-19 more than 25 research paper published from this centre alone . The salient achievements of this Centre during the year are as below:

Enzyme Development: The efficiency of cellulase enzymes, named DICzyme-1 developed using engineered fungal strain also validated from third party. Industrial collaboration with industry partner initiated for scaling up the enzyme production. In addition to catabolite repressor Mig1 deletion to obtain PfMig188 fungal strain, a fungal enhancer ClrB has been over expressed to improve the enzyme efficiency further and reach the cellulase protein titer to 16 g/L in the extracellular medium.

Yeast Engineering: Developed genetically engineered thermo tolerant yeast from strains for secreting CBH1 enzyme and co fermentation of C5/C6 with higher yields (yield and titer of 0.46 g/g and 30g/l) of ethanol. Also improved yeast strain for production of fatty acid ethyl ester (FAEE) with yield of 1.5 g/L

Systems Biology: Centre has strengthened capabilities in systems biology with focus on training and workshops. Metabolic labelling utilized to quantify precursor contributions to polyhydroxybutyrate (PHB) in cyanobacterium. Software developed to conduct stationary 13C-MFA using freely available tools, thus circumventing the need for MATLAB, a proprietary platform.

4. DBT Pan-IIT Centre for Bioenergy (Virtual Centre of 5 IITs) : The DBT Pan-IIT Centre for Bioenergy, a virtual Centre of Excellence spread across five different IITs (IIT, Bombay; IIT, Kharagpur; IIT, Guwahati; IIT, Roorkee and IIT Jodhpur). The Centre has been involved in developing novel

catalysts and enzymes for conversion of algal oil to hydrocarbons and utilizing lignocellulosic biomass for production of biofuels. The research done has led to 24 publications. To increase the Centre's scientific interaction within the national context, a two-day DBT National Workshop on Bioenergy was conducted by the Centre's IIT-Roorkee node in the month of July, 2018. This workshop provided an interactive platform to researchers from all four DBT funded Bioenergy Centres, to discuss the challenges associated with commercialization of bioenergy innovations.

R&D Projects: DBT participated in national 'Swachh Bharat Mission' through supporting research projects on generation of Energy from Waste. A total of twelveWaste to Energy projects initiated to develop/ demonstrate novel and viable technologies for sustainable utilization of Municipal Solid Waste (MSW) for cleaner madeto bring together stakeholders by organizing National Workshop on Waste to Energy Technologies and Way Forward in Sept. 2018 in Pune.

During 2018 various novel Waste to Energy technologies have been identified/ demonstrated to address the current challenges associated with solid and liquid waste management. Three demonstration projects of capacity 1ton-10ton MSW/day are being commissioned in collaboration with industry or Urban Local Body. The focus is on conversion of both Municipal Solid and Liquid Waste to Bio-Oil, Bio-CNG and Bio-Methanol.

Municipal Solid Waste (MSW) Treatment Technology: DBT supported various Demonstration and R&D Projects under 'Swachh Bharat Mission' across the country for developing and demonstrating technologies for sustainable utilization of MSW/ Biodegradable Waste for cleaner and pollution free environment as well as generation of the energy in the form of Biogas, Bio-Oil, Bio-CNG and Bio-Methanol etc. The focus includes modern and scientific conversion of MSW/ Biodegradable Waste Management. The three demonstration projects being commissioned are :

Waste to Energy Demonstration Projects: "Setting up Demonstration Plant to convert MSW into Energy" by DBT-ICT Centre, Mumbai in collaboration with BPCL, Chembur to convert 1 ton MSW/ day into 100 kg Methane.

"High rate Bio-Methanation of organic fraction of MSW for the generation of Biogas based power and Bio-Manure" by IICT, Hyderabad in collaboration with HIMSWL to convert 10 tons/ day of organic solid waste into Biogas and Bio Manure.

"Demonstration of a Waste to Energy project by Anaerobic co-digestion of Food Waste and Septage" by BITS-Pilani, Goa in collaboration with GSIDCL to convert 5 tons Organic Waste and 10 tons of Septage per day into Biogas and Manure.

The above mentioned technologies are being demonstrated at a scale of 1-10 tons/ day. However, the technologies would be advanced in order to increase the capacity upto 100 tons/ day for taking it forward by local bodies (Municipal Corporation).

Waste Water Treatment Technology: A novel Carbon Capture Reactor Technology has been developed at DBT-ICT Mumbai. CCR technology and CTL-Technology together provide a mega-scale central way to capture carbonaceous pollutants in waste waters of the city and convert these into energy, biofuels and chemicals. Based on this technology, a demonstration plant at Barapullah Nallah in Delhi will be set up soon for the treatment of 1 million Litres of sewage per day for production of Bio-CNG.

Production of Methanol using Biomass/ Municipal Solid Waste/ Sources other than Coal: NITI Aayog took an initiative inviting researchers to bring out innovative ideas for Production of Methanol using Biomass/ Municipal Solid Waste/ Sources other than Coal. Disposal of the waste and generation of power is in focus. There are several emerging technologies in the area of methanol production. Hence, in this regard, two proposals recently supported by DBT for demonstrating the technology for producing Methanol using Biomass/ Municipal Solid Waste/ Sources other than Coal at IISc, Bengaluru and IIT Bombay. A technology to convert Biomass to the required quality of syngas developed and demonstrated in a project at IISC Bangalore.

National Stakeholder's Workshop on Waste to Energy Technologies: Way Forward: Recently first National Stakeholder's Workshop on Waste to Energy

Technologies was organized by Department of Biotechnology at Pune on September 10th-11th, 2018. The workshop aimed at bringing all stakeholders from Government, Academia and Private Companies working on Municipal Solid Waste Management together to deliberate on various available Waste to Energy technologies specifically to convert Biodegradable Waste into Energy in various forms and identify the gaps to take these forward for demonstration of promising technologies in collaboration with Urban Local Bodies (ULBs).

New major projects are also under consideration by DBT for technology demonstration under Swachh Bharat with Municipal Corporation. Also it is proposed that the same technologies would be taken forward to set up small scale unit of the demonstration plant at few selected Aspirational Districts based on type of bio-waste material available.

Bio-Toilets in North Eastern India: The Department of Biotechnology funded a program to The Energy and Resources Institute (TERI) North Eastern Regional Centre, Guwahati to install toilets in schools in North Eastern India, and BIRAC is given responsibility for its implementation, management and coordination. In total 95 toilets (Assam: 35, Meghalaya: 15, Nagaland: 5, Tripura: 15, Mizoram: 10 and Arunachal Pradesh: 5. Manipur 10) have been installed till date. Substaltial water saving has been achieved due to change in design of toilet pan. There is 100% containment with no septage in ground water and hence, the bio-digestor technology may prove to be successful in North East India where the water table is very high.

Bio Toilet at NCR-India

- Based on 2G Ethanol technology developed by DBT-ICT Bioenergy Centre, a plant of 100 KLD ethanol capacity will be set up at Bhatinda. Trials run and technology transfer under progress.
- Indigenous Cellulytic Enzyme has been developed and tested with industry. Scale up under process
- India's first continuous Steam Explosion pilot plant & Extractor system for pre-treatment of Biomass has been installed at DBT-IOC Center Faridabad.
- Three demonstration plants are being set up to convert Municipal Solid Waste into Energy with suitable collaborating partner.
- Sewage water treatment with generation of energy demonstrated using microalgae photo bioreactor based technology. A demo plant is being commissioned at BPCL Colony
- Based on Carbon Capture Technology a sewage treatment plant of capacity 1 Million Liquid per day will be set up at Barapullah, New Delhi.

Capacity Building in Bioenergy

Capacity building in Bioenergy strengthened by launching third call of Bioenergy Awards in Cutting Edge Research (B-ACER) and continued support to Energy Bioscience Overseas Fellows. Also, Indian Biological Engineering Competition

(iBEC) 3rd call was announced this year which gave opportunity to 25 UG students to present their research work at an international platform through iGEM Competition.

Student teams from 5 different institutes were given support to participate in an International Genetically Engineered Machine (iGEM) contest held in October 2018 at Boston, USA. All 5 teams got opportunity to present their proposals at an international platform and secured Gold/ Bronze medals.

International Co-operation in Biofuels

An International Conference on Sustainable Biofuels was organized with active participation of the Biofuture platform in 2018. The New Delhi declaration was released for Sustainable Biofuels, highlighting intent of MI countries to work in collaboration mode in development and deployment of sustainable biofuels on commercial scale by sharing best practices. Indo-Brazil Bilateral meeting was held on 28th February, 2018 to discuss area of co-operation in Sustainable Biofuel.

India is also an active member of Biofuture Platform which is an action oriented, country-led, multi-stakeholder mechanism for policy dialogue and collaboration among 20 leading countries to accelerate development and scale up deployment of modern sustainable low carbon alternatives to fossil based solutions in transport, chemicals, plastics and other sectors. Based on inputs provided by 20 member countries and partners a report on Creating Biofuture for low carbon bio-economy has been developed and released on 10th December during High Level meeting at COP 24 held in Katowice, Poland. More details about Biofuture Platform may be seen at website http://biofutureplatform.org

Accelerating Clean Energy Innovation through Mission Innovation

Mission Innovation (MI) is a global initiative of 23 countries and the European Union to dramatically accelerate global clean energy innovation (http://mission-innovation.net/). This initiative will dramatically accelerate the availability of the advanced technologies that will define a future global energy mix that is clean, affordable, and reliable. India is an active member of the Mission Innovation initiative and DBT is Coordinating National efforts in collaboration with DST and other line ministries.

India is actively engaged in global calls (MI Challenges), to action aimed at accelerating Research, Development, and Demonstration (RD&D) for Clean Energy Development. India is an active participant in all the eight MI challenges and is a co-lead in three challenges (Smart Grids, Off-Grid access to Electricity and Sustainable Biofuels). During 2018-19, India has been actively focusing on key Mission Innovation tasks of Information sharing, Analysis and Joint Research.

3rd Mission Innovation Ministerial (MI-3) in Malmos Sweden from 22nd - 23rd May, 2018: Hon'ble Minister Science & Technology and Earth Sciences, Dr. Harsh Vardhan led the delegation for the 3rd Mission Innovation Ministerial (MI-3) and Ninth Clean Energy Ministerial (CEM9) meeting held at Malmo Sweden where he announced Champions Program and also launched an International Clean Energy Incubator.

Analysis and Joint Research : India being an active member of AJR sub-group, has actively participated in the design, schedule, assessment of the Innovation challenges as set by the Mission Innovation Secretariat. Based on the recommendations from the AJR co-lead meeting held in October 22-23, 2018 in Brussels, India has made commetted investment in R&D programmes by announcing

the funding opportunity announcement of **US$17 Million on Sustainable Biofuels, Converting Sunlight and Carbon Capture Innovation Challenge.** A total of 47 collaborative projects have been recommended for funding support in above three areas.

Supporting Public Private Partnerships and Innovation in India: Supporting Public Private Partnerships and Innovation in India: Clean Energy International Incubation Centre (CEIIC): The Department of Biotechnology (DBT) & BIRAC have joined hands with Tata Trusts, to set up the first "**Clean Energy International Incubation Centre (CEIIC)"** in Delhi under "Mission Innovation". The incubator will support a wide spectrum of clean energy innovations and the centre is open to innovators and start-ups from MI countries ensuring synergy in fund flows and more concerted efforts in supporting the growth of new and clean energy solutions internationally.India has partnered with Sweden for a Sustainable Future, Avoided Emissions Framework. A challenge call has been announced, and eight successful case studies to show case at the 4th Mission Innovation Ministerial to be held in Vancouver Canada (May 2019)

An Action plan has been devised and has been submitted, focusing on more engagement, communication, enhanced leadership and wider collaboration amongst the SBIC members.

R&D activities initiated as a follow up of an International Conference on Sustainable Biofuels (ICSB) which was organized in New Delhi in Feb 2018. During this ICSB, New delhi decleration was relesed which highlighting intent of MI countries to work in collaboration mode in development and deployment of sustainable biofuels on commercial scale by sharing best practices. Accrodingly, many collabrative project initivatived for 7 innovation challenges with MI members countries.

RD&D Investment Mapping for enhancing Clean Energy Transition: IEA and the Ministry of Science and Technology, Govt. of India, have agreed to joint work on mapping of Indian R&D investments in clean energy development by Public and Private sector in India. The project is conceived to provide support to India's actions under the Mission Innovation initiative, in cooperation with key relevant national stakeholders and government entities. A successful round table meeting between MST and IEA concluded on 6th December 2018. The round table meeting worked around to develop a working relationship between the key staff from the IEA and relevant Department of Government of India Public Sector Units Energy R&D funding and Policy organizations. Indian R&D Data and Energy programs building a common foundation for ensuing project work to implement the MoU.

The roundtable meeting effectively brought out a range of valuable information and experiences on energy innovation in India and data tracking methodologies being used by IEA in other countries of the world.

Supporting the Clean Energy Champions: This is an award given under Mission Innovation program to any individual innovator who are accelerating the clean energy revolution. India has actively participated in the MI Champions programme by widely outreaching it. From India, a total of 91 applications were submitted, out of which 23 applications underwent international peer to peer review. Out of these 23 applications one international champion for India has been selected and who would be given an opportunity to represent

India at the 4th Mission Innovation Ministerial. In addition to one international champion Govt. of India has decided to select four National MI India Champions who will be supported via innovation / Research grants to expand or scale their innovations. The four India MI Champions have also been selected by international review process. These champions can play important role as ambassadors for accelerating innovations and clean energy transitions in the country.The details about MI International and MI India Champions are available at (http://mission-innovation-india.net/mi-champions/).

Supporting Breakthroughs in Global Cooling Technologies: Dr. Harsh Vardhan, Hon'ble Union Minister of Science and Technology, Environment, Forest and Climate Change, and Earth Sciences, Government of India formally launched the Global Cooling Prize by DST . This is an innovation challenge to develop a cooling technology with 5X less climate impact. **Further details are available at :** http://www.dst.gov.in/global-cooling-prize-launched-awarding-breakthrough-innovations-cooling-technology.

screening is ongoing. Currently 21 applications from India have been selected and after a peer to peer review a Panel review is currently under process.

- Mission Innovation Champions programme has been announced to celebrate and support innovative individuals who are accelerating the clean energy revolution.
- Clean Energy International Incubation Centre (CEIIC) set up in collaboration with Tata Trusts, in Delhi under "Mission Innovation" to provide suitable ecosystem to innovators and Start-ups.
- Government of India formally launched (through DST) the Global Cooling Prize - an innovation challenge (IC#8) to develop a cooling technology with 5X less climate impact.

Waste to Wealth

The Department in collaboration with Dutch organization for Scientific Research (NWO/ STW) and IIT Delhi, NEERI, Nagpur and TERI, New Delhi have implemented a project on cleaning of the Barapullah Drain (LOTUSHR). Under this, an Advanced Analytical Lab at IIT Delhi was established to analyse different emerging contaminants present in the raw influent and treated waters.

Advanced Analytical Lab at IIT Delhi

Investigators at NIT, Durgapur and Central University of Haryana, Mahendragarh in association with Universitécatholique de Louvain, Belgium and Universidade Nova de Lisboa, IBET, Portugal have developed three photocatalysts and two TiO2 based catalysts for treatment of antineoplastic agents in hospital waste water and laboratory scale testing is under progress.

In a study supported under Indo - Brazil programe on Biorefining of sugarcane bagasses for production of bioethanol and value-added products, NaOH pre-treatment condition of sugarcane bagasse, hydrothermal pretreatment condition, hydrothermal pre-treatment using cattle urine as a solvent and loading for pre-treated bagasse were optimized for production of bioethanol and value added products.

Visit of Brazilian delegation on bioethanol, to India in November 2018

A Microalgae Biorefinery approach in Indian and Brazilian scenario was undertaken to demonstrate the phycoremediation potential of two algal consortia, P6 (consortia of *Phormidium* and *Chlorella*) and HL (algal consortia from Hauz Khas lake) were studied and based on their biochemical composition, HL was selected for biogas production and P6 for hydrothermal liquefaction (HTL). Further studies are underway.

"Under India-UK Industrial Waste Challenge five (5) multidisciplinary and multi-institutional pilot studies with an obligate participation from industries, demonstrating waste to wealth treatment have been kicked off for three years. These studies emphasize conversion of industrial discharges such as paper & pulp, sugarcane and municipal solid waste to commercially valuable products sugars, BioCNG, lactic acid, Butanol, VFA, etc."

ENVIRONMENTAL BIOTECHNOLOGY

Environmental Biotechnology programme is one of the areas where impetus is on waste management and environmental improvement. Focus has been on development of microbial technologies for environmental improvement, development of treatment process of industrial effluent, bioremediation of xenobiotic compounds, etc. Scanning of the microbial diversity of various environments and deciphering their genetic information was also carried out with the aim of isolating microorganisms that could be in bioremediation processes.

Department has also identified priority research areas like development and demonstration of wastewater specific effective remediation options, technologies for solid waste management, remediation technologies for agricultural run-off for removal of chemical fertilizers and pesticide pollution. Effort is also made to generate/formulate consortia from the existing isolates as well as new isolates for site-specific remediation of xenobiotics from the environment etc. Department has also initiated R&D projects on remediation and reclamation of Hexa-Chloro-Cyclo-Hexane (HCH) dumpsite by using microbial bioremediation technology,

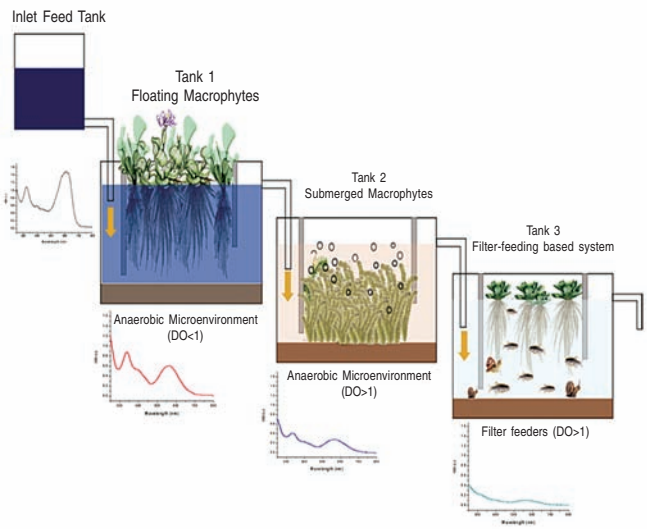
Bioconversion of CO2 to platform chemicals through microbial catalysed electrochemical approaches. Further, development and demonstration of pulp paper mill effluent detoxification technology after secondary treatment by combination of bio-augmentation and constructed wetland treatment process for re-use and prevention of river pollution, design of biosensor for detecting of xenobiotic pollutants in river water, development of novel fluorescent platforms for the detection of heavy metals in water etc. Some of the salient scientific and technical outcomes emanated from the project supported under the programme are highlighted below.

Under India-EU Water Cooperation seven (7) multidisciplinary and multi-institutional pilot studies with an obligate participation from industries, demonstrating various water treatment solutions through biological, physical and chemical means for rural and/or urban populations have been kicked off on 14th & 15th February, 2019 for three-five years. This is a partnership call between DST, DBT and EU.

A network project has been initiated with an aim to establish the electrode assembly in plant rhizosphere region to study the function on role of electrogenic activity, rhizosphere activity and microbial activity in the direction of enhancing the performance of constructed wetland system in treating textile dye wastewater in the framework of eco electro design. Design parameters are being optimized. Pilot scale system will be designed and evaluated at Five Stars in MIDC area, Kolhapur, Maharashtra to treat the industrial effluents.

Lab Scale Ecological Engineering System

At PU, Chandigarh, research leads have been obtained towards enhanced enzyme production from *Rheinheimera species* using industrial waste based media. Optimization (statistical) of environmental and aeration conditions resulted in enhanced laccase production with reduction of incubation time from 72h to 36h. Also in an industrial set-up, laccase mediated deinking reduced chemical consumption by 50% without use of costly mediator with improved properties of old news paper pulp.



Schematic representation of EES

In a project on development of sustainable environment-friendly indigenous biological solutions to mitigate arsenic contamination for safeguarding food chain in the arsenic prone areas of India for safe crop cultivation,CSIR-NBRI, Lucknow has developed prototype of a novel soil fungal consortium for reducing bio available soil arsenic fraction and arsenic uptake to arsenic accumulating paddy varieties in multi-location trials conducted in arsenic-contaminated agriculture fields of West Bengal. It has been observed that the fungal consortium has slightly promoted paddy growth and yields.

In the project on bio-restoration of degraded mangrove forest, WBSU, Kolkata, two ha site of restoration has been fully restored by following a site-specific restoration technology. Restoration was carried out maintaining the diversity and successional prototype of the pristine mangrove forests in Indian Sundarbans. Investigators have also established strong correlation between levels of accumulated osmolytes from 21 species of mangroves and associates with seven ecosystem dimensions of degradation viz. soil nutrients, soil and tidal conductivity, soil phenol oxidase activity, sulphide content and forest cover percentages across the degradation gradient and concluded that the osmolyte accumulation, as the most potent physiological predictor of mangroves ecosystem degradation levels by a regression model.

Technologies for the reclamation of sodic and saline-sodic soils have been developed at TNAU, Coimbatore. Promising results were obtained with the integrated application of chemical amendments, organic manures and microbial inoculants. These leads can be effectively utilized in two ways viz., i) to mass multiply the calcite dissoluting microbes to demonstrate these technologies among the farming community; and ii) utilization of identified calcite dissolutingmicrobes, amendmentsand salt tolerant crops along with new sources for the reclamation of calcareous soils.

A novel lipolytic microbe, *Bacillus cereus* strain isolated from deoiled flax seed cake which could effectively utilize Jatropha deoiled seed cake to produce lipase (TERI, N. Delhi). Process parameters have been optimized to enhance the lipase production performance of this strain. Performance/activity of lipase produced by this strain is significant and close to the commercial grade lipase.This microbe also significantly degraded lipid contaminants from the FOG contaminated kitchen waste water, waste cooking oil.

In a project on carbon sequestration and seed oil biosynthesis in *Pongamia pinnata* at University of Hyderabad, study results indicates that roots play a key role in conferring salt-tolerance in *P. pinnata*. Further, vacuolar sequestration of Na+ in roots minimizes Na+ translocation to the shoot system. Uptake of K+ in the leaves might contribute in maintaining leaf water potential and photosynthetic efficiency.

The study on characterizing anuran species as an indicator of environmental quality in human dominated landscapes has generated data for developing realistic, predictive models useful for mitigation and restoration of dispersal corridors in a rapidly changing urban landscape. Two new species of frog have been discovered and reported to science *Nasikabatrachus bhupathi* and *Blythophryne beryet.*

FOREST BIOTECHNOLOGY

Department has taken an initiative aiming to take up scientific research & demonstration projects on Forest and Conservation Biotechnology. Overall aim of the programme is 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. Project proposals were invited built upon innovative ideas on study impacts of climate change on the forest ecology and development of mitigation & adaptation technologies to minimize climate change impact, modelling and control of invasive species in protected areas, technologies for measuring and maintaining ecosystem services from protected areas and use of biotechnological approaches on afforestation and regeneration of degraded protected forest areas. Out of 205 R&D proposals, Expert Committee recommended 22 project proposals for financial support by DBT.

New R&D projects have been started 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 has been taken up. Projects have also been started on co-management and sustainable use of Non-timber forest products in three protected areas of Western Ghats and efficacious management of wood borers in protected areas of forest by pheromone loaded organogel.

BIORESOURCES & SECONDARY AGRICULTURE

The aim of the programme is to support R&D programme in the area of Bioresources and Secondary Agriculture for biomass biotransformations, bioresource systems analysis, and technologies associated with conversion production of value added products and processes from natural resources.

Brainstorming-cum-Consultation meetings were organized for prioritization of R&D areas based on available research leads. Department took initiative towards development of network project on exploration, discovery, and utilization of biological resources for sustainable development in North East India. The project is a long-term, multi-institutional, multi-investigator involved program aimed to strengthen science and sustainable development in Northeast India. The program will explore, discover and document bioresources of the region, assess their economic importance to regional economy, develop models of sustainable resource use based on new discoveries, product development, and indigenous knowledge, and build capacity as well as strengthen institutions in biodiversity science.

In the project on assessing the genome sequences of *Termitomyces clypeatus* for novel metabolic discovery through whole genome sequencing methods and characterization of the metabolites for application in biotechnology at IICB, Kolkata, analysis reveals that there are 10000 genes annotated as hypotheticals. Among others investigators found many genes responsible for carbohydrate degrading enzymes.

Bio-prospecting of anti-microbial peptides from Hymenopteran (ants, bees and wasps) insects, was supported at UAS, Bengaluru & RGCB, Trivandrum. *Monomorium indicum*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. Besides, venom of the solitary predatory wasp, *Anterhynchium abdominale* was characterized using the bioassay guided isolation and characterization approach. The wasp venom yielded two antimicrobial peptides. Further work is underway.

In the network programme for enrichment and update of plant chromosome database for Spermatophytes and Archegoniate, data sheets of 8610 species / subspecies / varieties and 781 genera covering 119 families were prepared. Data sheets for all Indian gymnopserms and peteridophytes were also completed. Data sheets on species and genus containing 29 and 22 cytogenetical and genome related parameters as well as taxonomic nomenclature and classification were completed and more than 10724 references downloaded and abstracted in data sheets and about 1526 species uploaded in the database software which was also made available online asD-GRIP (Database on Genome related information for Indian Plants): http:// sbtju.in/ Dgrip/index.html.

At TERI, Mumbai, a large number of mushroom samples were collected from different forest and sacred grove regions of

Maharashtra and Goa. Identification of mushrooms at species level has been donebesides, preparation of digital library and screening of the isolated purified cultures for nutraceutical and pharmaceutical values has been done. Digital library was finalized for 65 mushroom species and uploaded in websiteAt TERI, Mumbai, a large number of mushroom samples were collected from different forest and sacred grove regions of Maharashtra and Goa. Identification of mushrooms at species level has been donebesides, preparation of digital library and screening of the isolated purified cultures for nutraceutical and pharmaceutical values has been done. Digital library was finalized for 65 mushroom species and uploaded in website.

Mushrooms, rich in proteins, vitamin D, dietory fibres, have anti-oxidant, anti-cancerous and anti-microbial activities enhancing their neutraceutical and pharmaceutical importance.

Wild edible plants are a medicinal and nutrient treasure trove and deserve better recognition in food and nutritional security in both urban and rural context.

In the network project on characterization and consolidation of *Hippophae* genetic resources and propagation of elite genotypes for varietal evaluation, a total of 256 accessions representingfive Himalayan states were genotyped. Two major clusters were obtained corresponding to two species, namely, *Hippophae rhamnoides* and *H. salicifolia*. The genetic diversity within accessions from Himachal Pradesh was highest which was mainly due to presence of more than one species in the germplasm collected from Himachal Pradesh. A significantly higher genetic diversity was present within *H. rhamnoides* accessions as compared to within *H. salicifolia*.

In the project on exploration of Plant Growth Promoting Microbes (PGPM) for crop enhancement and disease suppression in tea plantation of TokeaiExperimental Station, Assam, qualitative screening of the pure culture isolates for nitrate reduction, phosphate solubilisation and plant growth promoting traits have beencarried out. Most of the isolates were capable of reducing inorganic nitrate to nitrite and solubilize inorganic phosphates. These isolates produce considerable amount of soluble phosphates, IAA, GA3. Antimicrobial activity of 18 strains has been demonstrated against four pathogens causing damage to tea plants.

In the network project on development of herbal formulations from seabuckthorn fast and reproducible method has been developed for quality assessment of the raw material. Various extraction techniques performed like reflux, sonication, maceration, decoction for optimization of extraction process. Several classes of compounds were detected by HPTLC with different derivatizaing reagents. Flavonoids and its glycosides were identified by LC-MS data in fruits, pulp and leaves. Further analysis is going on.

Microbial repository established at IBSD, Imphalhas collection strength of 44,000 microbial cultures including bacteria, fungi, yeast and actinobacteria isolated from different unique niches of NE India including pristine ecosystem, hot spring, cold spring, caves, endophytes (from medicinal plants), lakes, fermented food products and other extreme environment.Screening of 15,000 existing cultures has been done for antimicrobial activity against human pathogens, mineral degradation and enzymatic activity and P-solubilization and nitrogen fixing ability. Culture characterization using MALDI-TOF analysis of 15000 cultures was carried out.

In order to document the diversity of Indian honey bees and stingless bees, multi-institutionalnetwork project has been implemented with UAS, Dharwad as lead centre. Total of 120 grids from ten biogeographical regions have been identified.Collection of samples of *Apisdorsata*,(45 locations) *A. cerana,(*41 locations) *A. florae* (35 locations) and *Tetragonulairi dipennis* (35 locations) have been collected

from 7 different biogeographical regions. Morphometric studies of these samples completed and a honey bee repository has been established at Department of Entomology, UAS, Dharwad.

Conservation and Digitized inventorization

Centre of Excellence for National Centre for Microbial Resource (NCMR) : National Centre for Microbial Resource (NCMR) started as Microbial Culture Collection (MCC) in 2009 with a mandate to preserve and catalogue diversity of bacteria collected from different ecological niches from all over India and to make them available for biotechnological exploitation by researchers.

With more than 180000 microorgnisms in its collection NCMR is the largest culture collection in the world and single-handedly lifted India to 3rd place among countries having collection of microorganisms. It was recognized as an International Depository Authority (IDA) for the deposit of microorganisms for the purposes of patent procedures under the Budapest Treaty by the World Intellectual Property Organization, Geneva. NCMR also got recognition as a Designated National Repository under the Biodiversity Act of 2002 from the Ministry of Environment, Forests and Climate Change, Government of India. It is an affiliate member of the World Federation for Culture Collections (WFCC) and registered with the World Data Centre for Microorganisms.

NCMR has supplied more than 20,000 cultures to various research Institutions across the country for. In addition, the scientists are also actively involved in the research in the area of microbial ecology and taxonomy. This Centre has already begun to provide services to academic and industrial establishments for microbial identification. Currently it offers 16S rRNA based identification, FAME and MALDI profiling. The details of services offered by MCC in the current year are as follows:

Different services offered by NCMR

Services	Total
Preservation and Supply of Cultures	
General Deposits Accessioned (Bacteria)	108
General Deposits Accessioned (Fungi)	128
Cultures supplied (Bacteria)	146
Cultures supplied (Fungi)	66
Deposits under Budapest Treaty	34
Safe deposits	19
Identification Services Provided	
16S rRNA gene sequencing as an identification service	88
MALDI	7879
Phylogenetic analysis	13
Other Related Identification Services Provided	
FAME	41
DNA-DNA hybridization	4
% GC content	3
Phenotypic Characterization	15

Considering Antimicrobial Resistance is global public health threat, the Department has expanded the mandate of existing repository at National Center for Microbial Resource, National Center for Cell Science Pune 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.

Indian Bioresource Information Network (IBIN):

Indian Bioresource Information Network (IBIN) has been launched as a single window gateway to access distributed bioresource database available in the country to offer spatial and non-spatial services on diverse domains of bio-resources and biodiversity. It is a de-centralized bio-resource database based on distributed architecture. It works on the principle of spatial data infrastructure wherein distributed databases available across the country are accessed through one single window gateway. It provides spatial datasets on biodiversity from IIRS (ISRO) and species datasets from University of Agricultural Sciences (UAS), Bangalore as core data nodes of IBIN.

IBIN is the largest Interactive database including information

on Data on 73,276 species of Plants, animals, marine organisms and microbes including the spatial database. All the distributed data providers are now retrievable through a single window (www.ibin.gov.in). The end-user can also input the data through the crowdsourced mobile application. During this year, a web based Data Quality Checking application for species datasets has been developed.IBIN Android Apps have been developed for 'Rare Endangered and Threatened Plants of Western Ghats' to identify Rare, Endangered and Threatened (RET) plants, Butterfly Identification and for proper identification of the species. This citizen science based app is designed and developed to observe, collect and integrate the data on bio resources with spatial features, especially those species whose current geographical occurrence are not encountered yet, for biodiversity observation and planning studies. Efforts have been undertaken towards expansion of IBIN through connecting new Bioresource Information Centres and integration of IBIN services to Bhuvan Geoportal.

During the period, the DBT has taken an initiative jointly with Ministry of Earth Sciences and CSIR to develop a Marine Bioresource and Biotechnology network programme. This will be a virtual centre in a "Hub and Spoke Model" and DBT would integrate the activities with a Deep Ocean Mission of Ministry of Earth Sciences on exploration, understanding and conservation of marine biodiversity. The Virtual Centre Network would be setup along with MoES, CSIR, DBT institutes and other Universities working in this area. The DBT has organized a consultation meeting on 6th February, 2019 to discuss the structure and framework of the proposed Network, next steps, networking with Institutions working in this area, future roadmap and time-bound action plan for the above network Centre.

Indian Initiative on Earth Biogenome Sequencing (IIEBS) has been undertaken to participate in the Earth Biogenome Project, a global effort that aims to sequence the genomes of all life forms on our planet. It is a grand challenge for the global scientific community. The main objective is to sequence about 1000 plants and animal species in the next five years. The background document for IIEBS has been prepared. A Brainstorming-cum-Consultation Meeting on Earth Biogenome project was organized with a view to discuss about India's participation and finalize the priority species. A Core Group was constituted for India's participation in the Earth BioGenome Project. Two Working Groups have been constituted to compile the list of priority species / organisms for sequencing from India under IEBP. A meeting of Working Groups was convened on February 16, 2019 at NIPGR, New Delhi for developing a base paper on "Indian Initiative on Earth Biogenome Sequencing (IIEBS)".

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. The major objective of NCS-TCP is to facilitate production and distribution quality planting materials. To achieve the above objectives, tissue culture companies are given recognition on the basis of infrastructure and implementation of quality management system. Apart from recognition of tissue culture companies, test laboratories have also accredited under this program. After recognition, tissue culture companies become eligible to get their tissue culture raised plants tested and certified by these Accredited Test Laboratories (ATLs). Two Referral Centers have also been identified for testing of disputed samples, training etc.

Biotech Consortium India Limited (BCIL) is assisting DBT as the Management Cell for National Certification System for Tissue Culture Raised Plants (NCS-TCP). NCS-TCP Management Cell has created a web portal under the guidance of DBT. The NCS-TCP web-portal broadly includes processing of applications from tissue culture companies for recognition and subsequent renewal", testing and certification of tissue culture raised plants, referral activities, coordination of meeting and information management, database management and instant report generation.Being a part of NCS-TCP, companies have attained better visibility and thereby, access to national and international market particularly, small scale companies which are established in rural areas could extend their market-reach and accessibility for their produce, to fetch better prices providing sustainability to their business.

This year approximately 50,000 tissue culture samples have been tested by the recognized Accredited Test Laboratory (ATL) and more than 100.00 million plants have been certified. The NCS-TCP website was renovated providing a

new look and features. The web-portal has been developed to provide more transparency and convenience among the various stakeholders. The web-portal has been operationalized and TCPFs may now apply for recognition, renewal, testing and certification activities through website.

TRANSLATIONAL RESEARCH ON MEDICINAL AND AROMATIC PLANTS

Department is providing research support across the country towards developing products and processes from medicinal and aromatic plants following multi-disciplinary approach for conducting R&D utilizing rich traditional knowledge disciplines on the basis of conventional traditional knowledge in the country under three available regulatory frameworks: (a) US-FDA-Botanical Drugs, (b) DCGI-Phytopharmaceutical Drugs, and (c) AYUSH mode. The aim is to develop a herbal drug pipeline. Under this programme, routine screening programmes will not be considered.

The DBT has taken initiative on developing Phytopharmaceuticals 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 phytopharmaceutical products for therapeutic use following 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, Phytopharmaceutical development of three plant species – "Development of *Boswellia serrata* based phytopharmaceutical drug for rheumatoid arthritis"; Development of *Cannabis* based CBD-Enriched Phytopharmaceutical Drug for the treatment of Epilepsy" and Development of *Cannabis* based "CBD-THC Enriched Phytopharmaceutical Drug for Pain management" will be taken up during 2019-20. DBT has also taken initiative on developing Phytopharmaceuticals Mission Programme in North East Region and two projects for developing phytopharmaceutical drug from *Ficus emicordata*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.

An 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.

A Brainstorming-cum-Consultation Meeting on Turmeric Mission was organized on November 01, 2018 with an aim to develop a mission programme on turmericto generate high-quality raw material for developing nutraceutical products / dietary supplements from turmeric for global market.

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

Work has been continued to develop Plumbagin ointment as topical anti-microbial agent for the treatment of *S. aureus* skin and wound infections. The carbopol hydrogel was prepared by the cross-linking with triethanolamine and plumbagin was added to the hydrogel. It was found that Plumbagin possess excellent antimicrobial activity against Gram positive bacteria, viz, multi drug resistant (MDR) *Staphylococcus aureus,* including methicillin resistant and mupirocin resistant *S. aureus*, with minimum inhibitory concentration of 5 mg/ml. Immuno-compromised patients, cancer patients, HIV patients, solid organ transplantation patients are at higher risk for developing *S. aureus* infections.

A project has been supported to develop a species-specific marker that can help to distinguish individual medicinal plant ingredients from its closely related species using next generation sequencing technology in three classical ayurvedic formulations (*Punarnava churna*, *Guduchi Churna* and *Rasnadi Churna*) for authentication of the formulation as well as individual plant species used thereof. Medicinal plants in ayurvedic pharmacopoeia of India namely *Boerhaavia diffusa* (Punarnava), *Tinospora cordifolia* (Guduchi), *Pluchea lanceolata* (Rasna) along with their adulterants/substitutes were selected for the study. The work so far has provided 316 unique target contigs for development of species-specific markers to identify *Boerhaavia diffusa* plant. Species-specific primers are being designed using Prime 3, prime designing tool. Validation of the same is underway to generate species-specific marker.

Work has been recently initiated on germplasm collection and chemotyping of *Andrographis paniculata, Bacopa monnieri* and *Withania somnifera* from West Bengal and Odisha. Study on seasonal variation on drug yield of *Andrographis paniculata* from Odisha completed and in West Bengal is in progress. 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 *Microsporum canis* and *Trichophytonmentagrophytes* suggests its utility in treating animal dermatophytes, common in pets. Based on research leads generated under this project, a follow up proposal has been formulatedtowards Phytopharmaceutical Development of *Trachyspermum ammi* for Post Kala-azar Dermal *Leishmaniasis*.

Work has been recently initiated to study the role of Non-polar fraction of Aloe vera gel as a pre-conceptive herbal therapy towards management of female fertility in Polycystic Ovarian Syndrome rodent model at M. S. University of Baroda, Vadodara. Efforts have been continued to induce santalol biosynthesis in sandalwood cell suspension cultures by simultaneous overexpression of three genes of the lower mevalonate pathway namely farnesyl diphosphate synthase, santalene synthase and p450 hydroxylase under control of constitutive promoters at Vittal Mallya Scientific Research Foundation, Bangalore. A study has been supported at Christian Medical College and Hospital, Vellore to study the pharmacokinetics and toxicology of toxins in boiled aqueous extract of *Cleistanthus collinus* leavesto identify *Cleistanthin C* as the major toxin in the boiled aqueous extract

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. Salient achievements during the year are summarized below:

Development of improved races of silkworm for enhanced productivity: Efforts continue to introduce sex-limited foundation crosses for cocoon colour as a male component for the production of commercial cross breed at APSSRDI, Hindupur. Among the 45 crossbreeds (PM x SLFCs) tested, SFLC27 was identified as a promising crossbreed for commercial use. The patent is filed for newly developed sex-limited foundation cross (SLFC27) for preparation of crossbreed for commercial use as farmers' level.

Under a network project on use and validation of DNA markers in silkworm breeding programme for NPV resistance being implemented jointly at Seribiotech Research Laboratory (SBRL), Bangalore; Central Sericultural Research & Training Institute (CSR&TI), Mysore; CSR&TI, Berhampore and CSR&TI, Pampore, J&K, using conventional back crossbreeding techniques combined with molecular marker assisted selection, three lines of silkworm, marked-assisted selection lines for NPV resistance (MASN4, MASN6 and MASN7) were synthesized. The pure lines of MASN were multiplied at silkworm satellite breeding station at Coonoor and tested for markers for NPV tolerance and confirmed the presence in individual moths. In order to conduct large scale field trial, 15000 disease free layings (DFLs) of F1 of PM x MASN4 were distributed to Madiwala and Tumkur region of Karnataka and cocoons were produced. For large scale field trial, 7500 DFLs of MASN4 x CSR4 were supplied to Berhampore region and were reared by different farmers and cocoons were produced.

Assessment of SNP variation in silkworm (*Bombyx mori*) by RAD sequencing and genome-wide association mapping of important commercial traits has been continued jointly at CSR&TI, Mysore and R. V. College of Engineering (RVCE), Bangalore. About 100 diverse silkworm genotypes (Multivoltine & Bivoltine) were collected from different regions and characterized for five qualitative traits and nine economically important quantitative traits. Analysis of variance indicated significant differences among the genotypes for all the parameters studied.

Work on identification of thermo-tolerant bivoltine breeds based on expression of heat shock protein coding genes in silkworm, *Bombyx mori* has been recently initiated jointly at APSSRDI, Hindupur, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad and Sri Padmavati Mahila VisvaVidyalayam, Tirupati. Initial screening of silkworms for thermo-tolerance was conducted in which 14 bivoltine breeds that include six breeds with peanut cocoon shape and eight breeds with oval cocoon shape by rearing from hatching to spinning at high temperature. Based on the performance

data at high temperature conditions, 8 breeds with higher survival rates were selected out of 14 breeds. Their survival rates are studied. The second rearing of the selected eight breeds and stage specific sample collection for further transcriptomic study is under progress.

Development of Disease and Pests Control Measures: A PCR-based technique has been developed for early detection of baculovirus causing tiger band disease *Antherarea proylei* in NE Region at SBRL, Bangalore. The technique has been successfully used to detect the virus at egg, larval and moth stages. The viral copy number in different tissue samples i.e. egg, larva and moth were also quantified through qPCR.

Improvement of Host Plants: Under a multi-component network project on genomics approached for mulberry improvement being implemented jointly at seven institution Central Sericultural Research and Training Institute (CSRTI), Mysore, RV College of Engineering, Bangalore, University of Agricultural Sciences, Bangalore, Central Sericultural Germplasm Resources Centre, Hosur, University of Delhi South Campus, Delhi, National Chemical Laboratory, Pune and Jawaharlal Nehru University, New Delhi, work has been initiated towards multiplication of about 340 germplasm accessions under nursery beds. Saplings of mulberry germplasm are getting ready for phenotyping work of different traits (Drought adaptive, yield and NUE). F1 segregating population was developed for root rot disease resistance. Optimization of genetic transformation protocol in tobacco using transgene construct is being continued and optimized regeneration protocol from cotyledons and hypocotyls of mulberry.

Silk Proteins as Potential Biomaterials: At CSIR-National Chemical Laboratory, Pune, surface coatings for biomedical implants have been used to prevent premature failure of implant due to bacterial biofilm formation and foreign body reaction. A novel process has been developed that results in the formation of a stable silk fibroin coating on PDMS substrate. The coating is resistant to mechanical stresses in tensile, torsion and bending modes. It has been demonstrated that the quorum quenching activity of the biomolecule is retained during the processing steps and these coatings exhibited excellent antibiofilm activity against common infection causing bacterium *P. aeruginosa* and *S. epidermidis*. These silk fibroin-glycomonoterpene coatings can be used for implants in biomedical applications such as breast implants and catheter tubings.

Utilization of By-Products: At CTRTI, Ranchi, higher quantity of sericin has been isolated from Daba ecorace of tasar silkworm. No significant variation of molecular weight distribution of protein was observed between different tasar ecoraces. Raily ecorace sericin found to possess more non-polar and aromatic amino acids. Raily sericin possess higher inhibition percentage of tyrosinase, glutathione-s-transfease activity and hydrogen peroxide scavenging potential. As compared with other food plants, sericin separated from cocoons of Sal fed larvae posse's higher inhibition percentage of tyrosinase and DPPH scavenging potential.

Healthcare And Medical Biotechnology

Leveraging its focus on affordable healthcare for all, the Department is working towards prevention, detection and treatment of various diseases. The Department has funded numerous projects 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. The emphasis of the Department is on development of vaccines; diagnostics; affordable devices to detect and manage diseases as well as patient care and generating solutions for diseases; infectious disease biology; chronic disease biology; cancer biology; neuroscience; human genetics and genome analysis; maternal and child health; public health and nutrition; stem cells and regenerative medicine. DBT has been a front runner in reaching low cost vaccines to people and has been instrumental in levitating India to become a leader in vaccine development and manufacturing. Details of the areas under medical biotechnology are as follows:

INFECTIOUS DISEASE BIOLOGY

There has been a remarkable progress in the prevention, control and even eradication of infectious diseases with improved hygiene and development of antimicrobials and vaccines. However, infectious diseases still remain a leading cause of global disease burden with high morbidity and mortality especially in the developing world. Furthermore, there have been threats of new diseases during the past three decades due to the evolution and adaptation of microbes and the re-emergence of old diseases due to the development of antimicrobial resistance and the capacity to spread to new geographic areas. Considering the tremendous impact of the emerging and re-emerging diseases in India at socioeconomic and public health levels, steps were taken by the Department to redefine the Infectious Diseases Biology research in our country to harness the maximum benefit of this discipline in the line of developed countries. Some of the highlights are as follows:

In order to develop uniform SoP for the culture deposition and distribution for AMR-specific bio-repository at NCMR-NCCS, a Stakeholder meeting was conducted with all pertinent stakeholders in this area. After the detailed discussion, it was decided to connect this repository with existing national laboratories across the country in order to establish this national facility in the line of world class repository with international standard. In a process to fulfill the ambition of this Mission program, the Department in collaboration with BIRAC announced a Joint Call in the area of development of new antibiotics and alternatives to antibiotics to counter AMR.

Anti-Microbial Resistance

Considering AMR as a National priority, under National Action Plan endorsed by Govt. of India, 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.

Under India-UK Antimicrobial Resistance Challenge four (4) multidisciplinary and multi-institutional research studies focusing on i) identify distribution of resistant bacteria in humans, aquaculture and environment especially north eastern states of India, ii) mapping of antimicrobial usage & antimicrobial resistance (AMR) in poultry meat supply chain, iii) developing rapid diagnostic solutions to detect AMR in community settings, and iv) devising a smart regulatory approach to facilitate regulators and health workers toward AMR containment were supported.

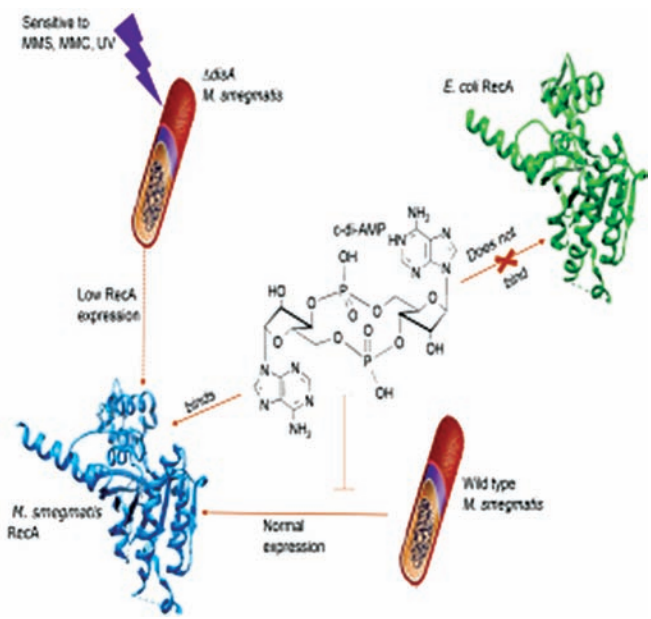
Under DBT-ICMR collaborative effort on HIV/AIDS, a consortia based Cohorts for HIV Resistance and Progression in Indian Children and Adults (CoHRPICA) Program was initiated in the previous financial year with the aim to create uniform standardized cohorts across stages of HIV-infection, the first centralized state-of-the-art bio-repository for access to biological samples and a national database to aid in identification of critical research questions and promoting multidisciplinary research collaborations to address the national HIV epidemic. In line with the WHO guidelines, the objectives and cohorts samples have been revised with the approval of Project Oversight Committee.

Under Indo-South Africa project on HIV and TB, scientists from THSTI, Faridabad and AIIMS, New Delhi have identified and prepared three HIV-1 envelope protein antigens suitable for single memory B cell sorting and isolation of neutralizing monoclonal antibodies from patient's PBMCs.

Scientists from Translational Health Science and Technology Institute (THSTI) have comprehensively characterized toxin-antitoxin (TA) systems from *M. tuberculosis*.

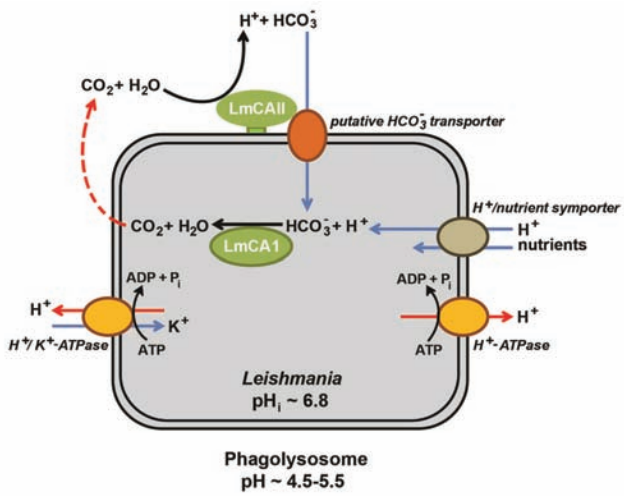
Scientists from Indian Institute of Sciences, Bengaluru investigated and proposed that Integration Host Factor (mIHF) of *M. tuberculosis* is a novel nucleoid-associated protein and also demonstrated that IHF directly and positively regulates integrative recombination, and also contributes to the survival of bacteria in highly hostile environments. Further, they have uncovered an unknown role for cyclic di-AMP in the negative regulation of DNA strand exchange promoted by mycobacterial RecA proteins, and it does not affect the functions of the prototype *E.coli* RecA.

Investigations have revealed that cyclic di AMP is involved in recA gene expression and DNA damage repair; it attenuates the DNA strand exchange promoted by MsRecA as well as MtRecA through disassembly of RecA nucleoprotein filaments, whereas the nucleoprotein structure and DNA strand exchange activity of *E. coli* RecA nucleoprotein filaments remain totally unaffected.



Group of scientists and clinicians from Jamia Hamdard, New Delhi, Safdarjung Hospital, New Delhi and IIT, New Delhi co-established a large cohort of TB patients at DOTS centres at Hamdard Institute of Medical Sciences and Research, Jamia Hamdard, Hamdard Nagar, New Delhi as well as Safdarjung Hospital, New Delhi. Clinical validation of "iMC^2 and See-TB" (Kshay Drishti) devices as affordable point of care TB diagnostics has been initiated under this project. Further, chorismate mutase has been identified as potential new drug.

Leishmania Parasite Research: Scientists from Indian Institute of Science Education and Research (IISER) Kolkata have established for the first time the role of *Leishmania major* alpha-Carbonic Anhydrase (LmCAII) in cytosolic buffering of the parasite and the role of this enzyme in intracellular growth under acidic pH. This has significantly enhanced the understanding of strategy of *Leishmania* parasite to circumvent the host defense.



Model describing the mechanism of LmCA1 and LmCAII mediated intracellular pH regulation in Leishmania

Malaria Research: A group of Scientists from IISc, Bangalore, ILS, Bhubaneswar and JNCASR, Bangalore have revealed that pure curcumin (99%) has the protective activity in *P bergehi*-infected Balb-c mice and with the approval of DCGI office, clinical trial to treat simple malaria using curcumin as an adjunct drug has been planned.

A group of scientists from ICGEB, New Delhi, NII, New Delhi, CCMB, Hyderabad and IoB, Bengaluru have revealed several atypical features of the autophagy system in malaria parasites,

and also demonstrated its indispensability for parasite development.

HIV Vaccine Translational Research (HVTR) Laboratory: The HIV Vaccine Translational Research (HVTR) Laboratory at THSTI has been carrying out early translational research and development under the joint partnership program between THSTI and the International AIDS Vaccine Initiative (IAVI). The HVTR laboratory has established capacity in isolating antigen-specific broadly neutralizing monoclonal antibodies (bnAbs) from peripheral blood mononuclear cells (PBMC) obtained from a well-defined HIV-infected elite neutralizer as a part of technology transfer under ongoing partnership program from the IAVI-Neutralizing Antibody Center (NAC). One patent entitled "Engineered recombinant protein antigen of trimeric mimic of HIV-1 envelope glycoprotein spike" was obtained.

Therapeutic Antibodies Research: With the vision to establish basic platform technologies for production of high affinity antibodies for developing Immunochemical tests, scientists from UDSC, New Delhi and AIIMS, Bhopal have developed antigen detection tests for Tuberculosis and for anti-Polyhistidine antibody. Considering snake bite a serious problem, a brain storming meeting on "Strategies for Treatment Modalities for Snake Bite with special focus on Recombinant Antibodies" has recently been conducted to promote awareness in the scientific community.

CHRONIC DISEASE BIOLOGY

Chronic Diseases are long-term medical conditions that are generally progressive. Chronic diseases, such as Heart Disease, Diabetes, Stroke, Asthma, Cancer, Chronic Respiratory Diseases, Chronic Obstructive Pulmonary Disease, Diabetes Mellitus, Hypertension, Lipid Disorders at present, are the major causes of disability and death globally, representing 60% of all deaths.

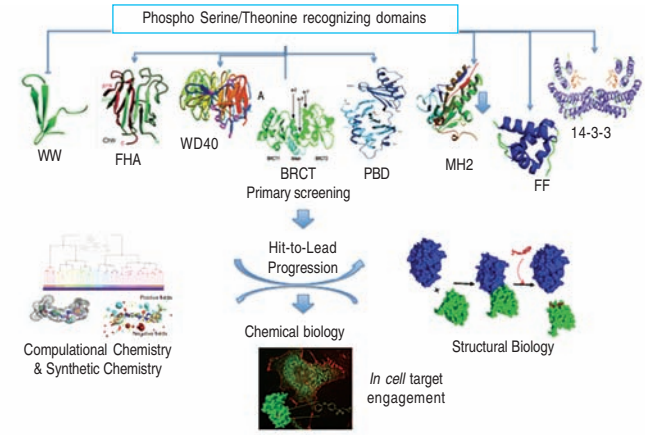
Hence, DBT through Technical Expert Committee (TEC) and Expert Groups is focusing on R & D and Capacity Building in: Cancer Biology; Metabolic Disorders/Diseases; Neuro-Disease Biology; and Auto-Immune Diseases.

Cancer Biology : DBT supports Cancer Biology Research in various ways, which includes sponsoring research to identify the causes of cancer; sponsoring research on screening, diagnosis, and treatment of cancer; and the provision of proven, effective, preventive and treatment interventions. It provides resources to individual investigators and to institutions, provides leadership to national infrastructures to carry out basic, applied and clinical research and to develop new methods to prevent and treat disease and conducts research especially in challenging areas pertaining to different types of cancers such as breast, oral, cervical, pancreatic, prostrate, multiple myeloma, myeloid leukemia, hepatocellular carcinoma, ovarian cancer, etc.

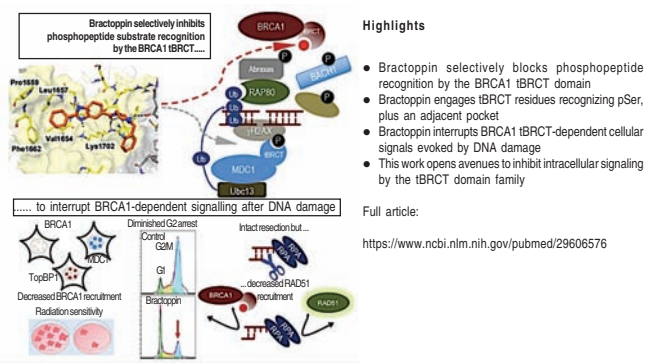
As part of its commitment to address solutions in cancer research, DBT has supported a variety of team science approaches. One such is the Virtual National Cancer Institute (VNCI) Program. DBT's support to VNCIs is focused on fostering excellence across two identified cancer research spectrum such as breast cancer and oral cancer. One technological advance with profound implications for clinical practice and research is the evolution of so-called non-invasive cancer diagnostic methodology. DBT through a process of Brain Storming mechanism has evolved a Grant Call on 'Non Invasive Cancer Diagnostics' that will be announced shortly.

The Department has recommended the setting-up of Carbon Ion Radiation Therapy (CIRT) facility at Tata Medical Center (TMC), Kolkata. The first of its kind not only in entire India but South East Asia to enhance and improve outcomes of all cancer patients and promote education and research into cancer biology and particle beam therapy research.

Centre for Chemical Biology and Therapeutics (CCBT) : The mission of the Center for Chemical Biology and Therapeutics (CCBT) since its establishment in 2013 has been to pioneer new scientific approaches to create small-molecule tools that modulate novel classes of targets, and use them to conduct hypothesis-generating and hypothesis-driven research on experimental systems of biomedical importance. The long-term vision is to foster knowledge-driven therapeutic interventions for important human diseases through fundamental new insights into disease biology. The scientists at CCBT has been able to establish a unique integrated platform for the discovery of selective chemical leads against novel molecular targets, which combines biophysics, structural biology, computational chemistry, medicinal chemistry and cell biology.



Over the past year, CCBT discovered a potent and selective drug-like inhibitor of phosphopeptide recognition by the BRCA1 tBRCT domain, to exemplify chemical leads that target this previously undrugged structural class and demonstrated that this inhibitor selectively interrupts BRCA1 tBRCT-dependent signals evoked by DNA damage, illustrating the potential of such an approach to interrupt intracellular signaling via the modulation of phosphopeptide recognition as shown below.



Graphical representation of Bractoppin, a selective inhibitor of phospho-substrate recognition and BRCA1-dependent signaling pathways in cell after DNA damage

Ongoing work aims to enlarge the scientific and conceptual basis of these findings to create selective leads that target additional phosphopeptide-recognizing domains of biomedical importance. The scientists at CCBT have developed a tBRCT domain-focused small molecule library, and begun to deploy it to target the tBRCT domain of ECT2, a component of protein complexes that control guanine-nucleotide hydrolyzing enzymes during mitotic cell division and protein synthesis. Ongoing efforts aim to validate the binding mode of CCBT5041 proposed from mutational data and ligand based SAR through X-ray crystallography.

The core purpose of the CCBT has been to pursue cutting-edge science that enhances the reach and scope of chemical biology and therapeutics development - and not to provide an academic "drug discovery service".

Besides its scientific programs, the CCBT has sought to fulfill an important strategic purpose to nucleate capabilities for chemical biology and therapeutics development in the NCBS/inStem campus, and provide a model for such capabilities that may be useful at other institutions in India.

The CCBT has been designed to operate through the uniquely integrated effort of multidisciplinary project teams using common technological platforms, and not as a collection of PI-led labs pursuing independent aspirations subservient to an overall scientific theme.

Societal Impact

The findings of chemical probes that modulate intracellular signaling offer unique potential to explore the chemical biology of intracellular signaling by the tBRCT domain family with potential insights into fundamental biology as well as its perturbation in human diseases. Studies exploring the biologic mechanism of action of these new leads - which modulate previously "undrugged" tBRCT domain targets - will be vital to provide a firm foundation to explore therapeutic concepts that help to define clinical indications for future drug development.

International Cancer Genome Consortium

With the objective of obtaining a comprehensive description of the genetic basis of human cancer, a multi-country project - called the "International Cancer Genome Consortium Project" - has been initiated. Specifically, the project aims to identify and characterize all the sites of genomic alteration associated at significant frequency with all major types of cancers.

Comprehensive knowledge of the genetic basis of cancer would provide a permanent foundation for all future cancer research and have far-reaching implications for basic, clinical

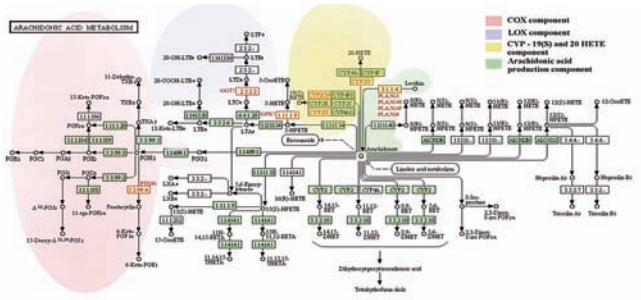
and commercial efforts to understand, prevent and treat cancer. It has the capacity to reveal the subtypes of cancers and would systematically identify the cellular pathways that are deranged in each subtype. This would increase the effectiveness of research to understand tumor initiation and progression, susceptibility to carcinogenesis, development of cancer therapeutics, approaches for early detection of tumors and the design of clinical trials.

India, after detailed national-level discussions and deliberations, is participating in this important international collaborative project with the goal of excavating and understanding the genomic basis of oral cancer, which is the most prevalent form of cancer in our country. The India project is being led by the National Institute of Biomedical Genomics (NIBMG), in collaboration with the Advanced Centre for Treatment, Research and Education (ACTREC) in Cancer.

The India Project has made two important discoveries using next generation sequencing technologies:

(1) Alterations mainly in tumor suppressor genes are responsible for initiating oral cancer. Some genes are specific to oral cancer (*USP9X, MLL4,ARID2, UNC13C* and *TRPM3*), while some others are shared with general head and neck cancers (for example, *TP53,FAT1, CASP8, HRAS* and *NOTCH1*). Molecular subtypes of patients with distinctive mutational profiles were identified. Mean duration of disease-free survival is significantly elevated in some molecular subgroups.

(2) The arachidonic acid metabolism (AAM) pathway promotes tumor progression. It has been found that non-synonymous somatic mutations in genes of this pathway act as natural inhibitors and increase post-treatment survival of oral cancer patients. Patients with mutations have a significantly longer median disease-free survival (24 months) than those without (13 months). Chemical inhibitors of AAM pathway may therefore be used to prolong post-treatment survival of oral cancer patients.



The Arachidonic Acid Metabolism pathway promotes oral cancer progression. Chemical inhibitors of this pathway can prolong survival after oral cancer surgery and treatment.

METABOLIC DISORDER/DISEASES

India with its unique BMI is topping prevalence & incidence of metabolic diseases. Among the Non Communicable Diseases (NCDs), diabetes is one of the most common and most easily measurable NCD. The practical management of diabetes is difficult due to poor accessibility, lack of effective services and costly treatment, non-compliance to treatment, especially for sub-urban and rural areas. DBT has initiated studies on: 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. Joint Cohort Development addressing basic and clinical questions and monitoring structures with long-term funding options are being explored with the clinicians at the tertiary care hospitals.

Indian Chronic Kidney Disease (ICKD) Study: The Indian Chronic Kidney Disease (ICKD) project is the first prospective, observational cohort study of Chronic Kidney Disease (CKD) patients from a developing country. It will provide a comprehensive description of outcomes of CKD in India and identify potential areas for further research with respect to preventing progression of CKD and its adverse outcomes. The ICKD study is a part of International Network of Chronic Kidney Disease cohort studies (iNET-CKD), an initiative of International Society of Nephrology for building an international network of existing, Chronic Kidney Disease cohort studies.

A total of 3444 patients have been enrolled in this study till date and a total of 1558 subjects have completed 1st follow-up, 313 has completed 2nd follow up and 55 have completed 3rd follow up. Total 262 events have been recorded excluding

death (68 subjects) and end-stage renal disease (ESRD) (66 subjects).

Auto-immune Disease: Systemic Lupus Erythematosus (SLE) is an autoimmune disease with prevalence varying from 5-10 per 10,000 population globally but with no data from India. Since it mainly affects women in the reproductive age group, it poses significant social and economic burden to the society. In India, about 20% of SLE starts in childhood, posing a huge challenge. Till date most of the work on SLE has been done on describing the clinical phenotype. Owing to its increasing significance, DBT has recently implemented a Multi-centric Network Program on SLE comprising of basic researchers and clinicians. The group would 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.

NEUROSCIENCES

The ongoing projects in neuroscience address a wide spectrum of neurological disorders. A multi-centric program on Dementia involving eight sites across the country has been implemented. Long-term population-based and hospital-based cohorts of Dementia patients will be set-up and followed to provide reliable data regarding incidence, prevalence, biomarkers, risk and protective factors. DBT has initiated programs on identification of the function of hypoxia induced changes in Blood Brain Barrier; effect of hypoxia on different neuronal cell types; identification of the alterations of glutamatergic excitatory neurotransmission; role of notch signaling in abdominal neural stem cells and modulation of innate immune cells in neuro cysticercosis. An impactful study funded by DBT has demonstrated for the first time that modulation of insulin signaling pathway can be exploited as a novel approach to treat the human neurodegenerative disorders. The finding therefore, could be immensely useful for novel drug development and therapeutic interventions against devastating human brain illness.

The Department has implemented 5 projects for exploring various aspects of Glial Cell Biology for PHASE II titled 1. Epigenetic regulatory mechanisms in neuroglial functions in chronic alcohol induced impaired neurogenesis-mediated neuroglial plasticity at CCMB, Hyderabad, 2. Exploration of role of Angiotensin Converting Enzyme-2/Angiotensin (1-7)/Mas receptor (ACE2/Ang-(1-7)/MasR) axis in neuroinflammation and glial activation in hypertension and neurodegeneration at CDRI Lucknow, 3. Elucidating the role of long non coding RNAs (lncRNAs) in neuronal cell death during Japanese Encephalitis (JE), BITS-Pilani, Hyderabad and NBRC, Manesar 4. Role of Ephrins/Eph receptors in HIV mediated neuropathogenesis at NBRC, Manesar and 5. Role of micro RNAs in Chandipura Virus in neuropathogenesis at BHU, Varanasi.

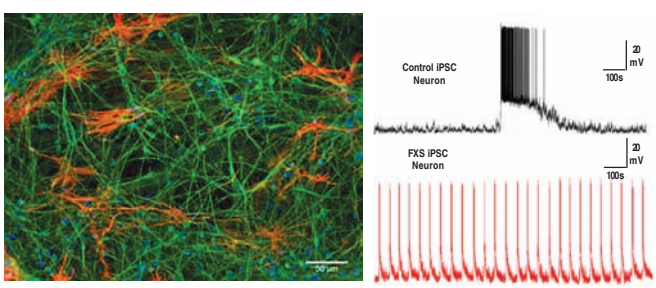
KALPANA: Brain Signal Processing Tool which is a Comprehensive MATLAB based Toolbox for Magnetic Resonance Spectroscopy Data Processing and Metabolite Quantitation. The Neuroimaging and Neurospectroscopy laboratory of NBRC has developed complete and integrated software that could help early diagnosis of mental health problems. Developed by a team of neuroscientists, the software can quantify a brain neurochemical called ã-Aminobutyric Acid (GABA) through neuroimaging of brain metabolites using Magnetic resonance spectroscopy (MRS). Software allows visualization and single-click processing of MRS data acquired using a variety of methods. With the incorporation of premade end-to-end processing workflows for a variety of data and use of algorithms that enable accurate estimation of chemical concentrations from the signal and a graphical interphase for its easy interpretation, the software offers distinct clinical scope.

Centre for Neurosynaptopathies (CNS), inStem Bangalore

The Centre for Neurodevelopmental Synaptopathies (CNS) has been established at inStem, Bangalore with an aim to understand neurobiology of autism spectrum disorders (ASD) and intellectual disability (ID) including neurodevelopment, synaptic function and plasticity, human stem cells and cognition-behavior.

This is a transformative program between inStem, NCBS, Bangalore and the University of Edinburgh (UoE) bringing together world-class expertise in several crucial fields to understanding ASD/ID neurobiology including neurodevelopment, synaptic function and plasticity, human stem cells and cognitive behaviour. The scientific objectives include delivering new knowledge regarding the cellular basis of ASD/ID in order to identify drug target and to use novel platforms for rapid discovery and testing of novel therapeutics

for ASD/ID. The Centre has developed new rat models of highly penetrant single-gene causes of ASD/ID to better model autistic and cognitive behaviors that can accurately reflect autistic features in humans. The focus is on Fragile X Syndrome (FXS) as well as mutations in key glutamate receptors and their primary signaling pathways as prototypic causes of ASDs. A detailed characterization of post- and pre-synaptic defects in the amygdala of the rat models of Fragile X Syndrome (FXS) has led to identification of deficits in activity-dependent synaptic plasticity in the amygdale. The scientists are also exploring the possibility of rescue of deficits, using oral treatment with Lovastatin, in the developmental acquisition of associative memory in the rat model of FXS. The results demonstrated that lovastatin administration restores normal associative memory which is maintained 4-months after treatment cessation. This behavioral rescue is associated with a rescue of plasticity and protein synthesis deficits, providing proof-of-concept evidence that neurodevelopmental disorders may be amenable to transient, early intervention to restore the normal brain developmental trajectory. These results are of therapeutic significance because Lovastatin, which reduces the amount of cholesterol made by the liver, is already approved for use in humans. Further an *in vitro* system based on human induced pluripotent stem cell (iPSC) has also been established to study cellular and synaptic mechanisms underlying ASD/ID and is also used for potential high throughput screening of pharmaceutical compounds.



Left: Human iPSC-derived cortical neurons co-cultured (8 weeks in vitro) on rodent cortical astrocyte feeder layer. The cells have been immune-labeled for DAPI (blue), MAP2ab (green) and GFAP (orange). Right: Current clamp traces show spontaneous bursting in control iPSC neuron (black) and FXS iPSC neurons (red).

Another recent focus of the Center is on sensory dysfunction, a prominent feature of autisms (ASD) and intellectual disabilities (ID). While changes in neuronal properties have been linked to sensory dysfunction, a detailed understanding of how these combine to alter neuronal integration is lacking. Therefore, the scientists at CNS have tested whether there is a functional relationship between dendritic spine function, dendritic integration, and neuronal output. It was shown that in Fmr1-/y mice, dendritic spines lose their structure-function relationship and show altered integration, resulting in increased dendritic gain. These findings lead to an alternative hypothesis of how neuronal dysfunction leads to sensory hypersensitivities.

Societal Impact

It is estimated that neurodevelopmental disorders like Autism impact over 1% of the global population. A recent study shows the frequency of such conditions in 0-7 years can be upto 12% in certain parts of our country. Currently there are no disease-modifying therapies for the ASDs/IDs. The scientists at CNS are trying to elucidate the biochemical and physiology mechanisms that underlie the behavioural and cognitive phenotypes and to determine the developmental time-points when treatments will be most effective. Additionally by comparing multiple rat models in tandem in a platform-based approach, a conserved signatures of ASD/ID is being explored that can then be targeted.

R&D Collaborative Programme Through International Partnerships

Investigators of Institute for Stem Cell Science and Regenerative Medicine (inStem) and National Centre for Biological Sciences (NCBS), Bangalore and University of Copenhagen, Denmark research have established two distinct models to understand the molecular pathology of Alzheimer's disease using human stem cell system. Significant progress has been made by identifying a potential novel translation defect due to ApoE 4.4 protein. Novel small molecule dyes for imaging mitochondria in live cells and tissues were also developed.

Institute for Stem Cell Science and Regenerative Medicine, Bangalore in collaboration with University of Gothenburg, Sweden have identified the pathway that the bacteria utilizes to carry-out molecular mimicry. The structure of SSS-type sialic acid transporter that describes how sugar transport is coupled with sodium transport in the bacteria was also elucidated.

These efforts might help in the development of new approaches to structure-based drug discovery.

HUMAN GENETICS & GENOME ANALYSIS

The Human Genetics and Genome Analysis program addresses issues related to specific inherited diseases concerning Indian population and major steps have been taken by the Department towards better understanding of genetic disorders prevalent in our country in terms of new research on diagnosis.

Considering the higher prevalence of genetic disorders, many consortia based R&D projects have been supported this year on Thalassemia, Hearing loss, Polycystic Kidney Disease, Maturity onset Diabetes of the Young, Movement Disorder, Cardiomyopathies and Hemophilia and many individual projects on other genetic disorders.

A program for establishment of Genetic Diagnostic Centers and Referral Labs has also been initiated by the Department in line with the NABL accreditation policy of our country. These are the need of the hour in our country and it will help facilitate diagnosis of genetic disorders for the common people and will also improve the societal awareness for these genetic disorders.

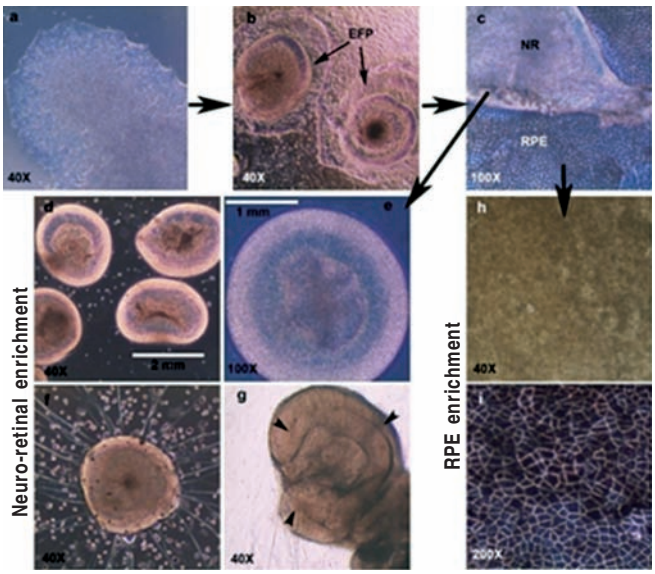
Human Genetics and Genome Analysis program emphasizes on research activities to advance our understanding of genetic and genomic components of human physiology and pathophysiology, and the interactions of these components with environmental factors and cultural practices, by promoting the conduct of cutting-edge research involving individuals, families and populations. It also recommends translating the understanding thus acquired to the improvement of human health by promoting development and dissemination of genomic methodologies and tools for prediction and prevention of human disease, and for therapeutic intervention; and promotes capacity building in human genetics and genomics by promoting training on technology platforms and methodologies for genome analysis in relation to human disease and other phenotypes. Twenty new projects have been supported under the thematic area Genomics to Health with the priority on Monogenic Disorders and Hemophilia. The Department is also in the process of initiating program on 'Establishment of Diagnostic labs (NIDAN-Kendra)' for genetic testing and counseling services and program on 'Training of Clinicians' in order to produce skilled personnel to establish new NIDAN Kendra.

Systems Biology of Complex Diseases-From Genetic Findings to Lead Molecule Development for Rheumatoid Arthritis (RA):

Identification of genetic determinants of complex diseases is expected to be useful for prediction/prevention and understanding disease biology which in turn may impact development of new therapeutics. A novel susceptibility gene ARL15 was identified by genome-wide association study in Rheumatoid arthritis (RA) and ARL15 variants were associated with increased adiponectin levels which has known anti-inflammatory roles & ARL15 appears to be a drug target. Now, three potential drug targets have been identified- from lab based GWAS leads- ARL15 & based on RA cell type specific networks - BTK & MAP3K8. The three potential drug targets ARL15, BTK & MAP3K8 have been prioritized and expression of ARL15 in RA synovial fibroblasts & TNF independent role of ARL15 has been established for the first time.

Translational Research on Eye Diseases: This program endeavors to identify genetic (and resultant RNA and protein) variants associated with eye disorders such as glaucoma and certain retinal dystrophies and the treatment of retinal dystrophic conditions. The investigators have screened the entire coding regions of the human genome in large cohorts of families and individuals across Telangana and Andhra Pradesh. Variations in 25 genes were found to be associated with glaucoma. In addition, the RNA and proteins from the patients' tissue samples have been analyzed and found some potential variants/proteins in the study population, enabling predictive testing and drug targets.

For the treatment of retinal dystrophic conditions investigatorss have generated induced Pluripotent Stem Cells (iPSCs) using the Yamanaka method, and differentiated them into Retinal Pigment Epithelial Cell sheets, 3D neuro-retinal cups and corneal organoids.



Human iPSCs derived RPE Cell Sheets and
3D Neuro-retinal Cups

iPSCs derived from skin fibroblasts are further chemically stimulated under controlled conditions, to make more of eye-specific cells, such as the retinal and corneal cells that are responsible for light perception. Figure shows the growing iPSCs (a), which upon differentiation generates eye field clusters containing retinal stem cells (b), which further matures to make retinal neurons and pigmented epithelial cells (c). The central neural progenitor clusters can be isolated and grown as floating 3D retinal cups, which contain all six different types of retinal neurons (d-g).

Primary Angle Closure Glaucoma - Genome Wide Association Study: Glaucoma is the leading cause of irreversible blindness worldwide. Primary angle closure glaucoma (PACG) is one of the major subtypes, prevalent mostly in eastern Asia and India. Approximately 30% people in India show narrowing of the irido-corneal angle but 0.5-1% actually develop glaucoma. An extreme phenotype and age-agnostic genome-wide association study (GWAS) should significant association between PACG and PACS (anatomically suspect controls).

The Human Gut and Eye Microbiome-An Insight into Eye Infections: The human gut has about 100 trillion bacteria and together the bacteria have 200 to 300 times more genes than the human body. This enormous microbiota in the gut is known as the microbiome and is consistently represented by four bacterial phyla Firmicutes, Bacteroidetes, Actinobacteria and Proteobacteria which constitute the "core microbiome". Imbalance in the core microbiome (variation in abundance and diversity) is known as "Dysbiosis". Dysbiosis has been implicated in several inflammatory diseases (obesity, enterocolitis, inflammatory bowel disease, uveitis and vaginosis). Dysbiosis in the gut microbiome of keratitis individuals compared to healthy controls was demonstrated for the first time. Bacteria with anti-inflammatory, probiotic and antibacterial activity were decreased in the gut of keratitis patients on the other hand, bacteria with pro-inflammatory and pathogenic properties were increased in the gut of keratitis patients. This is also the first study demonstrating the ocular surface fungal microbiome.

Initiatives have been taken to start a project on Human Genome which aims to sequence whole genomes of 10,000 individuals representing the geographic, culture and ethnic diversity of Indian population. The programme aims to create an exhaustive catalogue of genetic variations, construct the reference genome for Indian population and design genome wide arrays for undertaking diagnostics and basic or clinical research at an affordable cost along with creating a Biobank of DNA and plasma samples. UMMID initiative has been started which will have a comprehensive program on a) Skill development through “Training of in-service Clinicians’ from Government Hospitals on Biochemical Genetics, Cytogenetics, Molecular Genetics, Clinical Genetics, b) Establishment of National Inherited Disorders Administration (NIDAN) Kendra to provide comprehensive clinical care including diagnosis, management, multidisciplinary care, counseling, prenatal testing at Government Hospitals and c) Outreach program in seven aspirational districts by the way of, screening of 10,000 pregnant women and 5000 new born babies. New R&D project has been started on a multi-centric effort towards understanding a high-resolution, genomic architecture of congenital nonsyndromic deafness in India.

MATERNAL AND CHILD HEALTH

Maternal & Child Health is an important priority area for the country's health needs and also in line with the MDG 5 to reduce maternal and child mortality. Several initiatives have been taken for advancing research and scientific knowledge in this area which encompasses research from preconception

to adolescence. Programs have been supported on aspects of pregnancy complications, mechanistic paradigm governing the outcomes of pregnancy, congenital anomalies, diseases of neonatal period and early childhood. Several collaborative efforts have been initiated for hypothesis driven original research for answering questions relevant to our health need in the area.

Through the Cooperation with Canadian Institute of Health Research (CIHR), Canada the department has supported research projects on Placental Biology, Fetal Growth and Programming, Congenital anomalies and Endothelial dysfunction in children with chronic kidney disease.

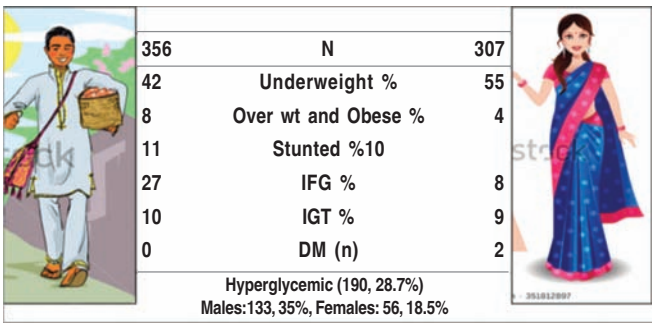
Maternal and child health program emphasizes on research activities related to pregnancy complication, factors of adverse pregnancy outcome, antenatal development, congenital anomalies and problems and diseases of early childhood. The projects supported so far focus on preeclampsia, IUGR, recurrent miscarriages, effect of maternal nutritional status on pregnancy outcome, development of neonatal immune system, neonatal sepsis and aspects of congenital anomalies. The overall goal is to support both basic research on Developmental and Disease Biology and application centric discovery under the competitive grant system.

Reproductive health was a priority area this year and a call for LoIs was made in the area of Reproductive Biology whereby 158 LoIs were received. 44 of them have been shortlisted in the area of PCOS, Endometrial Dysfunction, Preeclampsia, Recurrent Implantation Failure and would be reviewed in the next year.

Grand Challenge Research Program on Preterm Birth: India, with its highest number of preterm birth (PTB) *i.e.,*3.6 million of the 27 million babies born annually as preterm and with the highest number of preterm deaths worldwide, contributes 25% of the overall global preterm related deaths. An inter-institutional and interdisciplinary program was established in 2014 with the ultimate objective to acquire 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.

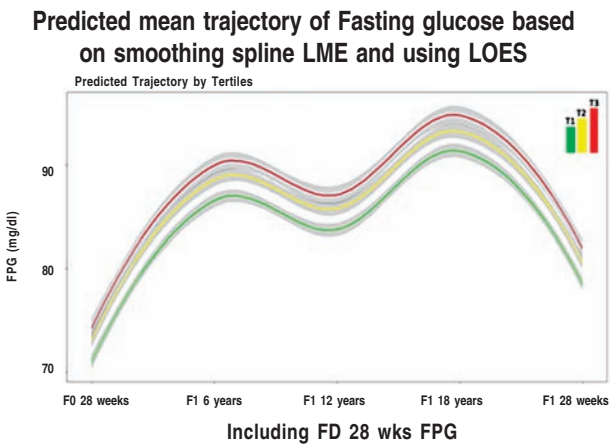
This program is coordinated by an interdisciplinary research group now christened as GARBH-Ini - (interdisciplinary Group for Advanced Research on BirtHoutcomes -a DBT India Initiative). The program envisaged to establish a cohort of pregnant women in Gurugram General Hospital, Haryana. Women are enrolled within 20 weeks of gestation and are followed until delivery and once at post-partum. Around 5293 pregnant women have since been enrolled and end of pregnancy outcomes were documented in 3822 participants. The high proportion of 14.0% preterm birth enrolled in the cohort till now is remarkable as these figures, are higher than those reported from economically developed (8.6%) or the low-income countries in Northern (7.3%) or Sub-Saharan Africa (12.3%). Importantly the cohort is showing a still birth rate of 2% and fetal growth restriction of 38% identified in the last trimester of pregnancy; both parameters have crucial public health implications. The initial analysis on the first 3000 mothers enrolled have shown that 9.5% of all PTB could be attributed to exposure to indoor air pollution, mid-trimester shortening of the cervix has 2.5 times higher risk of PTB, and 7.4% of all PTB are attributed to maternal underweight.

Fetal Programming Research: The program addresses the question 'why Indians are so susceptible to diabetes and what may be done about it'. It is based on the Pune Maternal Nutrition Study (PMNS) and the Pune Rural Intervention in Young Adolescents (PRIYA). PMNS is in the 25th year with enviable follow up rates and highlighted the 'thin-fat' body composition of small Indian babies which predisposes them to higher risk of diabetes, and highlighted association of maternal vitamin B12 deficiency and 'excess' folate with child's adiposity and insulin resistance. At 18 years of age 28% of offspring have 'prediabetes', predicted by lower birth weight but relatively higher current BMI (19 kg/m2). PRIYA investigates preconceptional micronutrient supplementation to reduce 'fetal programming' of diabetes. In the 6th year, 161 of 266 randomized girls are married and 121 have delivered a baby. Serial data collection in PMNS and PRIYA has allowed construction of a 3 generational landscape of glucose levels which demonstrated a worrying rise in pregnancy glucose levels within one generation.



Pune Maternal Nutrition Study (PMNS) 18 year Follow Up

The figure shows physical characteristics and glucose intolerance in 18 year old boys and girls in the PMNS. Despite a relatively low BMI (~50% are underweight by WHO criteria) there is high prevalence of pre-diabetes, twice in boys compared to girls. Those who were born light and grew relatively heavier are at the highest risk, illustrating the effect of intrauterine programming and subsequent transition in the risk of non-communicable disease.



Glucose Trajectory between Generations

The figure illustrates pregnancy glucose concentrations in the mother (F0), childhood, adolescent and adult glucose concentrations in her daughter (F1) ending with her own pregnancy glucose concentrations. This is the first description of such a trajectory and shows tracking of pregnancy glucose into adolescence and early childhood. The glucose concentration in pregnancy is considerably higher in the daughter compared to the mother, illustrating a rapid rise in 'gestational' glycemia within one generation in modern India. This provides evidence to improve metabolism of young girls before pregnancy to avoid fetal programming of diabetes.

Healthy Life Trajectories Initiative (HeLTI): The Healthy Life Trajectories Initiative (HeLTI) was launched as a joint initiative between India, Canada, South Africa and China in collaboration with the World Health Organization to address the rising epidemic of NCDs.

Poor maternal nutrition, impaired fetal growth, low birth weight, poor infant nutrition, and rapid childhood weight gain and obesity are well established risk factors for poor health trajectories and development of NCDs in later life. Integrated multi-faceted longitudinal interventions focusing on DOHaD (Developmental Origins of Health and Disease) concepts offer a novel approach to reducing the long-term risk of NCDs. There are four separate but harmonized intervention studies implemented in Mysore district (India), Shanghai (China), Johannesburg (South Africa), and three provinces in Canada. All projects are focused on developing evidence-based interventions that span from preconception across pregnancy and into the postnatal period with the goal of improving maternal, infant and child health, and ultimately the life-long well-being of the child.

Pediatric Renal Biology Program: Research on Nephrotic Syndrome: Idiopathic nephrotic syndrome, the most common chronic kidney disease of childhood, is associated with significant morbidity related to disease relapses and immunosuppressive therapies. This nationwide multicenter collaboration proposes to help understand aspects of disease pathogenesis, disease course and impact of therapies and outcomes in longitudinal cohorts of patients with steroid sensitive and steroid resistant nephrotic syndrome, and form the framework for conduct of collaborative clinical studies. The biorepository was also set up at two participating institutions with common standard operating procedures that will enable collaborators to address questions on disease pathogenesis. Links are being established among working groups on nephrotic syndrome within India, and international working groups in UK & USA through internationally funded projects (NEPTUNE; MRC) that allow for anonymized data sharing in registries and enable capacity building for research. This program will lead to understanding of the pathogenesis of proteinuria, natural history and basis of therapies in patients with nephrotic syndrome which is limited. On the medium term, this will enable research on novel and focused treatment options that impact the course of the illness, transforming into better

clinical outcomes.

Fetal and Neonatal Health Research: Studies have been supported on congenital birth defects with limb malformations, screening newborns for common genetic disorders, basic biology of fetal growth and development and Maternal-placental-fetal axis. Studies have also been supported to develop low cost methods for screening newborns for peroxisomal disorder, NGS based tests for 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.

R&D Collaboration through International Partnership: A Vital Signs Alert blood pressure measurement CRADLE VSA device was developed by researchers at KLE academy of higher education, Karnataka in collaboration with King's College, London (UK). The device is helpful in early detection of elevated blood pressure during pregnancy and was validated. Investigators at CCMB, Hyderabad in collaboration with University of Southampton (UK), have provided evidence when mothers were supplemented with micronutrients before pregnancy their body composition was improved which was manifested by higher birth-weight in the new born.

PUBLIC HEALTH AND NUTRITION

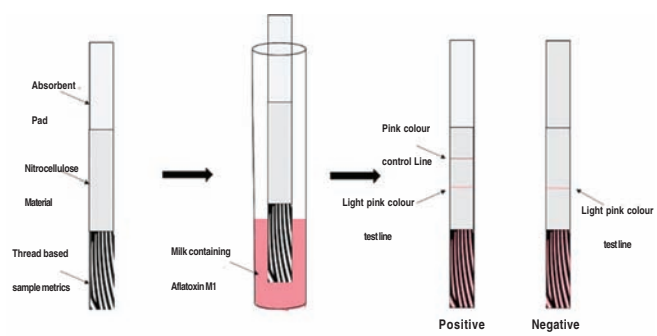
The Department continues its efforts to promote the area of Public Health and Nutrition. A call for proposals on Vitamin D deficiency was issued which invited overwhelming response. The highlights of the program include sensory studies on fortified rice premix developed for addressal of anemia (detailed inputs at mission mode programs); state of art whole body potassium counter to accurately estimate the body cell mass (lean body mass); development of flow assay strip device, megenetosome biosensors for addressal of biosafety and development of nanoaliumina based deflouridation filter etc.

The mandate of Public Health and Nutrition are addressal of micronutrient deficiencies, severe acute malnutrition, 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 Food Science and Nutrition Biology.

Achievements:

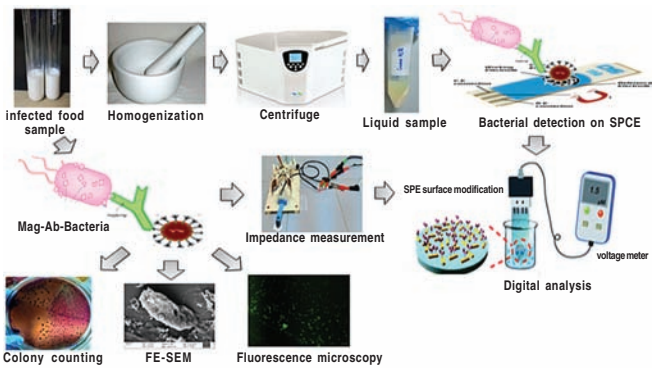
Whole Body Potassium Counter

A state of art whole body potassium counter to accurately estimate the body cell mass (lean body mass) has been built in St John's Research Institute (SJRI). This whole body counter is being utilized to answer research questions related to protein requirements in pregnancy, measuring the impact of diet on gestational weight gain and fetal growth, particularly of fetal body cell mass. Estimates of protein requirement for Indian pregnant women using data on protein deposition during pregnancy have been arrived at using this counter. The newly built whole body potassium counter can be used in clinical and research settings in future to study the body composition of children undergoing nutritional rehabilitation, where repeated measures of body cell mass can help in the planning of nutritional interventions. Additionally, this method would be useful in children with cancer undergoing treatment, children with chronic kidney diseases and in assessing growth of children, as each measurement is almost costless, and can be repeated any number of times.



Aflatoxin M1 Test Strip and Two Red Lone in the Center Part (Control and Test) Indicate the Presence of Aflatoxin M1 in Milk Sample while Single Light Pink Line indicate the Absence of Aflatoxin M1 in Milk

Nano-tag based lateral flow assay strip device proof of concept has been developed for the detection of the aflatoxin M1 from milk as shown in the Figure above. This is a simple, specific and rapid, point-of-care method to detect Salmonella, based on DNA aptamers conjugated to gold nanoparticles.



Impedance Measurement and Equivalent Circuit Analysis. Detection of Selected Pathogen in Food Sample

A rapid, cost-effective, sensitive and specific magnetosome-based biosensor has been developed for detection of four major food pathogens viz. *S. typhimurium, E. coli, L. monocytogenes* and *S. aureus* as shown in the figure above.

An eNose device has been developed which can be deployed at various stages of apple fruit supply-chain management and vegetable markets of broccoli to minimize wastage as well as contaminated foods induced food borne illnesses.

In another study, a high amount phenolics and flavonoids were found in the methanol extract of *P. minima* and *C. spinarum* fruit at different ripening stages (ripe and unripe). *C. spinarum*, fruits have shown a higher amount anthocyanin and resveratrol. Extracts from unripe fruits could efficiently prevent foam cell formation, which indicated their possible role in atherosclerosis.

The Stem powder of *Cissus quadrangularis* (CQ) were found to be holding huge amounts of Calcium and Magnesium than other available dietary sources and the entire daily recommended allowance of Ca and Mg can be met out from less than a 100 gm of CQ stem powder. Further, the free radical scavenging activities and active phytochemical constituent quantification reveals their values on health promoting effects.

A nanoalumina incorporated deflouridation filter has been developed. In the initial step, the filter removes sediment and turbidity and in the second stage fluoride is filtered at the rate of 1-3 Lit/hour. The filter works on gravity force and hence no electricity is required for the filtration process.

Filtration Unit made of Nanoalumina Incorporated Filter

Two probiotic strains (*L. rhamnosus and L. fermentum*) were found to have a tendency to restore epithelial barrier functions towards normal by attenuation of inflammation induced changes made by *E. coli*. Further, it was established that both lactobacilli initiated immune signalling towards maintaining immune homeostasis in epithelial cells with considerable degree of variations. Both strains of Lactobacilli appeared to perform better during exclusion and competition assays than displacement assays with live E. coli as well as its LPS.

- The method for preparation of native and modified milk protein-Vit D complexes was developed. Sensory analysis and physico-chemical characterization of milk protein-Vit D complexes fortified milk showed that milk protein-Vit D complexes can be used as promising fortificant since it had minimal effects on sensory, physico-chemical attributes and product shelf life.
- Fortified Millet cookies were developed and validated. Research indicated that multi millet flour can be used as a potential ingredient for preparation of cookies with desired quality characteristics such as moistness, flavor, texture and overall acceptability.

Microbial bioprocessing of sweet sorghum juice with *Leuconostoc mesenteroides* cells resulted in transformation

of sucrose into glucooligosaccharides and the glucose polymer, dextran. Microbial processing achieved yield of about 5 g L-1 of glucooligosaccharide and 4 g L-1 dextran in sweet sorghum juice.

- A novel method for rapid detection of aflatoxin in food using optical nanofibre probes was developed. This is a smaller, faster, cheaper and more sensitive nanosensor device for the detection of aflatoxin, which will result in high-quality agri-food safety.
- High prevalence of osteoporosis, hypovitamonosis D, secondary hyperparathyroidism and hyperhomocystenemia in postmenopausal women was revealed in a study conducted in Lucknow which signifies high morbidity of osteoporosis in Indian postmenopausal women.
- A high-throughput nanobiosensor for the detection of *Salmonella spp*. in food was developed. One aptamer S4-1 was been identified as an effective probe to detect *Salmonella* and the sequence of the ssDNA aptamer has been elucidated.

Vitamin D : Vitamin D deficiency (VDD) is prevalent globally and the data for last two decades suggests that it may be widespread in India as well. A call for proposals on "Vitamin D Deficiency in India: Public Health Significance and Interventions" was issued by the Department. The highlights of the programme include sensory studies on fortified rice premix developed for addressal of anemia (detailed inputs at mission mode programmes); state of art whole body potassium counter to accurately estimate the body cell mass (lean body mass); development of flow assay strip device, megenetosome biosensors for addressal of biosafety and development of nanoaliumina based deflouridation filter etc. research on the public health significance of VDD and potential interventions to address this malady.

Policy on Public Health and Nutrition: A scientific sub-committee of 'National Technical Board on Nutrition' (SSC-NTBN) has been constituted by NITI Ayog with Secretary, DBT and Secretary DHR as Co-Chairs. The mandate of this committee is to provide technical recommendations to NTBN (National Technical Board on Nutrition) on policy related issues and also to evolve strategies for mitigation of anemia, micronutrient and protein malnutrition.

STEM CELLS AND REGENERATIVE MEDICINE

The ability of stem cells to self-renew and give rise to subsequent generations with variable degrees of differentiation capacities, offers significant potential for generation of tissues that can potentially replace diseased and damaged areas in the body, with minimal risk of rejection and side effects. Keeping in view the therapeutic potential of these cells, the Department continues to support research and training in this important area of Medical Biotechnology. The overall aim is to promote basic, early and late translational research in the area of stem cell and regenerative medicine. Broadly the focus is on induced pluripotent stem cells; hematopoietic stem cells; mesenchymal stem cells and human embryonic stem cells. Scientific strategies includes basic biology of all adult stem cells, early and late translational research, developing gene editing technology for possible therapeutic applications, creation of animal models for various human diseases and training programs on various component of stem cells and regenerative medicine. In addition, the Department has also set up infrastructure at identified institutions to promote research in this area. The Department has set up an institute, 'The Institute for Stem Cell Science & Regenerative Medicine', (Instem) at Bengaluru with Centre for Stem Cell Research (CSCR) as its translational unit at CMC, Vellore, with the intention of using stem cell science for understanding human diseases and development of stem cell-based therapies. A Centre of Excellence has been supported at AIIMS, New Delhi with Good Manufacturing Practices (GMP) Facility for manufacturing stem cells of clinical grade for patient use. All safety issues and ethical principles applying to research must also be ensured in stem cell research and therefore the Department is actively involved in formulating and revising the National Guidelines for Stem Cell Research in the country, jointly with ICMR.

The Department has been supporting both basic as well as clinical research with a vision to effectively translate the results of stem cell research into applications for human welfare. The objective is to promote basic, early and late translational research and formulation of regulatory framework for stem cell research in India and to promote extensive and intensive scientific interactions and collaborations amongst clinicians and researchers. The Department also aims to promote capacity building in this

emerging area of research through various training programs and workshops.

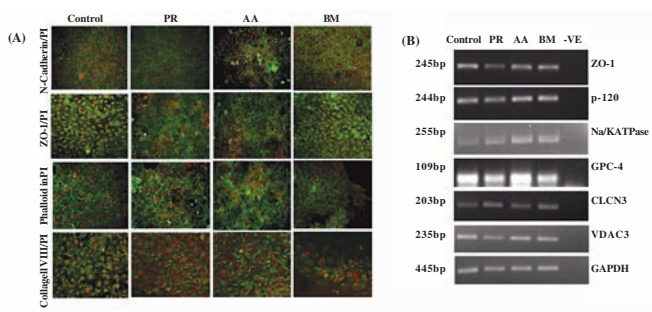
Major Initiatives: Embryonic stem cells are pluripotent for only a short window of time in the embryo and gradually lose potency as they commit to differentiating into specific somatic lineages early during post-implantation development. In pre-implantation embryos, pluripotent stem cells are referred to as 'naive', and they become 'primed' during post-implantation development. A study was supported to understand how embryonic stem cells could be maintained in their naïve state to achieve maximal efficiency in the use of human ES during regenerative medicine. The initial experiments identified DNMT methyl transferase enzymes expression in mouse embryonic stem cells maintained in different conditions, as DNA methylation aided by these transferases dictate the naïve vs. primed state, wherein hypomethylation associate with naïve state and hypermethylation associate with primed state of pluripotency.

Mesenchymal stem cells (MSCs) have proven to be reparative in several animal models and the clinical benefits of these cells have been demonstrated in several diseases. Therefore efforts have been made during the year to improve their method of isolation, differentiation and also to understand the immunomodulatory and regenerative effects of MSCs on other cells such as to improve the hematopoietic stem cell (HSC) engraftment in clinical settings. It has been proposed that the effect of extra-cellular vesicles (EVs) isolated from MSCs treated with specific signaling modifiers may improve the functionality of HSCs and research is underway to test this hypothesis.

Attempts have also been made to understand the mechanistic details of regeneration and to identify various transcriptional regulators for the realization of various stages of regeneration. In Zebra fish, remarkable functional recovery of the retina occurs through a series of genetic programs that occur in the resident Muller glia (MG) cells of the retina at different time points post-injury. Using zebra fish as a model system, the epigenetic status of the normal and regenerating MG was studied. The initial results hint towards the role of H3K27 acetylation and H3K27 methylation.

Induced Pluripotent stem cells (PSCs) derived from adult somatic cells can be reprogrammed to an embryonic stem cell-like state by introducing genes important for maintaining the essential properties of embryonic stem cells (ESCs). Since they can be generated patient- specifically, they have great potential for regenerative therapy in future. However, one of the major challenges for application of iPSCs is the optimization of protocols to overcome barriers to generate the desired target cell type. Therefore projects have been supported to improve protocols for reprogramming of somatic cells to iPSCs, their differentiation and trans-differentiation to desired cell types. One such study identifies the role of a RNA binding proteins (RBPs) Rbm47, in maintenance of ESC undifferentiated state and which may play a critical role in regulating the differentiation of pluripotent stem cells to different lineages.

An important aspect in regenerative medicine is to develop a scaffold suitable for the culture and transplantation of desired stem cells with physical supports and biochemical signals capable of supporting cell delivery, survival and integration. DBT has supported couple of projects in this area with an aim to develop a suitable scaffold by fabricating Indian silk variety for culturing and delivering corneal endothelial cells to restore vision in individuals with poor vision due to corneal edema resulting specifically from endothelial dysfunction. Further to improve the cell culturing on scaffold, a study has addressed the correlations between calcium signatures and phenotype of cells cultured on biomaterial scaffolds. The protocol developed for the confocal imaging of cells will help in functional characterization of biomaterials. This in turn can be used in hospitals in case of materials that are used in wound healing and healing of non-critical size orthopedic defects.

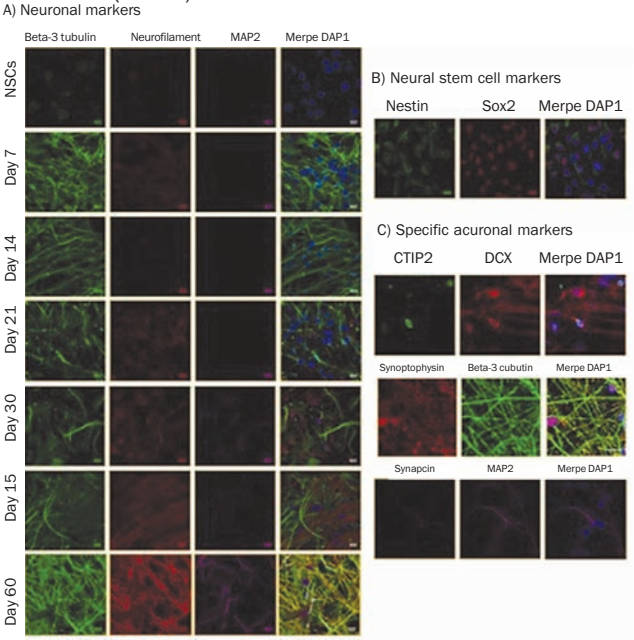


Expression of corneal endothelial markers. (A) The representative picture of different silk varieties eri, muga and mori showing positive expression for endothelial specific marker N-Cadherin, ZO-1, Col VIII, where as phalloidin staining represented the intact hexagonal morphology of cells on different substrates. (B) Expression of genes involved in in

vivo functioning of CE cells cultured on silk films, where fresh tissue is used as control.

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 is also involved in manufacturing stem cells of clinical grade for patient use. It also provides Amniotic Membrane Grafts (AMG) processed in compliance with GMP guidelines on non-commercial basis. The research efforts at this facility has led to establishment of a viral non integrating approach for generation of induced pluripotent stem cells (iPSCs). The Centre also organized a workshop and one lecture during the year for enhancing knowledge in the area of iPSCs. Training is also imparted to graduate and postgraduate students in stem cell research.

The Indo-Japan project - 'Accelerating the Application of Stem Cell Technology in Human Disease (ASHD)' was supported by the Department of Biotechnology (DBT) to facilitate research and capacity building in the area of modern stem cell technology for the 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)".



Expression of neuronal markers beta-3-tubulin (green), neurofilament heavy polypeptide (red) and MAP2 (magenta). B) Immunostaining of neural stem cell markers Nestin (green) and SOX2 (red). C) Expression of specific neuronal markers: Deeper cortical neuronal marker CTIP2 (green) with neuronal marker DCX (red), presynaptic marker synaptophysin (red) with beta-3-tubulin (green), synaptic marker synapsin (red) with MAP2 (magenta). All the antibodies were co-stained with DAPI (blue).

Under the ADBS program, the process of establishing a large cohort of dense families (>=2 affected first degree relatives) with major psychiatric disorders and unrelated healthy controls is in progress. So far 2975 families have been screened and 359 families have been recruited. Using biomaterial from these patients, 225 lymphoblastoid cell lines (LCLs), 61 human induced pluripotent stem cells (HiPSCs) and 20 neural stem cell lines have been generated. Genomic analysis w.r.t whole exome data from a set of 144 samples from 15 densely loaded pedigrees of Bipolar Disorder (BPAD) and Schizophrenia (SCZ) and informative control (n=34) has been completed. A protocol for differentiating neurons from human neural stem cell line of a normal human has been standardized. These neurons have also been characterized functionally by imaging calcium transients, a key event in neuronal development.

Under the NAHD component, a unique transgene construct has been developed and its functionality has been evaluated in two mouse models - one where the transgene was packaged in the AAV8 serotype and evaluated in the wild type mouse liver and the second where the transgene was packaged in the AAV3 vector and tested in the humanized mouse liver. This is the first demonstration of the use of AAV3 serotype in these unique mouse models. Four lentiviral globin vectors have been generated which shows stable and consistent expression after 17 weeks of transplantation in an ex – vivo system with a good vector copy number. Disease models for Diamond-Blackfan anemia (DBA) and congenital dyserythropoietic anemia (CDA) are being developed. Robust reproducible protocols for generation of mutant iPSCs, differentiation of iPSCs to haematopoietic progenitor cells (HSPCs) and differentiation of HSPCs to erythroid cells have been established. As a part of establishing a haplobank relevant to Indian population, so far blood samples from 234 donors have been collected and peripheral blood

mononuclear cells were isolated and cryopreserved inside GMP facility.

Training and Capacity Building Efforts under the Indo-Japan ASHD Program.

Capacity building and outreach is one of the major objectives under the ASHD project. Various training programs have been conducted on the generation and maintenance of iPSC cultures which was attended by researchers across the country. A training program was also organized for a group on Indian researchers at the centre for iPS cell research in Kyoto University, Japan for training in iPSC technology.

- The Hon'ble Minister for Science & Technology and Earth Sciences; Environment, Forest and Climate Change Inaugurated the Atal Anusandhan Bhawan, Institution for "Stem Cell Science and Regenerative Medicine" (inStem) at Bengaluru, Karnataka on 21st February, 2019. This institute, an autonomous institute of the Department of Biotechnology, Ministry of Science & Technology, Government of India is the first of its kind in the country which is committed to understanding the role of stem cells in health and disease, with a translational unit, the Centre for Stem Cell Research, at CMC Vellore which focuses on creating a strong clinical network for translating clinical research leads. The institute is also one of the partners of Bangalore Life Science Cluster which offers a strong research base with state-of-the-art facilities to attract investigators to its theme-driven interconnected network of research programs. The event was attended by the Senior Government officials, eminent scientists, researchers, clinicians, policy makers, industry, etc.

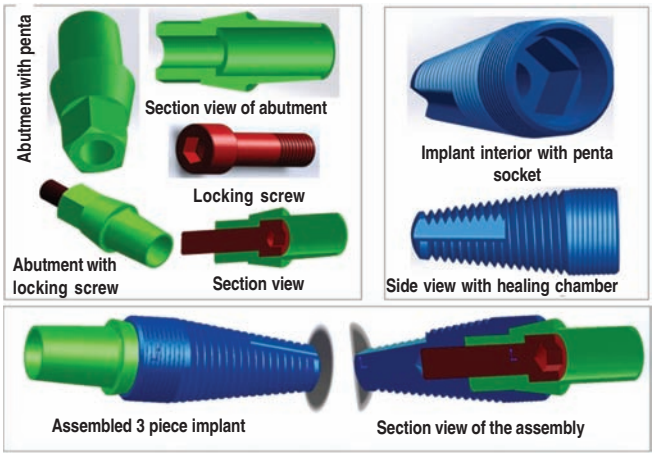
BIOENGINEERING

Bioengineering is a highly interdisciplinary area of research involving cross disciplinary knowledge from engineering and other quantitative sciences for unravelling the complexities of biological systems and provide cost-effective solutions for improved quality of life. With a priority to study emerging diseases, to manipulate/engineer genomes, develop transgenic systems and develop genome-based diagnostics the Department significantly contributes towards bioengineering field for development of affordable devices, diagnostics, bio composites, biosensors etc. Some of the significant achievement made during the year in area of bioengineering are:

A Translational Centre of Excellence on Biomaterials for Orthopedic and Dental Applications was supported at Indian Institute of Science, Bangalore. During the year, a new generation of polymer-ceramic hybrid acetabular socket of different sizes (40,44,46 mm) was fabricated using compression molding approach;

The scientists developed a unique technology for manufacturing of ceramic femoral heads for total hip joint replacement surgery which was patented. Optimization of the process conditions and material parameters to obtain an excellent combination of strength, toughness and wear resistance of the zirconia-toughened alumina-based femoral head has been accomplished.

CAD based 3D models of a complete 3 piece-dental implant system comprising of implant screw, straight and angulated abutments, locking screw, healing abutment and cover screw were designed. This implant system is designed with pentagonal anti-rotation feature and single healing chamber. Also, a novel acrylic ink was formulated for 3D inkjet printing of Titanium and ceramics. The surface topographical features of the implant have been benchmarked against that of the Straumann implant by conventional machining, followed by sand blasting and acid etching. Using ANSYS-based finite element analysis, the implant design was optimized for clinically desired biomechanical response in peri-prosthetic bone.



3D models of a complete 3 piece-dental implant system

Researchers established Breast tumor growth in Athymic nude mice using MCF-7 cells and tumor progression was evaluated on different time points post MCF-7 cells inoculation by photoacoustic spectroscopy. A particular frequency at 93.6 KHz was found to be increased with the progression of tumor growth, which may be considered as marker frequency of tumor progression. Further, discrimination analysis of malignant clinical breast samples from controls using supervised logical regression analysis demonstrated classification sensitivity, specificity and accuracy of 100%, 93.75% and 96.2% respectively. This technology has the capability to capture molecular alterations before the advancement of the disease adding to its prognostic potential. Hence, early breast cancer detection can be possible with this technique and accordingly treatment modalities can be planned to reduce the sufferings associated with the currently followed treatment of chemo and radiation therapy and thus life expectancy can be improved.

*Breast tumor growth/development post-*MCF-7 *cells injection*

In an another project, Porous Ti/SiO2 composite samples were prepared, which had shown good mechanical property comparable to that of natural bone. Also the developed samples confirmed biofilm formation.

Researchers explored 3D bioprinting strategy wherein the path of bone formation normally taken by load bearing long bones which are formed within a pre-figured cartilage template. 3D bioprinting of silk-gelatin laden with TVA-BMSC lead to the chondrogenic differentiation of mesenchymal stem cells followed by osteogenic differentiation thus mimicking the conditions *in vivo* that takes place during embryonic stage.

A novel Carrageenan/GeMA (1%+3%) bio-ink was developed and showed to be suitable for bioprinting applications given its biocompatibility with L929 fibroblasts, HUVECs and HUASMCs. A new approach for printing vascular construct was used with a method of printing on a rotating cylindrical substrate so that printed construct will be a hollow tube like structure. The 4-axis 3D-Printer was designed and fabricated with flexibility of additional features such as UV curing, temperature control, and future improvements in resolution. The long-term scope of this project is to help regenerate tissues with even complex architecture using bioprinting.

To address the issue of poor penetration of clinically used antifungal drug, a corneal epithelial penetrating specific peptide was designed which is further as Peptide- Natamycin-Polycaprolactone composite nanofiber may be used as an implant for corneal drug delivery.

A microfluidic device to study sperm chemotaxis was developed. This device generated a stable and linear gradient for longer time which was validated theoretically and experimentally. Once scientists succeed in developing the device for selection, it would be useful in improving the success rate of IVF.

Periodontal ligament regeneration is challenging as it necessitates the formation of new cementum and alveolar bone with newly laid collagen fibres connecting both the hard tissues. Bioactive barrier membranes that promote endogenous regeneration are advantageous in predictable regeneration of periodontal ligament. In a research work, the polymeric dendritic lysine-poly diacetylene (Lys-PDA) matrix was synthesized and characterised. Electrospun PCL membrane was biofunctionalized with Lys-PDA matrix. In the

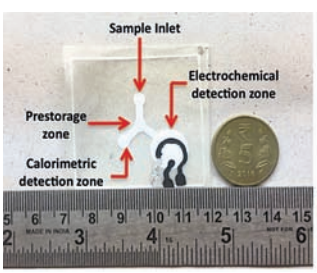
experiments it was observed that the biofunctionalized electrospun polycaprolactone (PCL) membrane with polymeric dendritic peptide matrix can be utilised in the treatment of periodontal defects in dentistry.

Rehabilitation robots are excellent tools for assisted movement training and have several potential advantages. Robots can provide intense movement therapy and assessment under intermittent supervision of a trained human therapist. The scientists at CMC vellore and IIT Madras completed the design and fabrication of basic structure of the system including the robot actuator and the WFE, WURD, and FPS mechanisms under a DBT supported project. A preliminary implementation of three types of robot controllers, along with two computer games to train wrist flexion/ extension movements has also been completed.

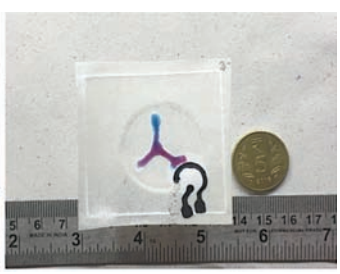
1. Height adjustable table top
2. Arm support
3. Wrist flexion/extension mechanism
4. Tablet for game play
5. Torque sensor
6. Maxon Motor
7. Height adjustment knob
8. Power supply with battery
9. Controller and associated electronics

Model of PLUTO's final form

Researchers successfully developed the dual mode paper analytical device (PAD), through simple photolithography with an easy way to incorporate the three electrode system without employing sophisticated screen-printing machine. The fabricated dual PAD could be used to develop a point-of-care testing platform coupled with a palm device for community based screening and diagnosis.



Fabricated dual PAD with electrochemical and colorimetric detection zones



Fabricated dual PAD flow test with color dyes

Promising research results have been reported in research works related to Surface Modified Hybrid Bioimplant by Pulsed Laser Deposition to Enhance the Implant Durability, Microstructurally designed in-situ toughened metallic and ceramic matrix composites for total hip arthroplasty, Bioartificial liver on a chip using dielectrophoresis based 3D cell patterning, Validation of a novel non-invasive method for measuring beat-to-beat blood pressure variability in humans and estimation of compliance and resistance of the arterial system in humans and animals using a new algorithm and in other research projects related to bioengineering.

During the year, the program support to Bioengineering research projects resulted in 28 publication, filing of 7 patent applications and support to about 50 manpower.

R&D Collaboration through International Partnership

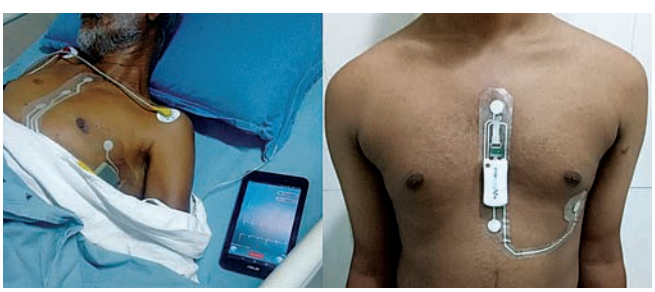
Biosensors and Devices:

(a) Investigators from IIT-Ropar, Universite de Sherbrooke, Qubec, Canada are developing a semiconductor based biosensor functionalized with biginella compounds for rapid monitoring of water reservoirs for the presence of pathogenic bacteria. On similar lines, investigators at University of Kashmir, Srinagar in collaboration with University of Laval, Quebec, Canada are developing a nanoparticle-based impedance-driven handhold biosensors for water treatment system. In another study researchers from Lovely Professional University in collaboration with McGill University, Canada are looking into the possibility of exploiting biochar filters as an innovative green technology for treating municipal and industrial wastewater entering rivers and streams.

(b) An easy to use ARTSENS® Pen device that can measure the stiffness of the blood vessels was developed by investigators at IIT-Madras in collaboration with University of Turku, Finland. The accuracy of the device was validated in a clinical study on more than 500 subjects, and its field feasibility was verified more than 1000 rural subjects.

The highly portable ARTSENS® Pen device for easy measurement of vascular stiffness

(c) In an ongoing collaborative project with Tampere University of Technology (Finland), continuous health monitoring researchers at IIT Madras have designed, developed and validated VitalSens - a cloud based, affordable, minimally obtrusive, real-time continuous ECG monitoring device for potential use in hospital (post ICU recovery), ambulatory and geriatric applications. Data collection studies showed that VitalSens platform was able to capture ECG changes in both rhythm and waveform morphology.



VitalSens data collection study

VACCINE RESEARCH AND DEVELOPMENT

Department of Biotechnology (DBT) has made concerted efforts in strengthening vaccine research and development since its inception in 1986-87 through various endeavors. Currently major efforts are being implemented through the National Expert Groups and Indo-US Vaccine Action Program (VAP).

DBT's Vaccine Programs have demonstrated major achievements like the lowest cost Rotavirus vaccine which became part of the universal immunization program & major strides towards vaccine for diseases like malaria & dengue. One out of every 6 children over the world receive vaccines manufactured in India

The Indo-US Vaccine Action Program (VAP) - a bilateral program of the Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India; and the National Institute of Allergy and Infectious Diseases (NIAID) of the National Institutes of Health (NIH), USA under implementation since July 1987. The VAP has been recognized internationally and considered as model bilateral program in biomedical research area. The program was extended for period of five years (up to 2022) through signing of Joint Statement by Prof. K. VijayRaghavan, Secretary, DBT and Dr. Anthony S. Fauci, Director, NIAID, NIH, USA

The VAP, since its inception has supported a large number of collaborative research projects, provided training opportunities for Indian students and scientists, held bilateral workshops on vaccines and infectious diseases. To date, the VAP have supported projects in the priority areas such as on viral hepatitis (e.g., hepatitis C), typhoid, rabies, rotavirus diarrhea, acute respiratory infections, tuberculosis, parasitic diseases (leishmaniasis, malaria), HIV co-morbidities, streptococcal infections and dengue. The most notable achievement has been the development Of Rotavirus Vaccine called ROTAVAC®. It is the first indigenous rotavirus vaccine,

developed from an Indian strain-116E by an Indian company (BBIL), and tested by Indian investigators in an effort led by the Indian government and supported by several national and global partners with an affordable cost ($1 per dose). The vaccine has been commercialized and introduced in the EPI programme of India and also has been introduced in 9 states namely Odisha, Andhra Pradesh, Haryana, Himachal Pradesh, Assam, Tripura, Tamil Nadu, Madhya Pradesh and Rajasthan as a part of India's Universal immunization Program. The ROTAVAC® has been granted WHO prequalification in 2018.

DBT and NIAID-NIH has constituted the Candidate Vaccine Advisory Committee under the Indo-US VAP to advise on the best way forward for evaluation of vaccines developed in India and at the NIH. The third Meeting of the CVAC was held on 15-16thJanuary, 2019 under the aegis of the Indo-US VAP and 11 candidate vaccines have been reviewed by the Indo-US experts. Efforts will be made to take forward development of candidates for: Dengue – 3, TB – 2, Chikungunya – 1, RSV – 1, Influenza –2. Intensive R&D efforts will be made on these important candidate vaccines during next five years towards vaccine development. DBT is further supporting the clinical development of six candidate vaccines in India through public private partnerships under NBM and BIRAC. The session also included discussion on flavivirus epidemiology and surveillance.

Leads in Vaccine Development:

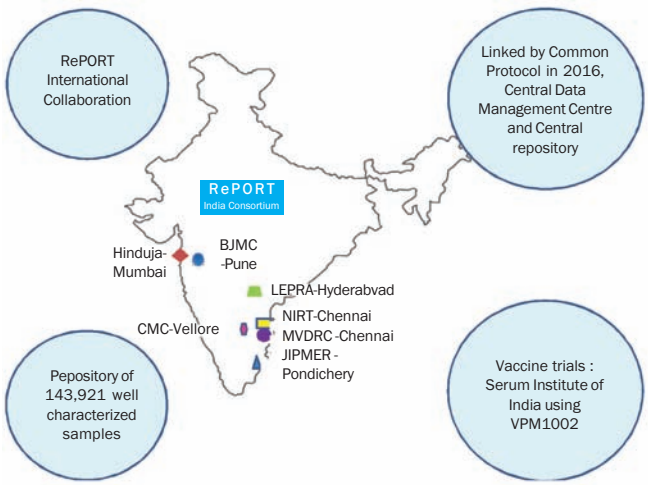
- Malaria Vaccine: Vaccine for *falciparum* malaria is under toxicology assessment (JAIVAC 2) and vaccine for vivax malaria has completed phase I trial (JAIVAC1).
- Dengue Vaccine: The International Centre for Genetic Engineering and Biotechnology (ICGEB) drug major Sun Pharma are partnering to use the recombinant EDIII- based sub-unit dengue vaccine candidate to develop an injectible vaccine that protects against all four dengue strains are endemic to India. The team is presently optimizing the production process and are expected to initiate clinical trial in the near future. Also a live attenuated Dengue Vaccine candidate licensed from NIH is being supported under the National Biopharma Mission.
- Development of Chikungunya, Influenza, and Cholera vaccine candidates are also being supported.

Further, with a mission to train the next generation of clinician-scientists and health professionals involved in clinical research, a one-week course on the "Principles and Practice of Clinical Research" was organized under the aegis of Indo-US Vaccine Action Program (VAP and the National Biopharma Mission of DBT- BIRAC at Hyderabad India from 16-21 April, 2018).

An international workshop on Chikungunya Vaccines-Challenges, Opportunities and Possibilities was organized on the 5th and 6th of February, 2018 jointly with the Coalition for Epidemic Preparedness Innovations (CEPI), and U.S. National Institutes of Health (NIH), National Institute of Allergy and Infectious Diseases (NIAID). The main aim of the workshop was to discuss the new research and developments in Chikungunya vaccine development. This is particularly important as Chikungunya poses a significant disease burden in the country. The workshop aimed to identify the key bottlenecks and challenges faced by vaccine developers and facilitate dialogues around solutions and opportunities for rapid development of a Chikungunya vaccine. The event was attended by national and international experts including vaccine developers, representatives of ministries of health from affected countries, academic researchers and funding organizations. Translational Health Science and Technology Institute (THSTI), an autonomous institution of DBT organized the above event in New Delhi.

Major Initiatives

Human Immunology Project Consortium (HIPC) Collaboration: The goal of this funding program is to promote India-US collaborative research on human immunophenotyping in the context of infectious disease and vaccine development, and in collaboration with investigators of the HIPC (Human Immunology Project Consortium). In response to the last Joint RFA, projects have been supported encompassing immunological studies focused on analysis of the follicular helper T cell repertoire in flavivirus infection and vaccination, trained immunity in HBV infected infants, Human B cell responses and receptor repertoire in dengue patients from India, Immune Signatures of BCG Vaccination at Birth and Revaccination in Young Adulthood and Systems Vaccinology of the Vi Conjugate Typhoid Vaccine in Infants.



Regional Prospective Observational Research for Tuberculosis - Report India Initiative

RePORT India is a bi-lateral multi-organizational collaborative effort designed to advance regional basic and clinical tuberculosis (TB) science in India. The goal of this program is to establish long term longitudinal cohorts of TB patients in India to strengthen TB research capacity and infrastructure, and foster research collaboration within India and with other countries.

The RePORT Consortium is comprised of research organizations in India with their U.S.-based partners and consists of seven distinct TB cohorts mainly in Southern India working in collaboration to address a wide array of scientific objectives and to institute a unified common prospective observational research protocol (Common Protocol) that is supported by a central Biorepository, a central data management centre. It aims at the utilization of harmonized data elements and specimen collection standard operating procedures (SOPs).

The Seventh Leadership Meeting of RePORT India Consortium was held on 15-17th Feb, 2018. The meeting was attended by representatives from the DBT, NIH, U.S. Embassy, and investigators, scientists, and other participants from India. The meeting covered a wide breadth of scientific, programmatic and operational topics. The face-to-face meetings and interactions were held with various stakeholders during the meeting that helped in (i) Approval of the policies and overall procedures of the Consortium (ii) Review and prioritization of study concepts (iii) Monitoring the performance of the CRUs (iv) Cross-study coordination of timelines, standardization of procedures, means for resource sharing, and other broad operational issues for effective implementation of the research agenda across all study sites.

The 8th Annual Joint Leadership Meeting of RePORT India was held on 4-6th February, 2019. The theme of the meeting was 'Biomarkers and Beyond'. India and US-based RePORT personnel also interacted on important agenda items ranging from follow-up site support visits and the NIH/NIAID/DAIDS RFA applications. New proposals have been received in response to this RFA and are being reviewed for funding.

Major Highlights of the Achievements in Projects Supported by RePORT India:

Cohort for TB Research with Indo-US Medical Partnership (CTRIUMPh) at National Institute of Research in Tuberculosis-Byramjee Jeejeebhoy Government Medical College-John Hopkins University:

- Established anti-TB drug concentrations in hair can be used as biomarkers. (Int J Tuberc Lung Dis., 20(6), 2016; PLoS One, 12(12), 2017).
- Demonstrated the high prevalence of latent TB infection (LTBI) in household contacts of pulmonary TB patients in high burden setting and compared the efficacy of QuantiFERON and TST tests in detecting LTBI. (PLoS One, 2018).

Bhagwan Mahavir Medical Research Centre aims to identify immunologic markers of persons at highest risk of progression of latent tuberculosis infection to tuberculosis.

- Technology Development: In-house assay for detection of IFN- g, which is cost effective and 96.7% specific and 95% sensitive as compared to the commercially available QGIT test. (BMC Infect. Dis., 2018)
- Biomarkers identified at baseline to pre-empt conversion to latent tuberculosis or progression to active disease: Stimulated IL-17 cytokine levels, IL-1á, Percentages of innate immune cells - monocytes, NK cells and memory like NK cells and T regulatory cells and Haematology& Endocrine hormones in HHCs aged 15-30 years. (J CLinImmunol, under review)
- Risk factor in contacts with latent infection: Alcoholism in young adults. (PLoSPathog., 2018).

Prof. M Vishwanathan Diabetes Research Centre and National Institute of Research in Tuberculosis aims to study the effect of diabetes on the severity of tuberculosis (EDOTS).

- Distinct and prolonged pattern of increased inflammatory cytokine protein expression in TB/DM: Inflammatory cytokines are the highest in TB/DM co-morbidity as compared to only TB or DM or healthy individuals. Systemic monocyte activation marker levels reflect baseline disease severity and extent in TB DM, differentiate KDM from NDM and are modulated by ATT and metformin therapy. (Immunology, 14, 2018)

Jawaharlal Institute of Postgraduate Medical Education & Research aims to identify the biomarkers for risk of tuberculosis and for tuberculosis treatment failure and relapse.

- Studied correlation between the already published transcriptional signatures to differentiate between active TB and LTBI on South Indian population cohort, established a large proportion of newer genes in the differentially expressed gene set during TB and LTBI. (Tuberculosis, 2018).

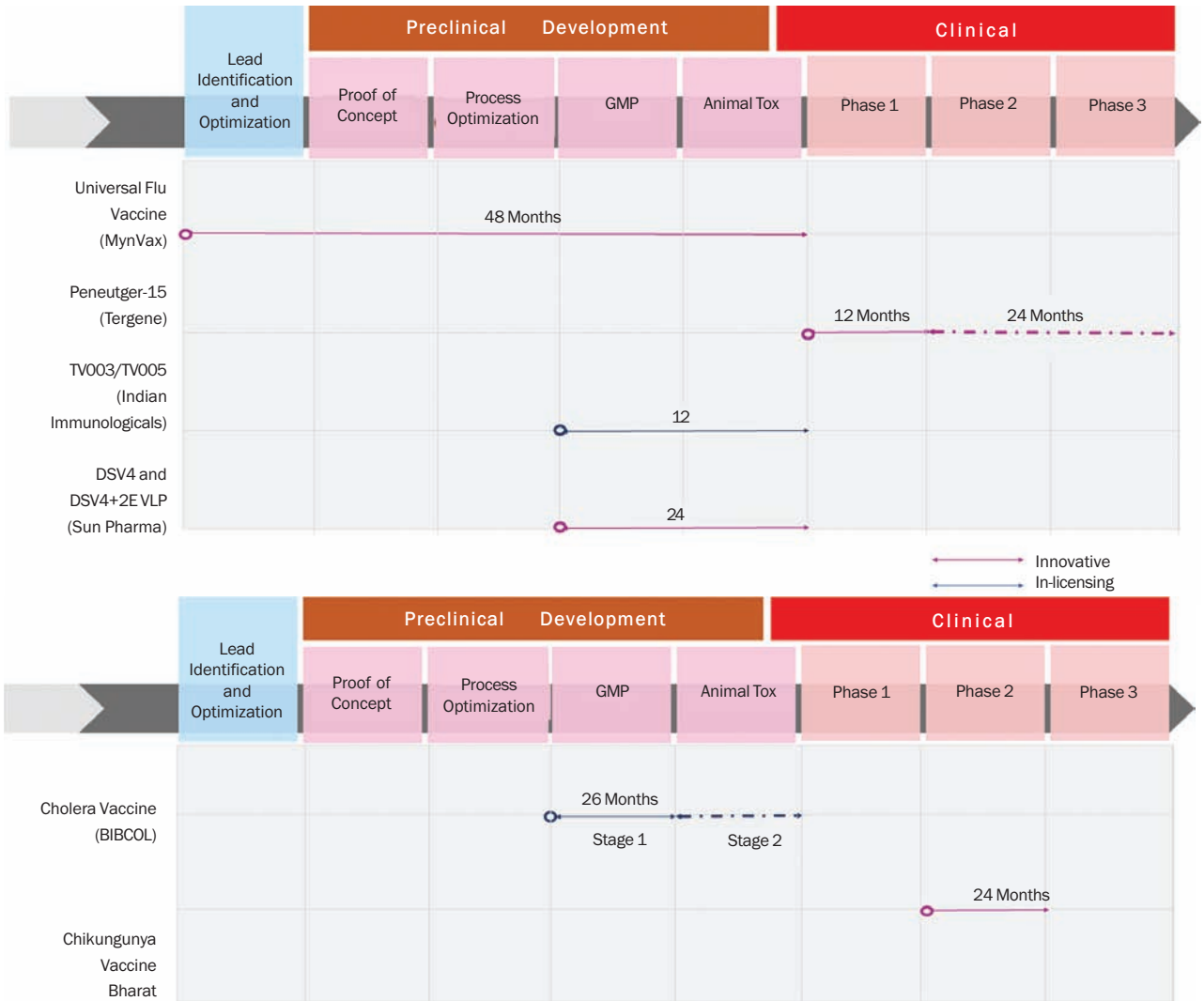
Christian Medical College aims to elucidate that host determinants in the eicosanoid pathway modulate the inflammatory response, disease outcome, and treatment responsiveness in TB.

- Successfully diagnosed extrapulmonary TB from pleural tissue using Xpert MTB/Rif: Xpert increases the sensitivity of the biopsy of results of thoracoscopic pleural tissues. (Respirology, 2018).

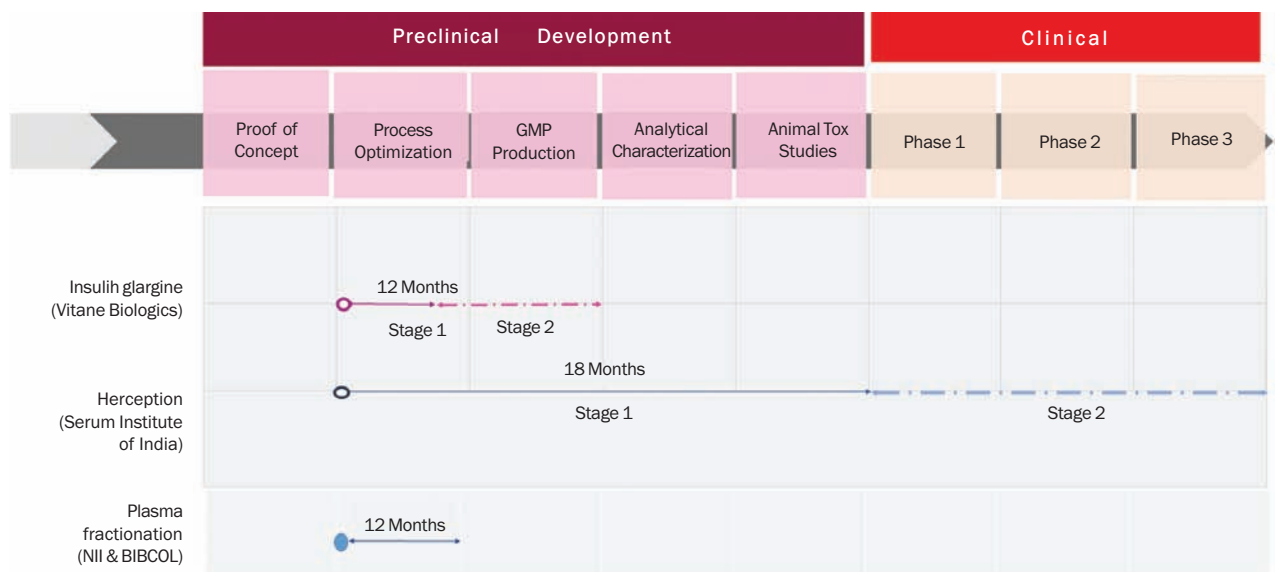
The Department jointly with ICMR and THSTI and NIH, USA organized the 5thmeeting of the Global Forum on TB Vaccines at New Delhi from February 20-23, 2018. The meeting aimed to bring together stakeholders from across the spectrum of TB vaccine R&D to share data, findings, concepts, and new approaches to R&D, and promote a global dialogue on the path forward for this critical research. The meeting was attended by a large number of eminent national and international researchers, product developers and policymakers including the officials and policymakers of Govt. of India and international forums such as NIH, and other international scientific organizations. The meeting was attended by more than 300 delegates having detailed deliberation on tuberculosis by sharing the latest research and data, identification and promoting innovative and transformative approaches to TB vaccine R&D by encouraging partnerships and collaboration to accelerate R&D in TB vaccine.

NATIONAL BIOPHARMA MISSION

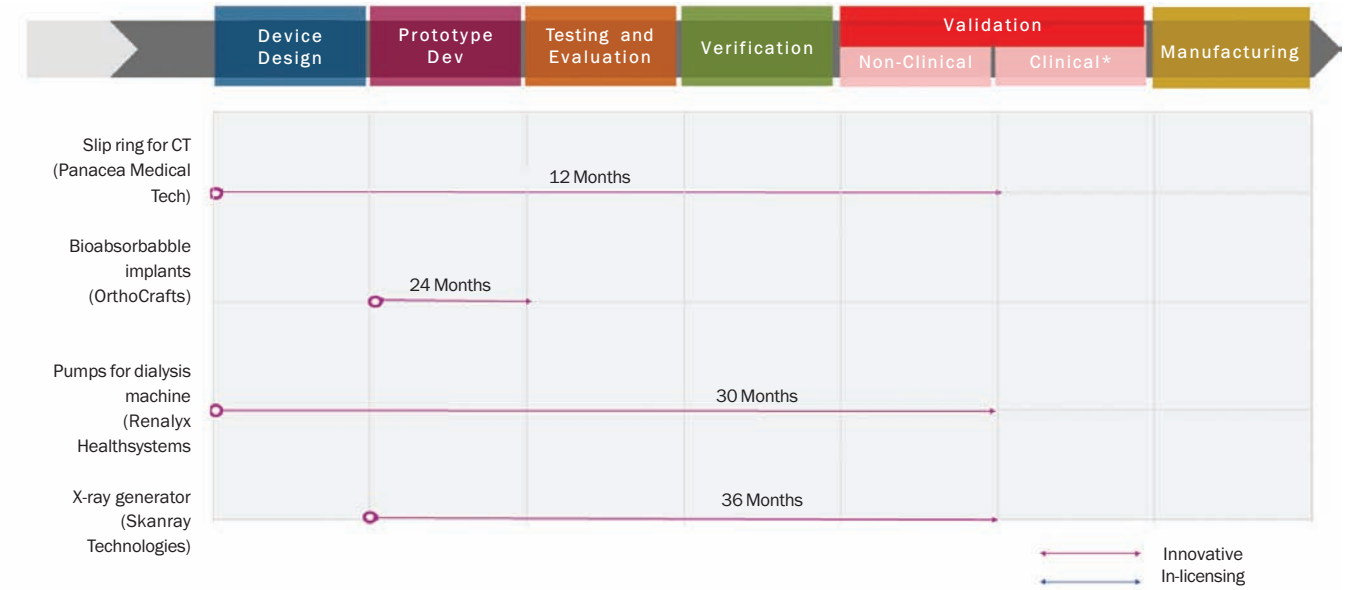
The National Biopharma Mission was formally launched by Hon'ble Minister for Science & Technology on 30th June, 2017 and the legal agreement with World Bank for flexible financing arrangements for this Mission of DBT was executed on April 24, 2018. The Mission aims to make India a hub for design and development of novel, affordable and effective biopharmaceutical products for combating public health concerns.It would strengthen translational capability of academic researchers; empower bio-entrepreneurs and SMEs by decreasing the cost and risk during early stages of product development and also elevate the innovation quotient of the industry. The global experience of World Bank would be instrumental in building sustained global linkages, technical assistance and knowledge flow between public private partners for business promotion in biotech sector.



Vaccine Candidates being supported under the Mission



Biotherapeutics supported under the Mission



Medical Devices and Diagnostics supported under the Mission

To initiate the Mission activities a dedicated Project Management Unit (PMU) at BIRAC has been established, there have been constitution of the Inter-Ministerial Steering Committee (SC) comprising of members from various Ministries; and the Program Technical Advisory Group (TAG) comprising of global and national leaders from industry and academia, to provide oversight to the National Biopharma Mission. First round of Request for Applications (RFAs) soliciting proposals from academia and industry focusing on development of (i) Vaccines for Pneumococcus, Dengue, HPV and candidates for other diseases of high burden in India (ii) Biosimilars for cancer, diabetics and rheumatoid arthritis and (iii) Medical devices and diagnostics (iv) Process Development Laboratory; Chemistry, Manufacturing, Control Units and cGLP validation facility for Bio therapeutics. Further to train the next generation of clinician-scientists and health professionals involved in clinical research, National Biopharma Mission organized a course on the "*Principles and Practice of Clinical Research*', in April at Hyderabad, jointly with NIH-USA under the aegis of Indo-US VAP of DBT.

Under the first published RFPs in November 124 proposals were received of which 17 proposals were finally recommended for receiving financial support

It is envisaged that this programme will help deliver 6-10 new products in the next five years, create several dedicated facilities for next-generation skills, and hundreds of jobs in the process.

MISSION PROGRAM "Ind-CEPI"

DBT is implementing a Mission Programme "Ind-CEPI" to strengthen development of vaccines for the diseases of epidemic potential in India. This Mission Programme aims to implement targeted support for rapid vaccine development and also build public health preparedness system for emerging infectious diseases in India. This will help in strategic engagement with the global Coalition for Epidemic Preparedness Innovations (CEPI) –an innovative global partnership between the public, private, philanthropic and civil society sectors undertaken with the aim to explore new ways of working to drive vaccine innovation to address public health in alignment with the WHO blueprint for R&D .The SFC approval for the IndCEPI Mission has been obtained in March 2019, for implementation by BIRAC.

MISSION PROGRAM ON SICKLE CELL ANEMIA

Under the Control Program for hematological disorders such as sickle cell anemia and thalassemia, an MoU has been signed with the Department of Health and Family Welfare, Govt. of Odisha. The program has been initiated in phased manner starting with Khorda, Sambalpur, Koraput (Aspirational district) and Balasore districts for starting the screening and testing of the risk population. These districts were selected based on their existing conditions which will

allow testing of the feasibility and effectiveness of the planned methods for the program. The first meeting of the Steering Committee was held on 30th January, 2018. Based on the recommendations of this Committee, a detailed project plan was developed.

GLUE GRANT SCHEME

Glue Grant scheme was initiated aiming to link Basic, Clinical and Public Health Research Departments in an inter-institutional linkage(s) leading to long-term partnership programs to bridge the gap between laboratory/field research and its application to clinical and policy outcomes with a potential for translational research and technological innovation and capacity building efforts. During the second phase, three projects have been implemented under thus scheme.

BIOREPOSITORIES, BIOBANKS – BUILDING THE ECOSYSTEM

Bio-repository for Pre-term birth : A Biorepository for the **GARBH-Ini** (interdisciplinary Group for Advanced Research on BirtHoutcomes - a DBT India Initiative) cohort has been established at THSTI. There are 294,684 serial ultrasound images of the fetus across pregnancy and the repository contains 600,150 of different types of biospecimens. This cohort and the biorepository will serve as a global resource to answer critical questions on preterm birth and other birth outcomes.

National Liver Disease Bio-bank : The National Liver Disease Biobank (NLDB) was established at ILBS, New Delhi to accelerate basic and translational research in the field of Hepatitis C (HCV), acute and chronic Liver and Biliary diseases, Gallbladder and various hepato-biliary tumors. NLDB will provide a launch pad for advanced research in the field of liver diseases in India with world class storage and advanced analytical infrastructure.

Bio-repository for Resistant Microbes/infective Agents: Under Mission AMR program, the Department has notified National Centre for Microbial Resource (NCMR), National Centre of Cell Sciences, Pune (an Autonomous Institute of DBT) 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.

Policy Center for Biomedical Research (PCBR):

The Policy Center for Biomedical Research was established at THSTI, Faridabad with the aim to bridge the gap between health researchers, those who implement and are impacted by that research by providing analysis on health technologies that could guide strategic planning to meet local health needs.

Following Initiatives have been taken during this period:

Partnership: The centre has facilitated partnership with INCLEN to identify the burden of influenza in pregnant women and with Accelerated Plan for the Elimination of the Lymphatic Filariasis (APELF) for creating enabling environment for LF elimination.

Validation of TB LAMP test: A network of sites is being created to validate the TB LAMP test at the CHC level in 5 states.

Point of Care Diagnostics: Requisite collaborations, validations and optimization of devices like LED lighting source for microscopy, ReaTBDx, TB LAMP tests and Surveillance of capabilities in doing diagnostic have been facilitated by PCBR.

Vaccines: Pertinent initiatives have been taken by PCBR for Oral Cholera vaccine, Rotavirus Vaccine, Pneumococcal Conjugate Vaccine, Influenza Vaccine, and Neglected Tropical Diseases.

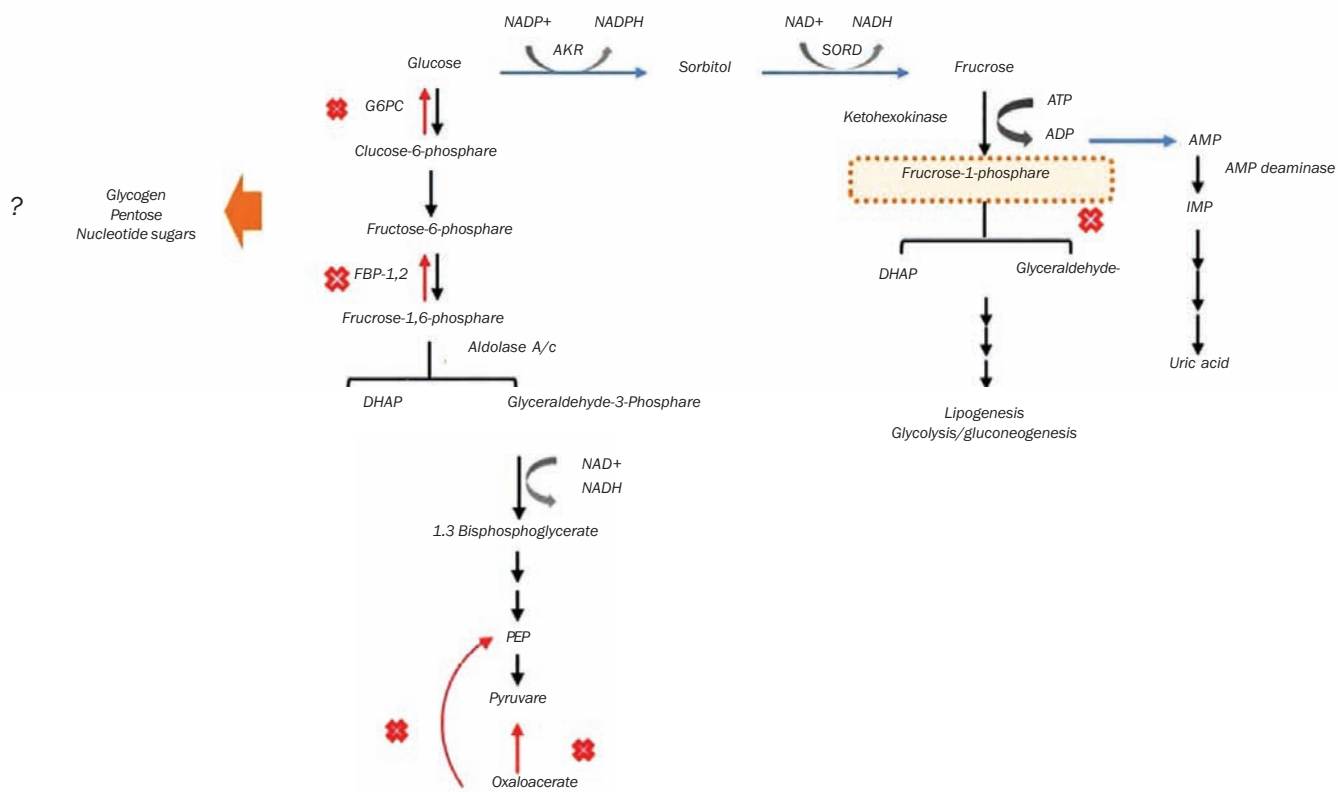
R&D Collaboration through International Partnership

Horizon 2020: India, EU join hands for Research Programme to Develop a Next Generation Influenza Vaccine. Union Government and European Union (EU) have collaborated for research programme named Horizon 2020 to develop Next Generation Influenza Vaccine to protect citizens across the globe. For this research programme, Department of Biotechnology (DBT) and EU have committed Euro 15 million (Rs. 240 crore). Horizon 2020 research aims at development of cost-effective and affordable univeral Influenza vaccine with reactivity against an increased breadth of Influenza strains. Rs. 240 crore funds have been earmarked for research and innovation actions under this

initiative. The vaccine development will be supported by EU-India consortia by bringing together multi-disciplinary stakeholders who represent any part of chain from lab to market. It will comprise of participants from or countries associated to EU programme Horizon 2020 and from India. Also, other countries are also free to join this initiative. The outcome of this project is expected to contribute to achievement of Sustainable Development Goal 3 (SDG-3) to ensure health and well-being for all. It will help international community to better prepare in the event of an Influenza pandemic. It will also give boost India's National Health Mission.

Indo-South Africa Collaborative Research Program on HIV, AIDS and TB: Recognizing the importance of collaborative & complimentary research to address regional needs, DBT in collaboration with DST, and Medical Research Council & Dept. of Science & Technology, Govt. of South Africa embarked on a collaborative Research Program on HIV, TB and TB/HIV. This collaborative program is under the framework of bilateral Science & Technology Cooperation agreement between the Department of Science & Technology, Ministry of Science & Technology, Governments of India and South Africa. Three joint proposals in TB, HIV, TB/HIV have been sanctioned under this collaborative effort.

Joint Centre for Cancer Biology & Therapeutics - NCBS, Bangalore and University of Cambridge, UK : The collaborative research has identified an upregulation of SLC2A5 (fructose transporter) and repression of enzyme Aldolase B - key in fructose metabolism which could be a possible factor driving clear cell renal cell carcinoma (ccRCC). Potential murine lung adenocarcinoma driver genes were also identified when datasets are compared with already published data.



Fructose-induced metabolic dysfunction, promote ccRCC progression

DBT-MRC "Joint Centre Partnerships in Health" - LVPEI, Hyderabad and University of Bradford, UK: The collaborative research effort has demonstrated that the multicomponent hydrogel formulations of besifloxacin and levofloxacin had superior corneal permeation with the potential for being used as topical ophthalmic preparations.

A drug eluting polymeric corneal contacts to deliver controlled release of combination of mixofloxacin and dexamethasone was also developed.

Indo-Dutch Collaboration: In a study implemented by AIIMS, New Delhi under Indo-Dutch collaboration (Erasmus Medical Centre, Rotterdam, The Netherlands), a cohort study of adults and elderly integrating brain MRI, the first-ever in India, has recruited 6840 persons from Vasant Kunj, Munirka, and Ballabgarh area of NCR for studying risk factors for stroke and cognitive decline.

Indo-Swedish Collaboration: IIT Kanpur and Lund University, Sweden have shown that the mineralization and sufficient new bone formation in osteoporotic hip defect occurs when nanohydroxyapatite based bone substitute supplemented with bone morphogenetic protein (BMP) and /or bisphosphonates, zoledronic acid (ZA+/-BMP) and MSCs derived exosomes for a period of 4 months.

Knowledge Generation, Discovery Research, New Tools And Technologies

Basic Research is a core strength in all disciplines of life-sciences to address various issues in Modern Biology. Integration of recombinant technology and process design, as well as *in-silico* modelling and process systems engineering for efficient Bio-processes development and manipulation of Bio-systems through metabolic engineering techniques is being attempted to provide novel enzymes, pathways and cells. Further, the department has emphasised on Bioinformatics, Computational Biology, Big Data, Nanobiotechnology and Genome Editing Technologies. These emerging and predicted future biotechnologies which are impacting on the life sciences speedily. These tools and technologies have far-reaching applications which impinge on every aspect of human existence. Highlights of scientific outcome during the year are as follows:

BASIC RESEARCH IN MODERN BIOLOGY

Key Achievements in Basic Research

- *Establishment of Large Scale Polymer particle laboratory at National Institute of Immunology (NII), New Delhi*
- *Identification of a new cellular role for D-amino acyl-tRNAdeacylase (DTD) in clearing glycine mischarged on tRNA(Ala)*
- *First report of SATB1 and SATB2 interaction and regulation of each other in reciprocal manner*
- *Identification of Vgl1 as an essential factor for heterochromatin integrity*
- *Three isoforms of Rab5 are regulated by three different transcription factors are demonstrated for the first time*
- *Distinction between polyadenylation in bacteria and eukaryotes is demonstrated*
- *Three plasmids are designed for overexpression of proteins*

Overall objectives of the programme is to provide sustained support to basic sciences encourage multi-disciplinarily research in biology, attract non-biologists to address biological questions, individual excellence complemented with mission and team-driven approaches to transform basic findings into applications, encourage emerging technologies such as synthetic and systems biology, nano-biotechnology, advanced proteomics, imaging, data-intensive discovery, bioinformatics etc. The programme covers an entire spectrum of the life science and the main focused areas includes: Cell & Molecular Biology, Biochemistry & Biophysics, Cancer biology, Microbiology, Cellular & Molecular Immunology, Structural & Chemical Biology, Vascular Biology.

Initiative has been taken towards the development of polymer based particles for vaccine development, to identify & develop strains for commercial production of Arginine/Lysine, understanding the 'glycine paradox', understanding neurogenesis, cell cycle, protein-drug interaction and fundamental biological processes. In addition, a call for proposal on 'Membrane Structural Biology' was invited.

Salient Achievements

During the year, more than 150 R&D projects were supported. R&D support to the basic biology research resulted into more than eighty research publications and two patents. The highlights of the major scientific and technological outcomes are as follows:

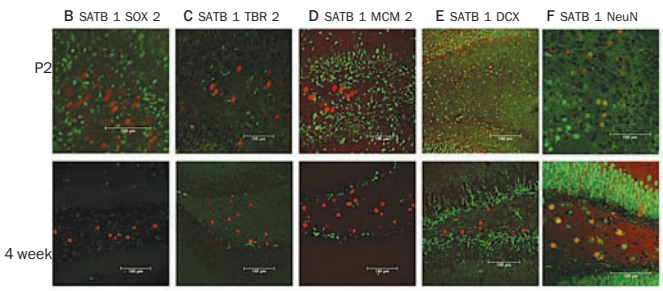
Large scale polymer particle formulation laboratory was established at NII, New Delhi for producing large batch of polymer particles entrapping small molecules and biologics. Particle formulation entrapping carbohydrates from *S. pneumoniae*serotypes is under progress to enhance the immunization capability of the carbohydrate and protein moieties of the *S. pneumoniae*.

The possibility of using strains with increased ArgO/LysO expression for commercial production of Arginine/Lysine has been explored at CDFD, Hyderabad. The design of genetic circuitry that will lead to a novel cost-effective process for increased yield of the commercially valuable amino acids Arginine and Lysine from bacterial cultures by fermentation is conceptualized. The possibility to further extend this work in industrial collaboration is being explored.

The study on the chirality based proofreading system has led to the identification of a new cellular role for D-amino acyl-tRNA deacylase (DTD) in clearing glycine mischarged on tRNA (Ala) thus establishing it as a critical factor in translation

quality control. This further led to the identification of tRNA based operational code by which the cellular pool of tRNA (Gly) escapes DTD surveillance in bacteria. In addition, a new proofreading factor calledAnimalia-specific tRNA-deacylase (ATD) was identified at CCMB, Hyderabad, which corrects a unique mistake in tRNA selection.

In a study at IISER, Pune,it was found that the chromatin modifiers SATB1 and SATB2 interact with each other. This is the first report about their interaction and reciprocal regulation. In addition, it was observed that during adult neurogenesis, differential transcript variant of SATB1 is important to commitment to interneuron.



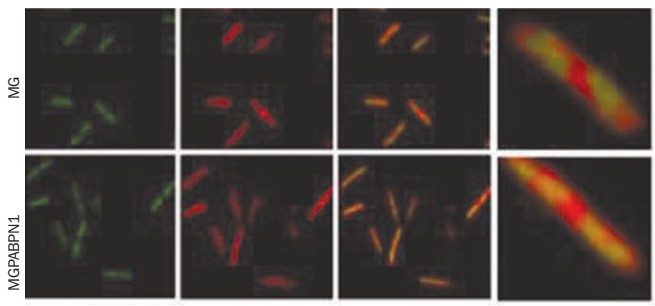
SATB expression in during various stages of neurogenesis. B) SOX2(green), progenitors C) Tbr2 (green), D) MCM2 (green), immature neurons E) DCX (green) and mature neuron F) NeuN(green). In the hilar region of both postnatal and adult brain SATB1 is expressed only by matured NeuN expressing cells (F). All images were captured and analysed using LASX software. Magnifications 40X.

Crystal structure of HtdX from *Mycobacterium tuberculosis* along with deletion/mutation and MD simulation studies at IIT Kharagpur, have under lined the regulatory role of á2-â2 loop in substrate binding which may serve as the basis for understanding the mode of protein substrate interaction thereby, paving way for the manipulation of the protein-drug interaction.

In a study, it has been demonstrated that the three isoforms of Rab5 are localized in the early endocytic compartment. However, the expressions of these three isoforms are regulated by three different transcription factors i.e. Rab5a expression is regulated by Sp1 whereas Rab5b expression is regulated by YY1 and Rab5c expression is regulated by JunB

of AP1 complex.

In a study at NIPER, Mohali, it was found that the stress-inducible aptamers reduced protein aggregation, concomitant oxidative stress and cytotoxicity in the cells expressing 103Q-htt. This finding can be applied to neurodegenerative diseases. In another programme at RGCB,Trivandrum, it has been demonstrated that the polyadenylation in bacteriaand eukaryotes is functionally and mechanistically distinct. By genome wide RNA-Seq approach, it has been shownthat overall mRNA stabilization on PABP expression similar to that of *pcnB* mutation. With the similar transgenesis approach, a new mechanism of stress response pathway and bacterial pathogenesis that is mediated through mRNA stabilization by poly(A) tailing in bacterial is identified.



PABP expression alters degradosome complex assembly in E.coli. The figure shows the prominent degradosome assembly in WT cells indicative of active mRNA degradasome imaged using PNPase antibody.

Proposals invited under a call for proposal 'Membrane Structural Biology' and 143 proposals received. After screening, 38 new proposals were evaluated by the experts in the next round and seven projects were recommended for support.

Occlusive vascular events like acute myocardial infarction and stroke are the leading causes of death in our country and platelets play the central role in the pathogenesis of clot formation. It has been observed that hypoxic platelets trapped within clot express HIF-2á regulated by prolyl hydroxylase and von Hippel Lindau protein. Further, platelets are stimulated by glutamate, which switches their energy metabolism to aerobic glycolysis. Based on these findings, the inhibition of aerobic glycolysis as well as glutamate signaling in platelets can be explored as novel anti thrombotic and anti platelet therapeutic strategies.

The mutagenesis of mouse Embryonic Stem cells to ablate CTCF (CCCTC binding factor) binding at desired sites (C6, C3 and C3C4) is established. Further, the 3C-qPCR analysis revealed the importance of CTCF not only in the large scale

organization but also in intricate configuration of chromatin that is necessary for appropriate cis-regulatory interactions like enhance-promoter and Recombinant signal sequencing (RSS) elements.

The mutation in TAF15 and loss of RNA binding have been implicated as potential cause of familial amyotrophic lateral sclerosis (FALS), these proteins can be used as target for therapeutic uses.

ELL and EAF proteins are involved in transcriptional elongation. Both ELL and EAF gene expression is involved in cell separation and telomeric silencing as observed. EAF also specifically affects antisense transcription.

Aging poses a risk factor for the development and progression of neurodegenerative diseases like Alzheimer's disease and Parkinson's disease (PD). The preliminary results in Drosophila w1118 flies suggests that chronic low dose exposure to the pesticide rotenone (a mitochondrial complex I inhibitor) results in upregulation of the NADase Sterile alpha and armadillo motif containing 1 (SARM1) protein.. It is also found that rotenone induced neurotoxicity in SHSY5Y cells is mediated by SARM.

BIOSYSTEMS AND BIOPROCESS ENGINEERING

Overall aim of this programme is to find innovative and efficient solutions for the development and improvement of sustainable bioprocesses of commercial interest, taking into account the environmental requirements and constraints involved in large scale production processes. The program is supporting interdisciplinary approaches towards analysis and synthesis of complex cellular systems based on the hierarchical structure and decomposability of biosystems. It also aims to integrate recombinant technology and process design, as well as *in-silico* modelling and process systems engineering for efficient bioprocesses development and manipulation of biosystems through metabolic engineering techniques to provide novel enzymes, pathways and cells. During the year major initiatives taken to support R&D projects on overexpression of proteins, identifying novel molecules from the bio-resources, importance of trace metals in nutrition supplementation and disease correlation.

Salient Achievements

During the year, more than 45 R&D projects have been supported. R&D support under this programme resulted into more than 15 research publications and one patent. The highlights of the major scientific and technological outcomes are as follows:

Major project was initiated for designing three plasmids, one for the cytoplasmic over-expression of proteins and other two plasmids for the over-expression of secreted proteinsat AIMS, Cochin.

Halophiles for Poly - 3-hydroxybutyrate (PHB) synthesis were isolated from western coastal region of India at Gulberga University, Karnataka. A total number of 26 isolates were initially screened for PHB, and compatible molecules of two strains were found having potential for PHB. After optimization, the yield of crude extract PHB of 20.2 g/l and purified PHB obtained was 3.5 g/l.

A study related to trace metal supplementation influenceon glycoformis carried out at NCL, Pune. Several trace metals were screened and results indicates that Zn2+ supplementation above 100 mM decreases galactosylation of IgG expressed in CHO cells. *In vitro* enzymatic assays and nutrient supplementation studies suggest this effect is due to decrease in galactosyl transferase activity and not due to metabolic limitation of UDP-Gal.

NANOBIOTECHNOLOGY

DBT has been engaged in advancing research and promoting innovation to address various issues related to health, energy, agriculture and environment through nanotechnology interventions. Major thrust areas include development of novel formulation of existing drugs to enhance their efficacy, smart nano-materials for tissue and cellular organelle specific delivery vehicles and tissue engineering, new therapeutics for important chronic and infectious diseases, sensors for detection of disease biomarkers. Emphasis has also been given to promote Regulatory Science research and help commercialization of Nano-enabled products.

DBT in association with Indian Society of Nanomedicine facilitated development of "Guidelines for Evaluation of Nano pharmaceuticals in India" by bringing in various related government stakeholder agencies such as DST, DBT, ICMR, FSSAI on a common platform. Once adopted at the national level by the Government (through DBT), these guidelines will help large number of researchers to design the experiments in compliance with regulatory requirements and help enhance

the translational values of the knowledge outcomes.

Emphasis was given to promote regulatory science research and help commercialization of Nano-enabled products. DBT is in the process of drafting the "Guidelines for Evaluation of Nano pharmaceuticals in India" by bringing in various related government stakeholder agencies such as DST, DBT, ICMR, FSSAI on a common platform. Once adopted at the national level by the Government (through DBT), these guidelines will help a large number of researchers to design the experiments in compliance with regulatory requirements and help enhance the translational values of the knowledge outcomes.

Essential concepts and hands -on modules in nanofabrication and characterization techniques for biologists and medical professionals was supported in IISC Bangalore to impart skill development in young researchers. The target beneficiaries include PG students, faculty members and medical professionals. The project also consists of a training program, combining theoretical lectures and hands-ontraining on nanofabrication and characterization tools. Training modules which will mimic an entire nanobio-research project, ranging from synthesis, characterization of a nano-system to therapeutics and sensing applications are also a part of the deliverables.

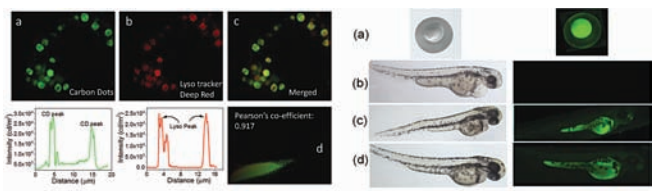
Salient Achievements

A new tannery solid waste management approach was developed by converting the limed fleshings into sound absorbing nanofibers. The nanofibers showed viability of around 95 % and were also found support adhesion and spreading of fibroblasts.

Novel Herbal Mosquito Repellent using Nanofibers with enhanced surface-to-volume ratio, high porosity was developed. The developed patch provided controlled release of essential oils for longer period of time for indoor and outdoor protection of day and night from mosquitoes. The technology was transferred to SJK Pharmacy, Rohtakon.

Researchers at CDFD, Hyderabad demonstrated that PPE18 protein of *Mycobacterium tuberculosis* controls the septic shock in septicemia mouse model. To develop therapeutic applications, PPE18 protein was nano-formulated with PLGA nanoparticles. These nano-formulations were shown to control the septicemiain both CLP induced sepsis and mouse model of *Escherichia coli*-induced septic peritonitis. This study is expected to have a great potential for anti-sepsis therapeutics.

CSIR-Central Salt & Marine Chemicals Research Institute, Bavnagar developed different nano-carriers with highly specific sub-cellular delivery system to specific organelles *viz.* lysosome, mitochondria and nucleus inside the cell. These nanocarriers were developed using polyurethane-based polymeric backbone which incorporates repetitive ester functionalities for enzymatic degradation.



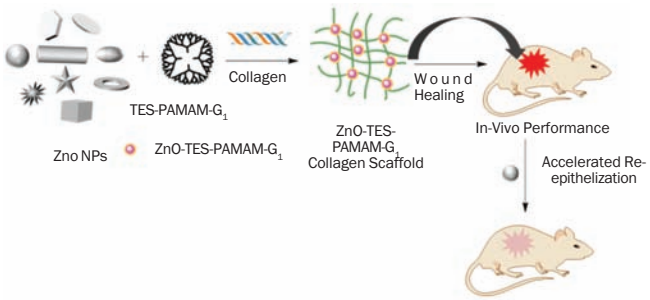
Co-localization experiments of intracellular localization of GQDs using Lyso Tracker probes in RAW cells

At IISc Bangalore, researchers have developed a high throughput microfluidic device with nano-scale liquid-air interfaces to investigate the mechanical response of erythrocytes under diabetic conditions. This study showed the cellular response with respect to changes in cellular physiology. This leads to change in their mechanical properties such as elasticity, viscosity, adhesion and poisson ratio. The researchers have used the cell stiffness as a biomarker for diabetes. The device is capable to measure erythrocyte deformability of a diabetic patient. The current study is helpful to understand the mechano-biology in diabetes and to develop a more generic diagnostic platform.

Retinoid therapy especially with All-trans Retinoic Acid (ATRA) therapy is not found to be effective in treating the solid cancers due to its poor bioavailability in cancer cells. The team at Karunya University, Coimbatore has developed smooth sphere shaped DOTAP liposome nano-formulations for delivery of ATRA in lung cancer cells with an entrapment efficiency of 92.53±1.42 %. This nano-formulation has also been shown to modulate the gene expression to induce apoptosis in lung cancer cells.

Collagen based scaffold is a promising class of materials for tissue engineering and wound healing applications. However, their limited physico-chemical (thermal and mechanical) properties restrict the potential application. The Scientists at Central Leather Research Institute, Chennai have developed ZnO nanoparticles complex with Triethoxysilane poly

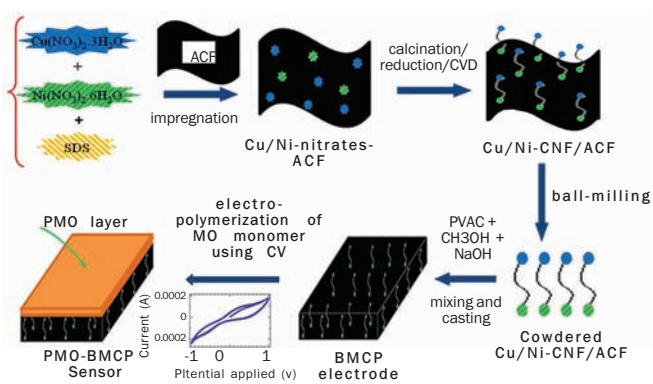
(amidoamine) generation 1dendrimers (TES-PAMAM-G1). The *in-vivo* wound healing study on Wistar Albino rats with this nano-complex showed accelerated re-epithelization in wound. This work provides a new approach for designing suitable functionalized nanostructure mediated collagen scaffold for tissue engineering and wound healing applications.



Schematic representation of in-vivo wound healing process with nanoparticle mediated collagen scaffold in Albino Rats

Mastitis in dairy animals cause heavy economic loss worldwide and also affect quality and quantity of milk production. Traditional antibiotic treatment showed low recovery rate. To improve the efficacy of antibiotic treatment of Mastitis, researchers at SKUAST, Jammu and Allahabad University have developed a solid lipid-chitosan composite nanoparticle to deliver ciprofloxacin and gentamicin with low dose.Targeted delivery of these antibiotics by composite nanoparticles at infection site maintain the antibiotic persistency for longer duration. This increases the efficacy and reduce the doses frequency and finally reduce the treatment time of Mastitis.

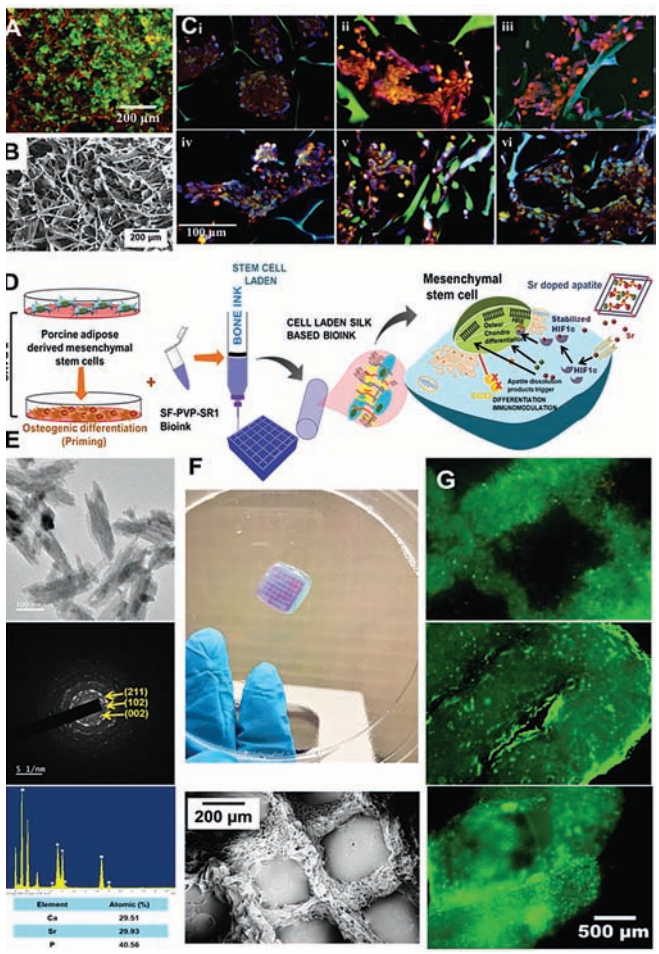
The researchers at IIT Kanpur developed a non-enzymatic electrochemical biosensor for detection of glucose, cholesterol and creatinine from human blood.



Preparation of bimetals-dispersed CNF/ACF, metal-carbon-polymer BMCP electrodeandelectropolymerization of the PMO recognition element.

Scientists at JNU, New Delhi have developed a nanoformulation of two anti-malarial compounds - Acriflavine and Artemisnin using FDA approved poly-caprolactone (PCL). They have shown that liposome and PCL encapsulated Acriflavine was able to hold the parasitemia two days post drug treatment.

IIT Guwahati has developed a micro-architecture of bone using silk-bioceramics based composites through conventional scaffolding and bio-fabrication. They have Nano functionalised silk fibbers with copper doped bioactive glass and used it as reinforcements to impart osteo-inductivity. The scaffolding matrices were derived from mulberry and endemic Indian non-mulberry silk fibroins. They have also developed silk-apatite based bio-inks which enables 3D bioprinting on osteogenically primed adipose derived mesenchymal stem cells. This study has great potential for bone grafts for treating variety of bone disorders.



Bioactive glass functionalized composite scaffold A) seeded with

osteogenic (bone like) mesenchymal stem cells and the microstructure as seen in B) scanning electron microscope, C) Proangiogenic potential in scaffold as seen by expression of von Willebrand factor (vWF) (stained green) and collagen-I (stained red); D) Scheme representing the overall work flow for developing 3D bioprinted stem cell laden bone grafts, E) Transmission electron microscopy images for synthesized biomimetic apatites, F) Silk based bioinks showing good print fidelity with gross morphology and microstructure as seen through electron microscope and enabling in printing stem cell laden constructs assessed by G) calcein-AM live cell (green) staining.

JNCASR, Bangalore in collaboration with NDRI, Karnal and NBAII, Bangalore have developed controlled release dispenser using the mesoporous silica and mesoporous carbon for semi-chemicals enables the stable release of the pheromone loaded into it. In the present invention the dispenser has lower load of semio-chemicals than commercial lures, thus cost-effective, while equally effective in terms of efficacy.

Translational Research Advancement Committee (TRAC) reviewed the research outcome of various R&D projects supported under Nanobiotechnology programme. TRAC identified the research leads with translational value for product development:

Nanotheranostics

- *Development of iron oxide based nanotheranostics for cancer diagnosis & therapy*
- *Preclinical evaluation of Gold-NP coated PLGA/PNVCL based cancer therapy*

Novel Formulations/Drug Delivery

- *Controlled release in-situ gelling Smedds as single shot therapy of malaria*
- *Controlled release dispensers for delivery of semiochemicals*
- *Self-fluorescent cell permeable glucose derived carbon nanosphere as a brain targeting vehicle*
- *Development of novel nanoparticle based hepatitis-B vaccine with enhanced antigen presentation and prolonged immunity*

Nanodiagnostics

- *Direct detection of enteric fever in blood by evanescent-wave optical illumination*
- *Development of indocyanine-green loaded cytokeratin targeted calcium phosphate nanoparticulate system for sentinel lymph node mapping in Head & Neck Cancer*
- *Fabrication of nano-enabled diagnostic kit and its validations for detection of apple scab*

Nanotherapeutics

- *Phospholipid based nanomaterials as novel therapeutics for cancer*
- *Nanocrystalline solid dispersions of polyphenols (Curcumin and Hesperetin) with enhanced oral bioavailability for cancer treatment*
- *Treatment of infectious wounds using antimicrobial nanocomposite chitosan bandages*
- *Developing and validating a single protocol based zebrafish model for preclinical safety assessment of nano-therapeuticsDevelopment of cost effective nanoparticle based drug delivery system of amphotericin B for treatment of visceral leishmaniasis*

The Centre of Excellence in Nano-biotechnology at Aligarh Muslim University, Aligarh is focused on mass production of chemically and physically difficult to synthesize nano-particles using bottom-up approach like biosynthesis and top-down approach like biomilling. Evaluation of the target sites, uptake and location of nano-particles inside the cells with reference to anti bacterial/fungal/algal property of some of the formulations will be done. Conjugation of the nano-particles with drug molecules (anti-diabetic and anti-malarial) will be taken up.

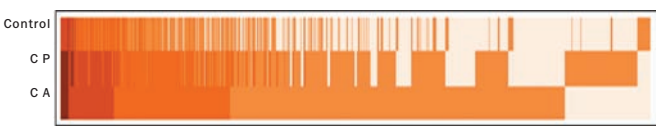
GENOME EDITING TECHNOLOGIES AND THEIR APPLICATIONS

Genome editing techniques can be exploited to engineer genome by insertions, deletions, modifications or replacements of DNA segments in a site specific location in the genome of a living organism leading to development of genetically engineered organisms for biomedical and agricultural applications. RNAi, Transcription Activator-Like Effector-Based Nucleases (TALEN), and the Clustered Regularly Interspaced short palindromic repeats (CRISPR/Cas9) system are the most widely used approaches in

genome editing. Recognizing the power of such technologies to study and manipulate the genome, DBT has been engaged in promoting research and innovation in the area of genome engineering technology and their applications. More than 40 New R&D projects have been initiated. Some of important projects are development of haploid inducer line, and enhancement of seed-meal quality in *Brassica juncea* through CRISPR/Cas mediated genome editing, CRISPR-based editing of regulatory region & expanded triplet repeats as therapeutic approach in india's most common hereditary ataxias, Genome editing for generating semen favoring production of cow, Establishment of an efficient platform for precise genome editing in rice etc.

Salient Achievements

Scientists at AIIMS, New Delhi have identified MicroRNAs as biomarkers in chronic pancreatitis patients with high risk for developing pancreatic cancer. The 10 most differentially regulated miRNA's expression profiles were seen in plasma samples of the patients. Known microRNAs expressed in CP and pancreatic cancer samples, targeted the genes involved in transcription, signal transduction and metabolic process.



Heat map representing of differentially expressed 902 known miRNAs across CP, PDAC and healthy control

Defective phospholipid signalinghas been implicated in several disorders, including developmental defects, cancers, diabetes and neurological diseases. The research team at NCBS, Bangaloreis developing genetic tools to understand the specific roles of different molecular players involved in phosphoinositide signaling using CRISPR in *Drosophila melanogaster*. The designed and cloned gRNA sequences would be tested for efficacy and used for generation of a germ line knockout of each selected gene.

Scientists at CCMB, Hyderabadare working on the functional analysis of Casein Locus in mouse through genome editing using CRISPRs and its role in regulation of lactation. Potential target sequences flanking the regions of evolutionarily conserved region (ECR) and entire casein locus were selected and synthesized in CRISPR/Cas9 plasmid using oligo annealing and ligation method. ECR knockout mouse has been generated successfully. This knockout mouse willprovide understanding of the use of the metabolic space for expression of pharmaceutically important gene(s) in place of casein.

To understand the clathrin dependent endocytosis, scientist at NCCS, Punehave successfully dissected the individual roles of Clta and Cltb in early mammalian development through selective CRISPR-Cas9-based knockout and knockin models. Knockout mouse embryonic stem cells for individual Clta and Cltb genes were successfully generated through CRISPR/Cas9 method. An embryonic stem cell line and mouse line harboring a truncated form of Cltb which resulted in the generation of a truncated form of the protein containing only the first 84 amino acids of the protein was also generated. They have also put together the donor for generating anmCherryknockin form of Cltb. Generation of these knock out and knock in models will help understand the process of endocytosis in multiple scenario. These models can be further modified for specific disease conditions or to explore potential therapeutic avenues.

An indigenous cultivar *Bhutjolokia,* one of the hottest chillies is vulnerable to Potato Virus Y (PVY). Research team atAssam Agricultural University, Guwahati are involved in engineering PVY resistance in *Bhutjolokia*by disrupting the function of the recessive eIF4E (eukaryotic translation initiation factor 4E) and eIF(iso)4E gene using CRISPR-Cas9. Studies would lead to generation of virus resistant lines which will immensely benefit farmers of the region.

Scientists at NIPGR, New Delhi are developing protocol on biofortification of branched chain amino acid–Leucine in Brassica crops using CRISPR-Cas9 mediated genome editing with aim to precisely target the regulatory region of *Brassica* isopropylmalate synthase proteins in order to desensitize the negative feedback inhibition of leucine without affecting their catalytic efficiency towards leucine biosynthesis. This transgene free *B. juncea* lines with enhanced leucine content will improve the nutritional quality of the crop.

Scientists at Punjab Agricultural University, Ludhiana are engaged in RNAi mediated gene silencing for identification of novel and potential targets in whitefly, *Bemisiatabaci*for its management. They have developed a construct which can produce dsRNA against target gene as well as improve the knockdown efficiency by down regulation of gut dsRNAses

in whitefly.

In a project at IISc, **Genome-wide RNAi Screens** have been developed, which have been shared with many researchers across country for study on understanding of Proteostasis, Cellular senescence and Chemoresistance.

GETin Fellowships: Indo-U.S. Genome Engineering/Editing Technologies Initiative (GETin) Overseas Fellowship has been started. The objective of program is to provide 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 provide support to 5 individuals in each category. Two batches of fellowships have been supported so far.

BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

Bioinformatics is the interface of different disciplines of biosciences.The institutionalization of bioinformatics research took place with the establishment of Biotechnology Information Systems Network (BTISNet) Centres, categorized into Centres of Excellence (CoEs), Distributed Information Centres (DICs), Distributed Information Sub-Centres (DISCs) and Bioinformatics Infrastructure Facilities for Biology Teaching through Bioinformatics (BIF-BTBI), in the research institutions of repute in various parts of the country. BTISNet grew as a concrete association and bioinformatics now developed as full-fledged research subject.Though, the efforts of DBT, more than one hundred fifty BTISNet Centres are functional in various disciplines like Structural Bioinformatics, Drug Design & Molecular Modelling, Metagenomics/High Throughput Genomics & Sequence Analysis, Medical Informatics, Animal Bioinformatics, Plant Bioinformatics, Agricultural Data Mining and Informatics, Biodiversity, Machine Learning and Bioinformatics Trainings. Various Investigators driven R&D projects have also been funded on different research questions, apart from BTISNet centres' activities.

State wise distribution of BTISNet Centres

Directional revamping of BTISNet: During the year, a brain-storm meeting of the eminent bioinformaticians and the coordinators of BTISNet Centers was held to discuss and deliberate the bioinformatics expertise in the country and what needs to be done to be globally competitive. The major recommendation was on the need to revamp BTISNet Centers keeping in view the speedy revolution in data sciences and its applicability in others sectors. It was emphasised that all BTISNet centres should be connected to each other and also scientists from other institutions should collaborate, to formulate National Network Projects on different areas to be identified by DBT. Emphasis was also given on establishment of National/Indian Biological Data Centre that should mirror the International Database in India and establishment of Virtual Bioinformatics Institute to manage Data Centre and National Network Projects and other activities. The department is proactively working on these two major recommendations.

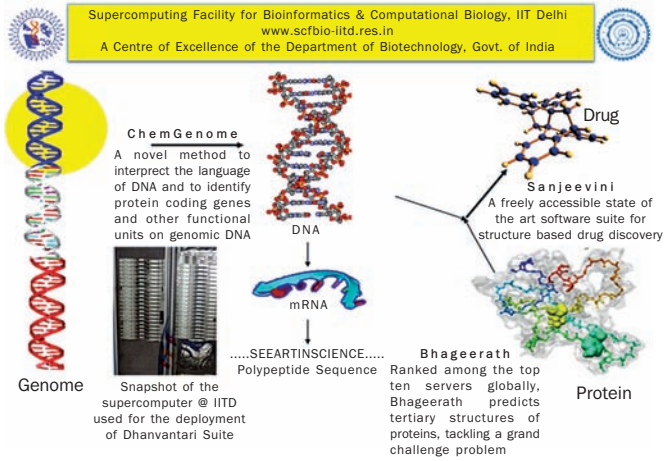
MANAV-Human Atlas: Recent times have witnessed an explosion in the amount of biological data generated. There are millions of research articles with pivotal information on

human health and disease, spanning from single molecule resolution to the level of the whole organism. However, this information is scattered in different databases, repositories and in the text of journal articles. The department has launched "Manav-Human Atlas" project to construct a comprehensive map of the entire human body which will explicitly document macro to micro level information. It is envisaged, that Manav will dramatically accelerate the understanding of the working of the human body and help design better therapeutic targets for treating diseases like cancer, diabetes and more.

International Partnership: *DAILAB to DAICENTER:* During the year, the steps taken towards up-gradation of DAILAB (DBT-AIST International Laboratory for Advanced Biomedicine) to DAICENTER (DBT-AIST International Center for Translational and Environmental Research) have strengthened the Indo-Japan research alliance. Collaboration got a major boost with the signing of a MoU between DBT and AIST on September, 2017, envisaging the expansion of DAILAB into a major collaborative research center called DAICENTER that will enhance the level of joint research, training and networking programs that had been underway through DAILAB and its SISTERS for the past four years. DAICENTER would focus to connect academia to industry and network innovation to entrepreneurship promoting science and technology relationships involving the DAILABs.

Salient Achievements

The Supercomputing Facility at IIT, New Delhi is engaged in creating a small drug molecule that can bind with high affinity and specificity to the Protein/DNA target but with least toxicity to humans with *Sanjeevini* software suite. The centre is determining the three dimensional structures of the protein targets through in-house approach *Bhageerath*. The centre is working in an endeavour to perfect the Genome to Drug (*Dhanvantari*) pipe-line to deliver reliable lead molecules to enable drug development.



"Genome to Drug" (Dhanvantari) pathway envisages delivering Novel drug molecules/Personalized medicine to society from genomic / proteomic information

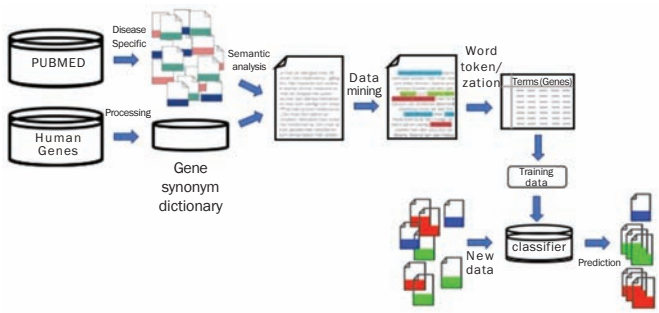
NII, New Delhi is developing novel data driven computational methods which will allow researchers to address practical questions by integrating information on three dimensional structures of proteins/DNA/RNA with genome sequences and other types of experimental data. The specific objectives are identification of novel secondary metabolites by genome mining, development of structure based approach for prediction of protein interaction networks, prediction of disease associated mutations in coding/non-coding regions of genomes and *in silico* drug discovery for infectious diseases.

The centre at Bose Institute, Kolkata has developed state-of-the-art computational facilities and established Data Mining and Text Mining Lab for NGS data analysis, isolation of phytocompounds from nutraceuticals to combat neurodegenerative diseases, etc. The centre has developed major bioinformaticsoftwares& databases like NAGGNER, Pronormz, Homokinase, MyCoTBbase etc.

MGIMS, Wardha is exploring Genome/Proteome analysis of Mycobacterium tuberculosis and Human Papillomavirus Virus strains. They have collaborated with ACTREC, Mumbai to study the pathogenicity of mutations in breast cancer associated BRCA1/BRCA2 genes and also set up MTB Culture lab to test different phytochemicals against MTB so as to propose a safe drug against tuberculosis.

IIT Kharagpur is working on miRNA analysis in *Cajanuscajan*, structural analysis of intrinsically unstructured protein, macromolecular assembly in ribosome, cDNA-micro array analysis of Entamoeba genome. Protein-RNA interactions, metagenomics, immunoinformatics are the major areas of research. Two web servers named "HotSPring" and "Layers" have been developed.

Text mining is a flexible technology that has been addressed in number of articles, especially in context of "Big Data". The scientists at Amity University, Manesar are working on setting up pipeline and algorithm to predict disease gene associations. The pipeline developed has integration of text mining, machine learning algorithm and sentiment analysis to predict class of previously reported and new disease associations from the published literature.



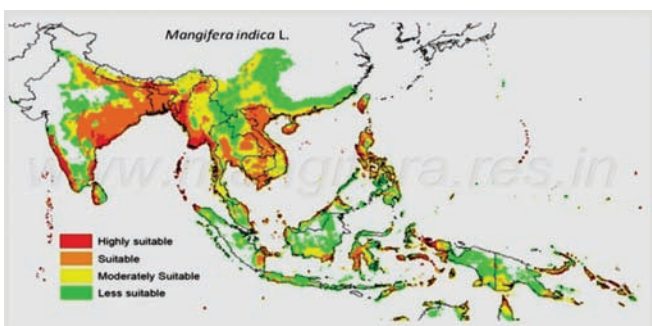
Workflow of the proposed protocol to indentify disease gene association using PuBMed data

While working on the project towards Building Integrated Pipeline for Cancer Genome Analysis, Jaypee Institute of Information Technology, Noida, have built a novel tool to screen cancer related genes from the millions of Pubmed records using text mining, machine learning and deep curation. The institute has initiated Personal Genome Project India in collaboration with Harvard Medical School to sequence genomes of Indians to build a valuable repository of open access personal genomes to advance medical sciences and cancer research in India.

PAU, Ludhiana is involved in network projects on NGS for whole genome assembly, transcriptome assembly, GBS data analysis for wheat, rice, maize, guava, bitter gourd and Xanthmonas. The centre has developed the reference genome of *Vigna mungo* and*Vigna radiate,* as well as reference transcriptome for Guava and Mango.

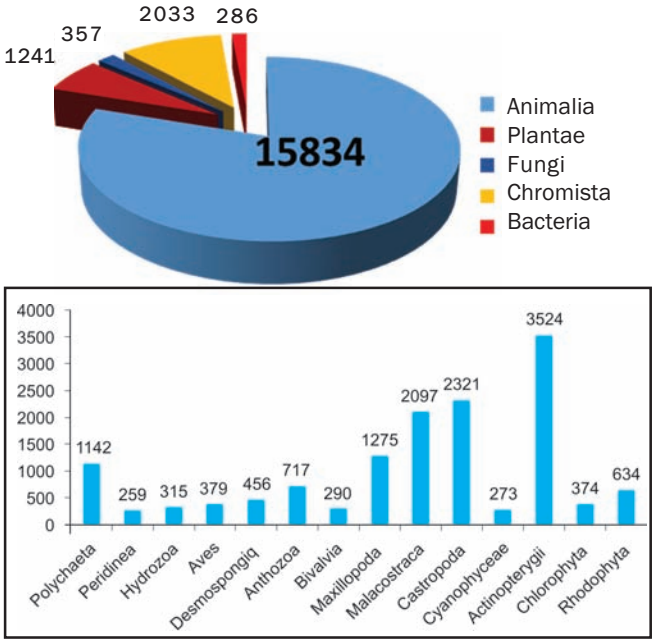
Some Sub-DICs viz NIPGR, New Delhi, IISR, Calicut and IARI, New Delhi along with BIFs at Guru Jambeswar University of Science & Technology and University of Calicut, Calicut are working in the area of agricultural data mining and informatics. Major initiatives taken are assembly, annotation and mining of whole genome and transcriptome data of spices; *in silico* screening of spice compounds and their bioprospecting; comparative genomics of agriculturally important microbes and plant pathogens; development of bioinformatics support tool box for genomics /transcriptomics and reconstruction of gene networks.

"National Database on Mango" project is being undertaken at Central Institute for subtropical Horticulture, Lucknow, in collaboration with other nine centres. *Mangifera* species suitability map of 38 species has been generated for South East Asia. 4500 mango accessions from sixty six field gene bank of *Mangifera indica* has been updated in the database. Characterization of 500 mango varieties and the details of 414 custodian farmers along with their varieties from different districts have been updated in the database.Mango phenology monitoring system is developed which can depict phenophases as per BBCH scale.



Mangifera species suitability map for South East Asia

NIO, Goa has developed comprehensive Indian coastal marine biodiversity database"*bioSearch*" representing 19760 organisms of marine flora and fauna highlighting hotspots of Indian coasts for Seaweed, Fungi, Birds, Sponges, Microbes, Mammals& Corals. The centre has digitized museum specimens, developed marine biodiversity catalogues, and facilitated marine biodiversity mapping and biogeographic studies.



The north-eastern part of the country is one of the bio-diversity 'hotspots'. NEHU, Shillong is engaged in database development and research on parasite genomics, next generation sequencing and analysis of selected trematodes, orchids, evolutionary bioinformatics and phylogenomics.

Immersion cooling technology is a new paradigm to solve the challenges of power, space and compute requirements in the age of big data storage and analysis. A state-of-the-art Green Data Centre with a machine based on Liquid Immersion Cooling system was inaugurated by the Secretary, DBT and Director, IIT Delhi at its Supercomputing Facility. The entire machine, which occupies a space of approximately 1m3and hosts 50 teraflops, is completely immersed inside a liquid bath.

Research at IIT, Delhi has resulted into a generation of the comprehensive information on protein targets for organic compounds in Tulsi, Turmeric and Neem based on robust tools, that is freely available to the scientific community utilizing a web portal hosted through SCFBio's website.

Centres of Excellence (CoE) in Bioinformatics

Super Computing Facility at Indian Institute of Technology (IIT), Delhi and four BTISnet Centres namely Bose Institute,

The research activities under the CoE at Bose Institute, Kolkata could be compartmentalized into the areas viz Structural Bioinformatics, Evolutionary Bioinformatics, Genomics, Proteomics, Stem Cell Bioinformatics, Regulatory RNomics and Oncogenomics, Functional Interactomics and Pulmonary Bioinformatics. The goal of the center is to deliver outputs which can be applied for healthcare. The initiatives taken up are systematic identification of potential biomarkers for asthma patient, novel treatment approaches to stop the allergic march towards asthma, genomics based diagnostic tools for predicting cancer susceptibility and design of inhibitor ligands for drug targets which would lead to drugs for tests and applications on human.

The CoE at Jawaharlal Nehru University, New Delhi is currently structured and focused on the core area of Computational and Systems Biology and gradually emphasis is being laid on Complex Systems, Massive Modelling, Simulation and analysis. The centre runs academic programmes like MSc-PhD degrees in computational and integrative sciences. The centre at Indian Institute of Science, Bangalore has been focusing its research activities in genome analysis, development of novel algorithms in bioinformatics, internet computing, integrated database development, structural analysis of biological macromolecules, structural pharmacology, including in-silico drug discovery, computational immunology and modelling and dynamics of protein-ligand interactions, protein folding by graph theoretical methods. The centre is successfully providing continuous, up-to-date information and access to software and databases, which is freely available to the scientific community worldwide. The computing servers developed by the faculty enable sophisticated analysis, manipulation and visualization of bio-molecular sequences and structures.

The main areas of research for the CoE at Savitribai Phule Pune University, Pune include Viral Bioinformatics, Structural Bioinformatics, Molecular Modeling and Simulations, Genomics, Transcriptomics and Proteomics. The research projects encompass important aspects of life sciences such as viral, parasitic and infectious diseases, structure-function studies of drug targets and development of inhibitors as potential drug candidates, agricultural and horticultural sciences etc. The centre is also a pioneer institute for long term and short term trainings and conducts high quality educational programs, viz. M.Sc. and Ph.D. in Bioinformatics. The department is implementing the scheme Bioinformatics

National Certification (BINC) since 2005 to identify and certify bioinformatics professionals to improve their job placement opportunities. Six Universities are running PG courses in Bioinformatics. The department has now decided to merge BINC with DBT-JRF and also the PG programs in Bioinformatics will be dealt along with other M.Sc./M.Tech. programs of DBT w.e.f. 2019. Apart from BINC and PG courses, during the year, the BTISNet centres of this department have organized more than 70 workshops/ training during the year and trained approximately 3000 manpower. So far 850 research papers and 23 patents were finalized. The department has now planned to revamp the BTISNet with fresh mandate along with centres' participation in National Network Projects. Setting up of Data Centre is identified as the topmost need of the nation. In this direction, the department will interact with NCBI and EBI, the major institutes in the world to finalize the road map.

DeLCON (DBT's e-library Consortium)

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 are 33 Institution, comprising of DBT Institutions and some institutions and 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.

ARTIFICIAL INTELLIGENCE

Recent advances in Artificial Intelligence have the potential to accelerate the access, affordability and quality of healthcare within the country. DBT has initiated a new Mission Program on "Artificial Intelligence application for Affordable and Accessible Healthcare- Big Data and Genomics". During the year, the related stakeholders met to collectively define the roadmap for DBT to undertake activities in AI and Big Data. Major projects like Genome India: Cataloguing the genetic variation in Indians, Earth Bio-genome on sequencing, analyzing, annotating and interpreting 1000 medicinal plants in India and some pilot studies for taking prototypes for diagnosis such as early screening and diagnosis of diabetic retinopathy, screening of breast cancer and cardiovascular diagnosis are being discussed.

A comprehensive data sharing policy including guidelines for data standards, format, tools and accessibility etc. is also being drafted by bringing together the valuable inputs from the academic and industry experts in the field of AI.

04

BUILDING A VIBRANT ECOSYSTEM : CONNECTING UNIVERSITY RESEARCH AND INDUSTRY

Research Resources, Service Facilities and Platforms (RRSFP)

The RRSFP program is to promote, upgrade and for establishment of new biotech facilities/infrastructure viz. animal house; gene banks; repositories for microbes, plants, model organisms and infectious organisms; towards augmentation of research activities of scientific community at regional, national and international level. Furthermore, it is aimed to promote growth of life science and biotechnology in the university system and linking research to education at every opportunity through creation/reengineering/ remodeling/up-gradation of life science departments in central/state universities.

Department of Biotechnology has established and created research related infrastructural facilities in several universities/Institutions across the country. Some of them are: Flow cytometry and imaging facility at ILS, Bhubaneswar; JNU-DBT National training and skill development facility for state-of-the-art equipment used in industry and academics, maintenance and operation of the biosafety facility (level 3) for tuberculosis research in UDSC, Delhi, Life Science Research, Education and Training in JNCSAR, Bangalore and Advanced Research Platform for Crop Sciences, New Delhi.

SAHAJ

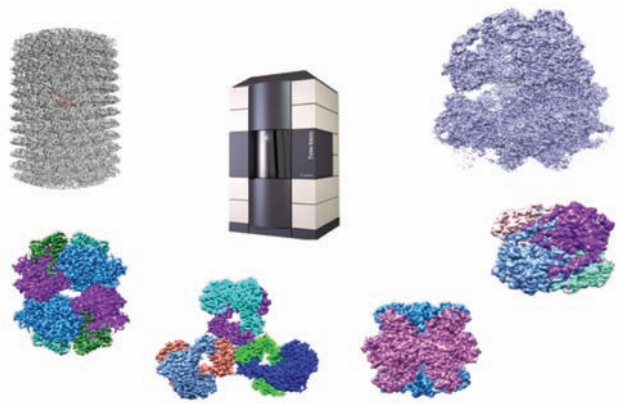
The Department of Biotechnology has launched its research resources and facilities supported across the country, through a portal 'Scientific Infrastructure Access for Harnessing Academia University Research Joint Collaboration, (SAHAJ)'. Each Autonomous Institute and DBT supported Infrastructure programmes will provide and share its equipment and infrastructure to Research Institutes, Universities, Colleges and Start -ups /Entrepreneurs. Their website will carry infrastructure facility usage forms with well defined usage charges, and terms and conditions. Around 15 institutes have been hooked on to this portal for providing a link to their resources and facilities. In order to facilitate students /researchers who do not have any central government funding/ fellowship or research grant, a special Infrastructure Access Grant, capped at Rs 10 lakhs / Year will be provided (on competitive basis) to the host institute to allow these students/researchers to access the infrastructure . The Director of the Institute hosting the facility shall be responsible for review of such applications and the decision reached will be conveyed in a time bound manner not exceeding 4 weeks.

BIOTECH FACILITIES

The mandate of the program is to promote, upgrade and establish new biotech facilities/infrastructure viz. animal house, gene banks, repositories for microbes, plants, model organisms and infectious organisms; towards augmentation of research activities of scientific community at regional, national and international level. Further, the program is designed to promote growth of Life Science and Biotechnology in the university system and linking research to education at every opportunity through creation/re-engineering/re-modeling/up-gradation of life science departments in central/state universities. The outcome of the research activities supported for strengthening the research infrastructure in Universities and Institutions are detailed below:

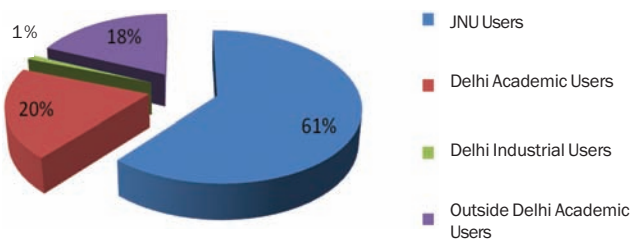
"Flow Cytometry and Imaging Facility" at ILS Bhubaneswar has been supported for Sorting Flow Cytometer, Confocal Microscopy and HTS imager, essentially required in the institute for advanced scientific research and drug discovery program. Sorting Flow Cytometer and Confocal Microscopy are the basic needs of modern molecular and cell biology labs to carry out cutting-edge research at par with international standards. HTS imager is needed for screening and identifying novel natural and chemical compounds for therapeutic targeting in cancer, neurodegeneration, inflammatory disorders and infectious diseases.

The National Cryoelectron Microscopy Facility has been installed at Bangalore Biocluster (B-Life) and officially inaugurated by Prof. CNR Rao and Dr. Richard Henderson (Nobel Prize winner for Chemistry in 2017) on 25th January, 2018. On this occasion, a symposium was hosted with several invited speakers including Dr Richard Henderson from LMB, Cambridge, Prof. Werner Kuehlbrandt, Prof. Wolfgang Baumesiter and Prof. Stefan Raunser (from the Max-Planck Institute) and Prof. Richard Kuhn (Purdue University). The symposium and the inauguration were attended by over 30 structural biologists from all over India by students/post-docs.



Gallery of structures determined at the B-Life campus using the microscope. These include some standard test specimens such as ribosomes but also new structures.

'JNU-DBT National Training and Skill Development Facility for State-of-the-Art equipment used in industry and academics' was supported as research programs are increasingly dependent on technology driven highly sophisticated instrumentation platforms. The primary mandate of this facility is to provide research instrumentation support and developing skill sets within the research community. AIRF which houses 27 sophisticated instruments, is best suited for the fulfilling the ever growing need of skilled manpower.



Relative Number of AIRF Users (%)

"Maintenance and Operation of the Biosafety Facility (level 3), for tuberculosis research" established at UDSC Campus, New Delhi has also been supported for a high TB burden and MDR strains of Mycobacterium tuberculosis (*M. tb*), which necessitates the design of effective control measures for the eradication of TB. TB is transmitted through aerosols containing infectious *M. tb*. Hence, it is highly important to work in a containment facility to protect TB researchers from getting infected. Scientists from premier institutes are actively utilizing this facility for TB research. A number of publications acknowledging the use of this facility for TB work is a true testimony of the success of this containment facility and also demands for its continued operation.

The Department has launched a scheme i.e. DBT-Boost to University Interdisciplinary Departments of Life Sciences for Education and Research (DBT-BUILDER) for advanced education and research for the up gradation/reengineering/ remodeling/ creation of Life Science departments in central and state universities. The objective is to promote interdisciplinary research and technology development at university level. So far, 25 universities have received support under this program The program has now been merged with Research Resources, Service Facilities and Platform as per the recommendations of the Expert Committee constituted for evaluation of schemes/programs of the Department for continuation beyond 12th Plan.

In JNSCAR, Bangalore, the teaching and research laboratories have been strengthened. Microbes (mostly bacteria and fungi) were isolated from the samples collected from the Central Indian regions, such as (i) mining area, (ii) agricultural fields, and (iii) polluted sites in and around cities. All together 120 microbes were isolated for future bio-prospecting. The lignin based nano-composites were synthesized using microbes and their applications such as antimicrobial agent were determined. The animal model (rat) mimicking human polycystic ovarian disease was established by using letrazole. Efficacy of exogenous melatonin from plant *Tephrosia purpurea* for its therapeutic potential during PCOS pathogenesis was also tested.

A Advanced Research Platform for Crop Sciences has been established in NIPGR, New Delhi. NIPGR scientists have sequenced many crop genomes, identified many genes and proteins that have potential for genetic enhancement of crops for social benefit.

Under these schemes, a large number of students, technical officers and young faculties have been trained and several scientific papers have been published in various national and international reputed journals.

NIPGR has developed novel chickpea lines with improved agronomic characters using marker assisted selection, transgenesis and genome editing. The institute has also developed mustard lines with low anti nutrients, long shelf-life tomato, identification of a rice gene that helps the plant

grow in low-phosphate soil and isolation of a fungus-eating bacterial strain that can mitigate rice sheath-blight disease. Several other useful findings based on pilot experiments are under progress.

NIPGR has contributed towards significant progress in three major research areas, viz. Genome/ transcriptome sequencing, Molecular mapping of important agronomic traits and Genetic engineering to improve agronomic traits and is expected to continue research under these broad areas with this established infrastructure.

Advanced Technology Platform Centre, Regional Centre for Biotechnology

The Advanced Technology Platforms Centre (ATPC) was conceived with the aim of providing access to cutting-edge technologies to researchers across India. Thus far, the Flow Cytometry Facility, Protein Expression and Purification Facility, Mass Spectrometry Facility, Molecular Interactions Facility and Optical Microscopy have been established at this centre. Facilities of ATPC are being utilized by the Scientists from THSTI, Faridabad; ICGEB, New Delhi; HAU; Vyome Biosciences, AIIMS, New Delhi; NII, New Delhi; NIPGR, New Delhi; University of Delhi; NBRC, Manesar; and IARI, New Delhi.

National Mouse Resource (NaMoR)

The Department has established a National facility for Mouse Resource & Research at NCBS & inStem, Bangalore with an aim to create a national state-of the-art rodent facility including transgenic and knockout mouse models of human disease. Integral to this mandate is providing facilities and training for academic researchers nationwide, and thereby create access to technology for researchers anywhere in India who require transgenic and knockout mice for their research in basic biology/translational bioscience.

The vision, mandate and objectives of this facility is to maintain mice and rats under specific pathogen-free (SPF) conditions and to provide a centralized source of standard and genetically-altered mouse and rat strains for researchers across the country and to create a training center for mouse embryology, genetic manipulation, and husbandry of transgenic/disease models so that personnel for running smaller facilities in research institutes and universities can be trained.

NaMoR is unique in the following features and provides a distinctive resource that is available to researchers throughout India: 1) NaMoR is currently the only academic high barrier SPF facility in India routinely monitoring for the full FELASA panel of pathogens and have successfully maintained mouse colonies FELASA pathogen free for over 3 consecutive years, thereby meeting the highest international SPF standards. 2) NaMoR is successfully providing genetically modified mouse strain cryopreservation, cryorecovery, *in-vitro* fertilization and strain re-derivations services 3) It is also providing micro-injection and embryo transfer services to generate new genetically modified mouse models to other research institutes across India.

During the year, the genome engineering facility that was established has thus far generated a number of transgenic mouse lines for internal and external users. A second Mouse Cryobiology / IVF workshop was held in August 2018 in collaboration with the Jackson Laboratories.

National Outreach and Service – At a glance

Workshops & Seminars:

- Biannual workshop with JAX on cryopreservation and IVF
- JAX-India seminars in Hyderabad and Bangalore
- Charles River/Hyalsco Seminar and Discussion
- ~150 attendees from institutes nationwide attended these intensive meetings

Training:

- Provided 10 individual training sessions for investigators from Indian academia and industry
- Staff serves as consultants and review board members

Material Sharing:

- Negotiated an MTA with JAX to distribute mice in India
- 26 labs nationwide received animals from ACRC stocks
- Assisted 5 external labs with import of animals

Societal Impact: A state-of-the-art facility has been established at NaMoR which is now fully functional with two different levels of SPF environments in the high barrier animal facility (SPF1- highest pathogen exclusion level; and SPF2- intermediate pathogen exclusion level) and can be used by researchers across the country. Two microinjection stations has been established comprising of an inverted microscope, two fully motorized micro-manipulators (for right and left hand micromanipulations), a femto air-injector, an oil ultra sensitive injector/cell manipulator, and a piezzo drill used for invasive oocyte microinjection procedures and ICSI (IntraCytoplasmic Sperm Injections). Together these two micro-injection setups allows to proceed to the various types of microinjections required for the main transgenic techniques. This will help in rapid advancement in scientific and translational research.

Access to Macromolecular Crystallography Beamlines at ESRF, France

A Beamline-14 Program Coordination Unit (DBT-BM14-PCU) at Regional centre for Biotechnology, Faridabad has been supported by the Department for providing access to Indian scientific community to synchrotron X-ray Beam line (BM14) in Grenoble, France. To provide continuous access to the Indian scientific community, a new agreement was signed between European Synchrotron Radiation Facility, Grenoble, France and Regional Centre for Biotechnology (RCB), Faridabad, India, to facilitate the access to six high intensity beam lines and SAXS Facility.

A total of 118 proposals were accepted for data collection, 51 scientists from 21 different institutes exposed 2948 crystals to the synchrotron beam exposure and collected 2763 data sets. Training of Ph.D. students and young scientists at the beamline was a mandatory requirement of the project. Efforts were also made to send researchers from different institutions across India. As a result, since the inception of the project, 25 PhD students have been trained at the site.

Centre for Cellular and Molecular Platforms, Bangalore

The Centre for Cellular and Molecular Platforms (C-CAMP) supported by DBT in a project mode at Institute for Stem Cell Science and Regenerative Medicine (inStem), Bangalore with a mandate to be an enabler of high-end research and innovation in the field of lifesciences in India.

Salient Achievements: C-CAMP, since its inception has gained an in-depth knowledge and experience of setting up and managing Technology Platforms, building a dynamic ecosystem to foster Innovation and Entrepreneurship. So far, more than 250 organizations have worked with C-CAMP through its technology platforms, more than 1000 research scientists have been trained on hands-on technology training programmes, more than 110 start-ups have been seed funded at idea stage, more than 20 start-ups have incubated at C-CAMP and several start-ups have received follow on funding successfully. During the year, C-CAMP has reached more than 100 publications through its technology platforms support. C-CAMP start-ups have been recognised as the ONLY INDIA STARTUP in worlds top game-changing innovations. C-CAMP have been featured in Forbes India as the engine/ catalyst of deep-science innovations in lifetech. C-CAMP became the first AMR Accelerator (Outside US and Europe) by CARB-X, a US Govt funded programme for AMR.

C-CAMP may play an important role as a nodal centre for life sciences technology platforms and innovation.

DBT IISc Partnership Program Phase II at IISc , Bangalore that intends for research in interdisciplinary areas of biology was initiated to improve existing research capacity and to forge crucial links between basic and translational research. As evidenced from the increase in the quantity and quality of publications, that IISc has benefited enormously from this, as well as the earlier sustained infrastructural supports since 1990. With this unique advantage of active collaborations with the scientists from sister divisions of chemical science physics and mathematical sciences, and engineering disciplines within IISc, DBS would now like to propose a new phase of the DBT-IISc partnership to expand on the culture of interdisciplinary research it initiated in the first phase (2012-2017).

Skill-Development Program under Genomics Core

Short-term (1-3 months), Medium-term (3-6 months) and Long-term (12-14 months) training programs will be established in two areas: wet-laboratory for genome-scale data generation, and data analytics for analyses of massive genomics data sets. A large number of M.Sc. students of

diverse but relevant backgrounds (including, biology, statistics, mathematics, bioinformatics, computer science, engineering, etc.) will be trained.

These training programs will feed into national PhD programmes across universities and institutes in India, many of whom will work on various national and international projects (e.g., Human Cell Atlas project); eventually culminating in High-level training of a smaller number of post-doctorals in institutions of international renown (facilitated by India's membership to EMBL), including the industry, or in Indian institutions by Visiting and Adjunct Professors from universities of international renown. The high-level training will essentially be a "train the trainer" programme on scale for it to have a cascading effect in building national genomics capacity

Outputs/Deliverables of the National Genomics Core may be measured using a multi-dimensional construct. The Core shall have a dual role of promoting genomics-driven discoveries and providing genomics services, including skill-development. One of the limiting factors for making genomics-driven discoveries is that researchers are unable to access the required genomics technologies with ease. Further, this limiting factor is also proving to be a major deterrent to undertake national-level and large-scale projects that is crucial to making meaningful genomic discoveries.

The Core will have an active program to identify and reach out to stakeholders, and encourage them to use the facilities of the Core. Except for undertaking focused development projects on technology and computation, the Core does not envisage undertaking scientific projects on its own initiative. Instead, the Core will be a facilitator for the initiation of national-level discovery or application projects, by bringing together experts and interested stakeholders. The Core will, however, have a vibrant skill-development program for institutions and the industry in genomics (a) wet lab technologies, and (b) data analytics and computation.

Biotechnology Science Cluster

Biotech Science Clusters are envisioned to promote innovation and accelerated technology and product development, in an approach wherein facilities for promoting life science research bioengineering, translational biotech sciences, platform technological resources and biotech entrepreneurship are located together to maximize synergy and efficiency. Keeping in view the importance of developing bioclusters, National Biotechnology Development Strategy aims to establish India as a world-class bio-manufacturing hub by creating a technology development and translation network across the country through establishment of bioclusters, incubators, technology transfer centres etc. The Government also announced for establishment of Biotech Science clusters at Faridabad (Haryana), Mohali (Punjab), Pune (Maharashtra), Kalyani (W. Bengal) and Bangalore (Karnataka) during the Budget speech in February, 2014. So far, four Bioclusters have been established at Faridabad, Bangalore, Kalyani and Pune to spur innovative research and development and entrepreneurship activities.

The Systems Medicine Cluster (SyMeC), Kalyani, West Bengal

The Systems Medicine Cluster includes six major institutions, both clinical and basic science and is poised to be an example of 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. SyMeC is using two common diseases (gingivo-buccal oral and cervical cancers, that are most prevalent forms of cancer among men and women in India, respectively) as exemplars to show that a combination of expertise of disparate domains can achieve the goal of understanding the pathobiology of disease and formulating a systems biology approach to clinical management. The institutions that belong to the cluster are: a) National Institute of Biomedical Genomics, Kalyani (Nodal Centre); b) Indian Statistical Institute, Kolkata; c) Bose Institute, Kolkata; d) CSIR-Indian Institute of Chemical Biology, Kolkata; e) Tata Medical Centre, Kolkata ; and f) Indian Institute of Science Education and Research Kolkata.

All six institutions comprising the cluster are working in close collaboration and in a networked fashion, complementing one another with different domains of expertise required to make systems medicine a reality.

The cluster aims to 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. Following progress has been made:

- A peptide has been designed to block a key gain-of-function oncogenic mutation in *TP53* gene.
- Retrospective samples have been collated to identify genomic signatures in cervical tumor biopsies to predict recurrence after treatment.
- Non-invasive signatures in cervical cancer: Data from assays in metabolites and diversity of microbiome have been generated, on small a sub-set of cervical scrape samples, out of 40 prospectively collected patients of cervical cancer. The data are now being analysed.

Awareness campaigning on the benefits of cervical screening on "Women's Health" (March 3, 2018 in Kalyani)

NCR Biotech Science Cluster

The NCR Biotech Science Cluster (NCR-BSC) has been established in Faridabad within the National Capital Region to foster biotech innovation through sharing of recourses and expertise of the various member institutions of the cluster. Processes have been put in place to achieve the objectives of the cluster and there is already a significant synergy in functioning of the various cluster institutions at the operational and scientific levels. NCR Biotech Science Cluster aims to provide strategic support to national & regional research organizations in creation and integration of scientific, technical & business related frameworks that would accelerate and translate discoveries and carry out validation and transfer of product technologies to enterprises.

The major initiatives/activities under taken during the year are as follows:

- Interim Office of Connectivity has been set-up.
- Common cluster facilities like the small animal facility, auditorium, student hostel, and common activities like the Electrical substation and general maintenance, horticulture/gardening, cafeteria, and campus security are fully operational and managed jointly by THSTI and RCB.
- Establishment and operation of Advanced Technology Platform Centre (ATPC) and Bio-incubator as the shared service resources for the cluster and the nation.
- Monthly seminar series rotating within the cluster institutions initiated.

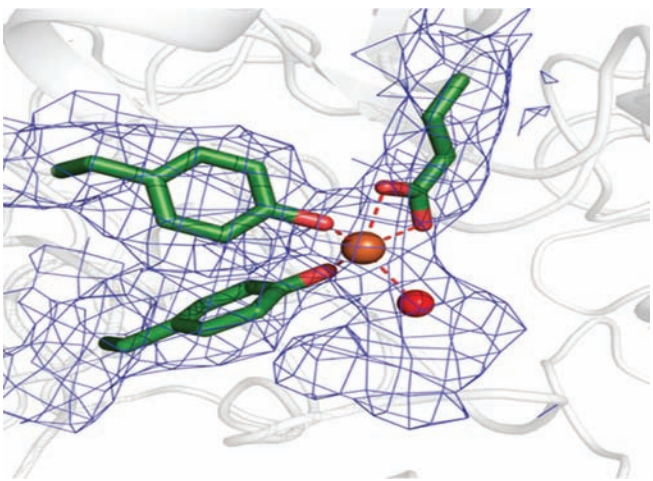
The operation of common facilities under the cluster concept has led to substantial savings to the government by pooling resources and avoiding duplication. Enhanced interaction among the scientists of the cluster institutions is expected to lead to interdisciplinary research and novel innovations.

NCR-Biotech Science Cluster, Department of Biotechnology

Bangalore Life Sciences Cluster, Bengaluru:

The Overall goal of the Bangalore Life Sciences Cluster is to build the necessary infrastructure, human resources and to enable research and innovation activities across life sciences and biotechnology domains by leveraging the existing resources in the Bangalore Life Science Cluster (inStem, NCBS, C-CAMP) and its partner campuses (IBAB, IISc, etc) and build on them.

During the year a national electron-cryo microscopy facility, accessory laboratories and a neuroinformatics resource have been set up at the Bangalore Life Science Cluster. The resource is now being used and several structures have been determined by people at the bio-cluster as well as by outside users. Eighteen different groups from different parts of the country have come and worked on the electron microscope. A training program to industry for use of the resources in drug discovery was organized.



Electron density from the active site of a thermophilic enzyme that is isolated from a bacteria involved in bioremediation in the tanneries of Kanpur. The enzyme is a formamidase with a novel active site with a Fe bound to two Tyrosines.

Pune Bio-Cluster

The project on "Establishment of a Pune Biotech Cluster, "Model Organisms to Human Disease" was sanctioned on 29.06.2018 with a total cost of Rs.12541.30 lakhs for a period of three years. The project is being jointly implemented by National Centre for Cell Science (NCCS), Pune and Indian Institutes of Science Education and Research (IISER), Pune. The Pune Bio-cluster aims to enhance academic interactions between various institutions in Pune and also to provide an opportunity for the members of the cluster to take advantage of each other's expertise in developing animal models for tackling human disease. The project also will provide the platform to use high end facilities developed as a part of the cluster to nucleate available resources for better utilization and encourage sharing of national resources which could also be used widely by start-ups.

The infrastructure is being set up. The training modules are designed and training workshops have been initiated for academic institutions using the high-end facilities. During the year, one hands on training and 3 demo activities on different microscopes have been undertaken. The discussions between institutions to leverage each other's scientific strength is under full swing and constant discussions are in place to utilise the common resources to benefit the academic institutions including students and staffs at large to the maximum extent possible.

- The project on "Establishment of a Pune Biotech Cluster on, "Model Organisms to Human Disease" was sanctioned with a total cost of Rs.12541.3012 lakhs.
- At **SyMeC** screened small molecule stabilizers of SMAR1 in cervical cancer cells: Two analogs have been identified.
- A National electron-cryo microscopy facility, accessory laboratories and a neuroinformatics resource have been set up at the Bangalore Life Science Cluster.
- Advanced Technology Platform Centre (ATPC), a Bio-incubator and a Small Animal Facility have been established at NCR Biocluster, as the shared service resources for the cluster and the nation. Interim Office of Connectivity has been set-up at NCR Biocluster.

05

PROMOTING ENTREPRENUERSHIP AND INDUSTRIAL GROWTH

Make-in-India and Startup India

Biotechnology has emerged as an integral part of the Indian bio-economy. The estimated value of biotechnology sector was USD 51 billion in 2018 with a recorded growth of 14.68% from 2017. The projected target for the government is to reach the market size value of USD 100 billion by 2025. Currently, Indian biotech industry holds 3% of the global market share and is 3rd largest in Asia-Pacific region. According to World Bank's Doing Business Report 2014-18, India is now ranked 1st among South-Asian countries compared to 6th rank in 2014. India was ranked 57th according to the Global Innovation Index Report 2018

The DBT alongwith BIRAC is playing a crucial role in the implementation and delivery of the flagship programs of the Government of India, such as 'Make-in-India' and 'Startup India'. DBT recognizes the necessity for entrepreneurship development among the youth in the country and hence has taken initiatives to build, support and promote Indian biotech ecosystem in healthcare, agriculture and industrial biotechnology.

MAKE IN INDIA

Make-in-India is a flagship program that was launched on September 25, 2014 by the Government of India. Owing to the fact that the country's biotechnology industry is in the growth phase where the opportunities are immense, biotechnology was chosen as one of the champion sectors in Make-in-India initiative. Realizing this fact, DBT entrusted the responsibility to BIRAC for establishing Biotechnology Industry Facilitation Cell.

➢ Objectives of Make in India Cell:

- Contribute to Make in India growth through identifying and promoting new areas in Biotechnology
- Catalyse the growth of manufacturing industry by mapping incentives and opportunities provided by Central and State Governments
- Facilitate Startups, SMEs and companies by communicating policies and incentives extended by the Government for the programme

Major activities of Make in India:

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. (http://birac.nic.in/mii/index.php)

After successful completion of Make-in-India 1.0, the facilitation cell at BIRAC under the guidance of DBT has formulated the Make-in-India Action Plan 2.0.

The Make-in-India Facilitation Cell at BIRAC is also involved in the various communication and outreach activities for disseminating various initiatives of DBT and BIRAC.

Identifying and promoting new areas in Biotechnology- SAEN (Secondary Agriculture Entrepreneurial Network) was launched in 2018 to promote new enterprises and to support existing industry in the secondary agriculture sector.

Launch of SAEN

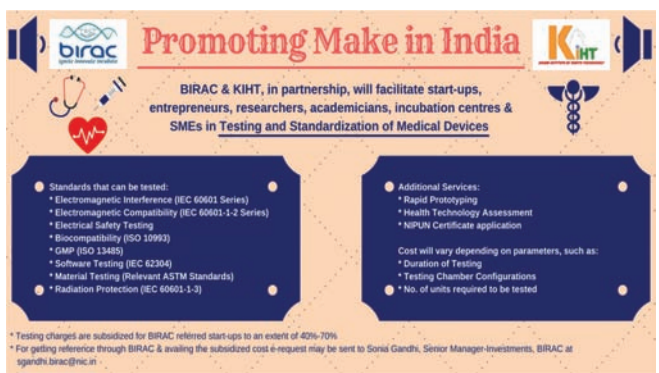
Regulatory Facilitation to Startups/ Entrepreneurs & SMEs

Role in strategic decisions and policy making

- MII Facilitation Cell provides key inputs for articulating major policy recommendations for the Biotechnology Sector both to the Department of Biotechnology and BIRAC.
- Strategy Meets and Stakeholder discussions are organized by the Cell to discuss and formulate the roadmap and strategies for DBT & BIRAC.
- Make in India Facilitation Cell at BIRAC had organized a Strategy Meet in July 2018 to discuss the road map for achieving $100 Billion bio-economy of India by 2025. DBT & BIRAC has already started implementing the recommendations.

Strategy Meet organised by Biotechnology Industry Facilitation Cell for Make in India

With an aim to promote Make-in-India, 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.



The Cell specifically monitors Startup India and Make-in-India action plan mandated activities and prompts the respective scheme coordinators regarding the progress of some of the important initiatives of DBT & BIRAC such as: BioNEST, BIRAC's Regional Centers, Equity Funding Schemes etc.

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 Government through this initiative aims to empower startups to grow through innovation and design. The Prime Minister of India formally launched the initiative on January 16, 2016. The department BIRAC endeavors to scale up the number of Startups in the

sector by nurturing approximately 300-500 new Startups each year to have around 2,000 Startups by 2020

1st International Incubator- Clean Energy International Incubator at Rohini, Delhi

Major Activities under Startup India Initiative:

41 Bioincubators have been setup across India with world class facilities. 1st International Incubator- Clean Energy International Incubator has been set up under Mission Innovation by DBT & BIRAC. Startups from 23 participating EU countries can potentially come & incubate in India and likewise startups from this incubator can go to the partnering countries facilitating access to global opportunities.

Department is supporting 4 Bio-clusters (NCR, Kalyani, Bangalore and Pune)

AcE Fund and SEED fund have been launched to provide capital assistance to start-ups and act as a bridge between promoters' investment and venture/angel investors.

BIRAC Regional Centers-4 regional centres and 4 Bio connect offices have been established.

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 single platform.

DBT is organizing national workshops on facilitating resolution of regulatory concern faced by innovators. In these workshops the regulators are reaching out to innovators to help them resolve their regulatory issues and hand-hold them to get market authorization. The first such workshop was organized on 10th December, 2018 at International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi. The workshop was organized in collaboration with Central Drugs Standards Control Organization (CDSCO) and Biotechnology Industry Research Assistance Council (BIRAC).

Impact of PPP programs: Start-up India and Make-in-India Initiatives (2018-19):

- No. of technologies/ products commercialised - 14
- No. of patents filed - 11
- No. of start-ups & entrepreneurs supported - 87
- No. of Bioincubators supported - 4
- Incubation space created - 57,000 sq.ft.

BIODESIGN PROGRAMME

Biodesign is a highly interdisciplinary programme to connect a medical insitutions and its resources with an engineering institutions and a basic science system for need identification (medical) with prototype development (engineering) and product validation (medical regulatory and engineering). This structure facilitates bench to bedside support to early leads for any of the partnering systems for pre-clinical and clinical development, regulatory support, market assessment, start-up establishment and any other activities on a tool considered relevant by the partners.

Realizing the importance of affordable, indigenous and accessible medical technologies in the country, Biodesign program has been implemented as a flagship program to foster and promote development of indigenous affordable medical technologies and creating an ecosystem for med-tech innovations and entrepreneurship in the country. Under the programme four biodesign centres have been established. School of International Biodesign centred at AIIMS and IIT Delhi; Centre for Biodesign and in-vitro Diagnostics at Translational Health Science & Technology (THSTI), Faridabad; Biodesign and Bioengineering Initiative program at IISc., Bengaluru; and Healthcare Technology Innovation Centre at IIT Madras, Chennai. Significant highlights are given below:

School of International Biodesign Program

School of International Biodesign (SIB) is a flagship program of Department of Biotechnology (DBT), Ministry of Science & Technology, Government of India, implemented in collaboration with AIIMS, IIT Delhi and International partners viz. QUT, Australia, Hiroshima University and Totorri University, Japan since 2015. SIB is built on the success of Stanford India Biodesign program. The mandate of this programme 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. The Phase IV of the program has been sanctioned during the year. 2018-19. The review and monitoring mechanisms is being strengthened. Site-visits to various centers for accomplishing external review has been planned. A total of 66 technology gtransfer appraisal committee meetings have been held since beginning for technology management of SiB projects.

Key achievements of SIB for the period as follows:

- During this year 7 medical technology innovators (Doctors, engineers, designers, entrepreneurs including fellows from Hiroshima University, Japan and QUT, Australia) have been trained.
- 3 provisional patent applications and 1 PCT has been filed.

Technology for 'Intra-osseous Device' was licensed to M/s Rcupe Lifescience Pvt. Ltd., Bangalore in presence of Secretary DBT, DR. Renu Swarup and other dignitaries.

Centre for Biodesign and In-vitro Diagnostics, THSTI

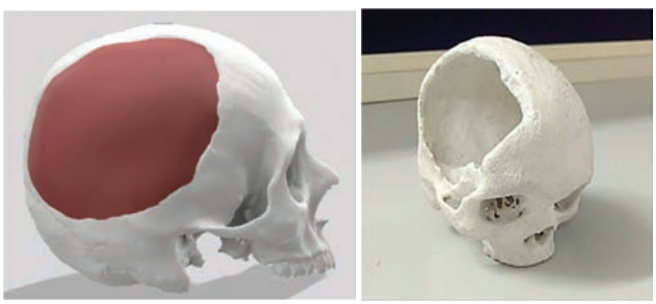
Centre for Biodesign and In-vitro Diagnostics (CBD) has been singularly successful in establishing a foundation for multi-disciplinary translational science and technology, tightly integrating clinical medicine with biotechnology and engineering. The Center for Biodesign was established at THSTI with focus on in-vitro diagnostics. The Centre has evolved core expertise around Products and Platform Technologies for diagnostics. The mission of CBD is to undertake innovation in medical technologies for affordable health care in India by utilizing the biodesign concept and support services that extend from strategic bench work to commercialization. CBD has created a broad platform to facilitate clinical needs-inspired biomedical innovation to lead THSTI's efforts in translational research, and emerged as the "mission critical center" for THSTI. The center has merged as a core division of the THSTI.

Biodesign& Bioengineering Initiative Program, IISc

The Biodesign-Bioengineering programme at IISc Bangalore was implemented in collaboration with St. John's Medical College and Majumdarshaw Centre for Translational Research, Bangalore. In the phase II of the project MoUs signed between IISc and CMC for jointly-supervised MD-PhD programme is under implementation. In this phase medical doctors and interdisciplinary team of scientists are closely developing novel biomedical products.

Clinical efficacy of 3D printed patient specific cranial prothesis is under process of clinical trials.

3D printed skull

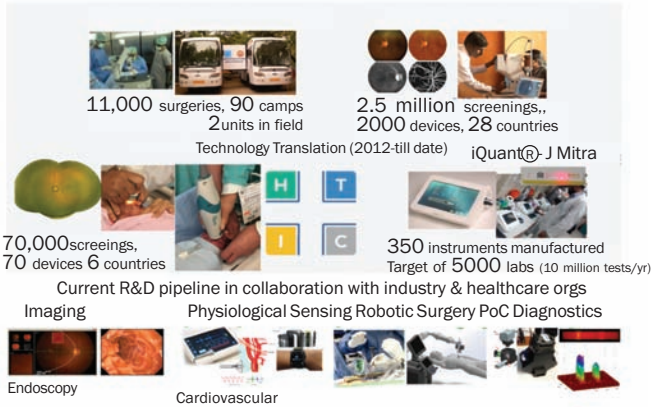


Healthcare Technology Innovation Centre, IIT, Madras

Healthcare Technology Innovation Centre (HTIC) is an R&D centre which has been established by DBT in IIT Madras to bring together technologists, engineers, doctors and healthcare professionals, industry and government to develop healthcare technologies for the country. HTIC has evolved into 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 is delivering innovations and technologies that are reaching the field through government and industry partnerships, bringing benefits to lives and our society, and helping businesses. HTIC is becoming a national asset of global standards in affordable healthcare technology innovation. During the year phase II of the program has been sanctioned.

During the year, the following advanced medical technologies have been developed for Cuffless blood pressure measurement; Non-contact neonatal vitals monitoring; Automated immunodiagnostics; Minimally invasive image guided surgery; and Deep learning and AI based medical image computing.

Commercialization of technologies into products through industry partnerships and start-ups are being taken-up in the Phase II support such as ; a) Immunodiagnostic analysers; b) Image guided minimally invasive spine surgery system ; c) Fever monitor ; and d) Endoscopy video processor Significant results have also been achieved in R&D on cuffless blood pressure monitor.



Societal impact :

The program has made a huge impact in fostering medical device innovation and in training of next generation of medical technology innovators & entrepreneurs. The Kalam Institute of Medical Technology (KIHT), a Society on health technology set-up through the support of the Department of Biotechnology has been providing all round support to entrepreneurs and start-ups in the area medical device manufacturing.

Biotechnology Parks & Incubators

The Department of Biotechnology has established Biotechnology Parks/Incubators across the country to translate research into products and services by providing necessary infrastructure support. These Biotechnology Parks offer facilities to Scientists, and Small and Medium sized Enterprises (SMEs) for technology incubation, technology demonstration and pilot plant studies for accelerated commercial development. The Department so far, has

supported 9 Biotechnology Parks in various States. 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; and ix) Chhattisgarh Biotech Park, Naya Raipur, Chhattisgarh.

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 stakeholders of biotechnology sector including academia and Government.

The Department has come up with 'National Biotechnology Parks Scheme' in which it is proposed to create an ecosystem to absorb the start-ups which have graduated from the incubators and give them a platform for further scaling up their R&D activities in collaboration with the state government and industry. The guideline on "National Biotechnology Park Scheme" is available on the web-link: www.dbtindia.nic.in/wp-content/uploads/guidelines_biotech_Park.pdf.

Biotech Park, Lucknow, Uttar Pradesh

Biotech Park at Lucknow in Uttar Pradesh is the first technology incubator. This has been set up jointly as a partnership between Central and State governments i.e. the Department of Biotechnology, Ministry of Science and Technology and Government of Uttar Pradesh. The Park is continuously striving to achieve its mission to develop knowledge - based economy in biotechnology and assure benefits of biotechnology to all sections of the society. The Park aims to expand its activities by exploiting current infrastructural support besides adding resources appropriately wherever required, acquire dynamic capabilities and exploit the entrepreneurial opportunities with an endeavour to develop a sustainable ecosystem around the Park.

Leveraging the human resource pool, knowledge base and facilities of the nearby Council of Scientific & Industrial Research and Indian Council of Agricultural Research institutes, like Central Drug research Institute, Central Institute of Medicinal & Aromatic Plants, Indian Institute of Toxicology Research, National Botanical Research Institute etc, the Park provides incubator facilities to entrepreneurs to perfect their technologies, up scale the products and even produce small quantity for testing and quality control at the Park. The Park has attracted 29 companies out of which 19 graduated out and presently Park is home to 10 companies. Another focus of the Park is to assist knowledge creation and promote biotech entrepreneurs through a service driven framework.

The Park has several programs for Human Resource Development in Biotechnology to generate adequate and appropriate skilled manpower required for Biotechnology sector in the country. Biotech Park is an active partner with UP Skill Development Mission, Govt. of Uttar Pradesh and is providing training in the areas of Flavor, Fragrances & Perfume and Agriculture. Biotech Park is providing useful services to society by providing bio-agriculture products, biofertilizes, biopesticides and human resource. Under the partnership with Institute of Bioresource and Sustainable Development, Imphal, Park has started joint projects on "Propagation of disease-free varieties of selected banana species of North-East India through plant tissue culture for enhancing lively hood of local farmers" and "Skill Development in Biotechnology in North India" by which most of the Famers and students from North East are being benefited.

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. 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 incorporates research laboratories, knowledge based service centres and utility generation facilities. It is mainly designed for development and scale up of bio processes and technologies.

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 existing infrastructure has successfully attracted more than 10 new companies in the cluster; most of them being startup/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 TN State Government with support from DBT. This Park has created infrastructure for Biotech R&D on 5 and has now achieved 100% occupancy with National and International clients. The tenancy area has 74 modules, 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 in our website, www.ticelbioPark.com.

The Golden Jubilee Biotech Park For Women, Chennai, Tamil Nadu

The Park was established by Govt. of Tamilnadu at Siruseri, Kanchipuram District with support from DBT and is fully functional since 2001 with a seed funding of Rs. 4 Cr from the Department of Biotechnology. 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. Presently it houses 13 companies inclusive of 5 start-ups and three 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. The new addition to the Park is the establishment of a Incubation centre with the support from BIRAC under its BIONEST programme.

Biotech Park Technology Incubation Centre, Guwahati, Assam

The Biotech Park Technology Incubation Centre (GBPIC) has been sanctioned by the DBT in 2009 for a period of three years. An interim facility for the Incubation Centre has been built in an existing building of IIT Guwahati. This facility now has 8 modular laboratories, specialized & support facilities ready to be used. A common instrumentation facility is being equipped with sophisticated instruments. This incubator is now trying to attract companies and incubates to develop commercial products based on the rich natural products of the region.

Assam Govt. has extended budgetary support for procurement of land in proximity to IIT, Guwahati and for construction of perimeter fencing and land development cost for the permanent campus of Guwahati Biotech Park.

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. BBC is located in 10 Acre campus with 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 Academic 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 incubates in the biotechnology Park. Rajeev Gandhi Centre for Biotechnology (RGCB) is the Institutional Partner of Kerala Industrial Infrastructure Development Corporation (KINFRA) for operating the Lab. At present, Kerala Startup 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). A common facility lab is being used by entrepreneurs as well as incubates.

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 State (Rs. 2466.00 lakhs) in June 2018 for 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 is being executed through CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM), Jammu for setting up to IBTPs and on completion, the facility will be handed over to J&K Industrial Biotech Parks Society.

The thrust areas for IBTP, Jammu have been prioritised for the current phase to include three areas: Micropropagation; Medicinal plants extract preparation and Enzymes/value-added biomolecules.

Biotechnology Park, Chhattisgarh

The Biotech Parks in the State of Chhattisgarh has been sanctioned by the DBT at a total cost of 2968.39 lakhs to be shared between DBT (Rs. 1473.05 lakhs) and Govt. of Chhattisgarh (Rs. 1495.34 lakhs) in July 2018 for a period of two years. The project is being executed through Chhattisgarh Biotech Promotion Society and Indira Gandhi Krishi Vishwavidyalaya, Raipur. The State is one of the richest bio-diversity hotspots in the country with 44% of its geographical area under forests. The Biotechnology park would facilitate innovation and product development through the optimal utilization of bio-resources available. The Biotech Park is expected to play a key role in promotion of startups leading to commercialization of biotech products.

The thrust areas for Chhattisgarh Biotech Park are: Biofertilizers, Biopesticides, medicinal plant extract, molecular diagnostics and industrial biotechnology. During the year a two days event on Startup Samvaad- 'a workshop on Innovation, Startups and Entrepreneurship' has been organized in association with Association for Innovation Development of Entrepreneurship in Agriculture (a-IDEA), National Academy of Agricultural Research Management (NAARM), Hyderabad and Indira Gandhi Agriculture University, Raipur. Total 15 startups presented their ideas and the best two ideas has been selected and awarded. 200 participants participated in the event.

06

BUILIDING INTERNATIONAL COLLABORATIONS AND PARTNERSHIP

International Collaboration

Collaborative research is indispensable for science driven society to have influence on scale globally. Therefore, joining hands and pursuing complementary targeted research with the best in the world will leapfrog Indian science and research community to the next level of innovation, transformation and skill development. The Government of India is increasingly trying to focus and promote collaborative research to solve a myriad of socio-economic as well as environmental challenges, which will have footprint on generations to come. The Department is implementing many such international collaborative programmes and the highlights of the achievements are as follows:

Major Initiatives

India-UK Cancer Research Initiative: The Department has announced an ambitious 5-year bilateral collaborative research initiative with Cancer Research UK (CRUK) that will focus on affordability of cancer prevention and care, and the potential to make significant progress against cancer consequences. Both CRUK and the DBT will invest £5m (~47 Crores INR) each in this initiative. This initiative will bring together leading Indian and UK experts to identify a core set of research challenges under the theme "affordable approaches to cancer", and provide funding to both develop new research alliances and undertake impactful research for affordable solution for cancer treatment. The MoU was signed by Dr. RenuSwarup, Secretary, DBT and Prof. Sir Leszek Krzysztof Borysiewicz, Chair, CRUK on November 14th, 2018 in Delhi.

Signing of MoU between CRUK and DBT

MoU between DBT and Business Finland : Recognizing innovation as the cornerstone of the collaboration, the Department has signed MoU with Innovaatiorahoituskeskus Business Finland (Business Finland) to cooperate based on mutual interest with Biotechnology Industry Research Assistance Council (BIRAC), the Public Sector Enterprise for funding and implementing ambitious industry-led innovative and transnational projects within the broad scope of research and innovation in Mission Innovation, Bio-future platforms, Environmental and energy applications of biotechnology, Business development of start-up and growth companies, Education technologies and games in life sciences and Other fields of life science industry.

Programme of Cooperation with Sweden: The Department of Biotechnology has signed a Programme of Cooperation (POC) with Swedish Governmental Agency for Innovation Systems (Vinnova), Sweden. The broad subject areas of cooperation under the Protocol shall be, but not limited to: Circular and bio-based economy, including biomaterials, Health and life sciences including biomedical devices and Start-ups, incubators, testbeds and bioclusters.

Programme of Cooperation with Denmark: The Department has signed Programme of Cooperation (POC) with Government of Denmark for cooperation in the field of Science, Technology and Innovation for the duration 2018-2020.The goal of the Programme is to encourage and facilitate cooperative activities between research institutions, universities, companies and other stakeholders in the respective national sciences and innovation systems of both countries.

United States of America: The Department has been implementing collaborative programmes with the National Institute of Health (NIH), since its inception. Major efforts have been implemented through the NIAID (National Institute of Allergy and Infectious Disease) and also through NEI (National Eye Institute) and NCI (National Cancer Institute)-NIH.

The Indo-US Vaccine Action Programme (VAP) 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. The programme is under implementation since 1987 based on the signing of a government-to-government Memorandum of Understanding

(MOU) establishing the VAP. The VAP is recognized internationally and considered as a model bilateral programme in biomedical research.

Indo-US collaboration on Vision Research: The Department of Biotechnology (DBT) has signed a Statement of Intent on 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 Diabetic Retinopathy, Genetics of Ophthalmic Diseases and Ocular Inflammation. The latest call for proposals was in October, 2018 for both the Indian and US side investigators. This round of funding opportunity is focusing on: Basic biology, epigenetics and genetics of ophthalmic diseases and visual disorders.

Indo-US Joint Programme on Cancer Research: An MOU was signed between National Cancer Institute of AIIMS, ICMR, DBT and National Cancer Institute of NIH for cooperation on Cancer Research, Prevention, Control and Management on 25th June 2015.The main aim of the collaboration is to promote and conduct high quality cancer research in order to strengthen the evidence base necessary for cancer prevention, treatment and management. The broad areas for cooperation that were flagged are as follows:

- Promotion and development of cooperation in the fields of clinical cancer research and patient care delivery
- Infrastructure development, training and capacity building
- Collaboration in cancer research including basic, translational and survivorship research, epidemiology, prevention, diagnosis, screening, treatment and control
- Direction of increased collaboration between appropriate Centers of Excellence and Institutions in both countries, as recommended by the participants; and
- Assessment and application of new and cost effective cancer diagnostic technologies for public health benefits, and the translation of technologies for global health

As one of the action points emerging out of various discussions with the NCI, it is proposed to establish an International Collaborative Research Center (ICRC) at National Cancer Institute, AIIMS, New Delhi. The aim of this centre will be: Translational research in prevention and cure of India centric cancers like tobacco related cancers, carcinoma gall bladder and carcinoma cervix. Besides these cancers, the centre would also focus on common cancers like breast cancer, carcinoma lung and evolving trends in cancer diagnostics and treatment. A Scientific Advisory Board comprising representatives from NCI-AIIMS, DBT and NCI-NIH would steer the functioning of the ICRC.

Brazil: MoU on Cooperation in the field of Biotechnology between Ministry of Science, Technology, Innovation and Communication, Federative Republic of Brazil and Ministry of Science & Technology of the Republic of India has been signed by the Secretary, Department of Science & Technology, India, was signed on 30th May 2018 at Brasilia, Brazil. The objectives of the MoU are to broaden and deepen cooperation in Science & Technology in the field of Biotechnology. b) To encourage industrial Research and Development (R&D) and related investment flows, bilaterally and/or regionally in the field of Biotechnology and c) to promote transparency through exchange in information and cooperation among relevant institutions.

Cuba: The ministry of Science and Technology of the Republic of India and the Ministry of Science, Technology and Environment of the Republic of Cuba, have signed a MoU on 22nd June 2018, at Havana. The MoU is focused to (a) transparently broaden and deepen cooperation in Science & Technology in the field of Biotechnology and b) encourage industrial and basic R&D, related investment flows, bilaterally and/or regionally in the field of Biotechnology. The Priority Areas of Cooperation are 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 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.

India and Cuba signing two MoUs in the field of biotechnology, traditional medicine and homoeopathy. The agreements were inked following delegation-level talks between President Ram Nath Kovind and his Cuban counterpart Miguel Mario Díaz-Canel at Revolution Palace in Havana.

Signing of LoI between BioCubaFarma, BIRAC & KIHT

BIRAC, KIHT led Indian Startup delegation visited Cuba from 20-22 June 2018 to explore collaboration opportunities between two countries in the area of biotechnology with a focus on vaccines, cell-based therapies and Devices & Diagnostics. A Letter of Intent (LoI) between BioCubaFarma, BIRAC & KIHT has been signed with focus on exchange of technologies, products & innovations and transfer of technologies and commercialization of innovative healthcare products of interest to both the countries.

Signing of LoI between BioCubaFarma, BIRAC & KIHT

South Korea: 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 at New Delhi in the presence of Dr Harsh Vardhan Hon'ble Minister for Science & Technology, Earth Sciences and Environment, Forest & Climate Change, Govt. of India and Mr. You Young-Min, Hon'ble Minister Science & ICT, Government of Republic of Korea One of the major objectives of this MoU is to expand and develop bilateral/multilateral relations and cooperation in the field of Science and Technology and in the area of Biotechnology.

The Union Minister for Science & Technology, Dr. Harsh Vardhan and the South Korean Minister for Science, Mr. You Young-Min signed the Memorandum of Understanding on Science & Technology, in New Delhi on July 09, 2018. The DG, CSIR, Dr Girish Sahni and Dr Renu Swarup, Secretary, DBT are also present.

Country	No. of Projects			Total
	Ongoing	Duration got completed	New Sanctioned	
Australia	6	50	1	57
Brazil	06	0	0	06
Canada	17	0	0	17
Denmark	06	05	0	11
EU	08	22	0	30
Finland	06	17	0	23
Germany	08	03	0	11
Netherlands	06	0	4	10
Russia	04	0	0	04
Spain	05	03	1	09
Sweden	07	09	0	16
UK	27	23	13	63

Country-wise summary of projects under international partnerships:

Ongoing Partnership Programmes

Canada: Department collaborates with the Indian Canada Centre for Innovative Multidisciplinary Partnerships to Accelerate Transformation and Sustainability (IC-IMPACTS), Canada International Science and Technology Partnerships, Canada (ISTP, Canada), Grand Challenges, Canada and NRC: PBI, Canada in all areas of Biotechnology. Till date 20 projects have been supported under the joint calls.

Germany: Department is partnering with German Federal Ministry of Education, Science Research and Technology (BMBF) and German Research Foundation (DFG) in areas of biotechnology.

Netherlands: The Department is partnering with The Directorate General for Enterprises and Innovation, Ministry of Economic Affairs, Agriculture and Innovation, Government of Netherlands in the mutually agreed area of cooperation of Plant Sciences and related Biotechnology, Food & Nutrition, Medical Biotechnology. Under this initiative till date ten projects have been supported under joint calls.

Spain: Department collaborates with Centre for the Development of Industrial Technology (CDTI), Government of Spain to promote and fund market driven research and technology development as well as to encourage partnerships and business led R&D&I collaborative projects in the field of biotechnology. Under theFourth Indo-Spanish Joint Call on Cooperation in Biotechnology, three proposals emphasizing industry centric biotechnology research explorations were funded.

Sweden: The Department collaborates with the Government of the Kingdom of Sweden in the area of Medical Biotechnology. Under this initiative the Department has supported sixteen R&D projects till date.

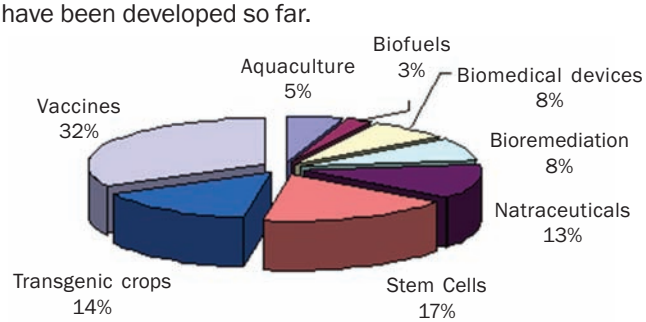
United Kingdom: Department also partners with Department for International Development (DFID); INNOVATE; British Council; Academy of Medical sciences (AMS); Cambridge University. It also collaborates with Biotechnology and Biological Sciences Research Council (BBSRC), Medical Research Council (MRC),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

Denmark: Department also partners with Danish Ministry of Higher Education and Sciences, Government of the Kingdom of Denmark for cooperation in the field of Biotechnology. Till date eleven projects have been supported under the joint calls.

Finland: The Department has partnered with Academy of Finland in the identified areas of Medical Biotechnology, Food Biotechnology, Agriculture Biotechnology and Environmental Biotechnology. Till date twenty three projects have been supported under joint calls for proposals.

European Union: The Department collaborated with the European Union in all areas of biotechnology, and till date 33 projects have been funded.

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. In the last 10 years of this collaboration, 57 projects and 10 workshops over 10 rounds have been supported in the areas of Healthcare, Agriculture and Bioenergy. 40 student exchange visits have taken place and 141 students have been trained under these projects supported. 132 papers have been published in various journals, 68 papers were presented in conferences. 7 patents have been filed. 15 Technologies and 13 products/ process have been developed so far.



Areawise distribution of funded projects

Russia: Under Indo-Russia cooperation a second joint call for proposals have been invited under the four priority areas of 'Genomic & Proteomics Instrumentation' Nano-Devices; 'Bioenergy - Photosynthesis based only' and Bio-reagents. Out of the 20 proposals evaluated, four proposals are recommended for joint support. All four proposals were

funded. The programme supported under Indo-Russia aiming at detection of bacterial resistance to antibiotics based on the changing properties of nanosized labels has been implemented as a collaborative project between JNU, Delhi, NII, Delhi and NIHFW, Delhi while the Russian counterpart is from Institute of Biochemistry Research Center of Biotechnology, Russia. The Indian scientist shall synthesize and characterize optically active nanostructures with different techniques, develop rapid screening methods for the multiplex antibiotics and eventually develop a nano devise for detection of specific antibiotics in food and clinical samples. The development of kit or strip for multiplex detection of antibiotics and its validation shall be carried out in Russia.

Switzerland: Thedevelopmentofkitorstripformultiplex detection of antibiotics and its validation shall be carried out in Russia. The Department has partnered with Swiss National Science Foundation (SNSF), Switzerland for blue sky research/basic research in the life science. So far, four projects havebeen supported under this call.

Brazil: The broad areas of collaboration of the Indo Brazil collaboration are a) Biomedicine and health, especially biotech based products, b) Agriculture breeding practices, c) Biofuels and Bio-energy, d) Nanotechnology and Bioinstrumentation and e) Biodiversity and Taxonomy. Six joint projects were recommended against second Joint call for Proposals.

1.	Number of joint publications	800
2.	Number of patents	48
3.	Number of technologies	11

Consolidated outcomes through international partnerships – At a glance

DBT's International Collaboration across the world

07

SPECIAL PROGRAMMES

PROMOTING WOMEN SCIENTISTS - SCIENCE FOR WOMEN - WOMEN FOR SCIENCE

Biotechnology Career Advancement and Re-orientation Programme (BioCARe): A Mission Programme of the Department for empowering Women Scientists of India

The Department has the mandate of promoting women in Science and science for women. With its vision to promote women in science and in an attempt to enhance the participation of Women Scientists in Biotechnology Research, the Department of Biotechnology launched a Biotechnology Career Advancement and Re-orientation Programme (BioCARe) for women scientists in January, 2011 and first call for applications was announced in the year 2011. The programme is mainly for Career Development of employed/ unemployed women Scientists upto 55 years of age for whom it is the first extramural research grant. The scheme is open for all areas of Life Science / biology (including agriculture, veterinary science and medicine). Women Scientists who are employed or unemployed or are desirous of coming back after a break can get back to the main stream by getting their first grant as the Principal Investigator. (Women Scientist who have already availed any grant as a Principal Investigator from any Government Funding Agency are not eligible to apply)

The purpose of the scheme is to build capacities for women Scientists employed fulltime in Universities and small research laboratories or unemployed women Scientists after a career break so as to help them undertake independent R&D projects. There are two categories under which support is provided for a period of 3 years. There is a Research Grant Opportunity (RGO), under which a research grant upto Rs. 60.00 lakhs is provided. Under this category, the women Scientists who are unemployed are provided monthly emoluments ranging from Rs. 50,000/- to 60,000/- p.m. The employed women Scientists in addition to salary get an amount of Rs.10,000/- p.m as an incentive. Under the Early Career Scientists (ECS) category, scientists having experience less than two years post PhD are eligible to apply for research grant of upto Rs. 40.00 lakhs. The unemployed women scientists are provided a monthly emolument of Rs. 50,000/-. The employed women Scientists in addition to salary get an amount of Rs.10,000/- p.m as an incentive.

Five calls have been announced so far. 315 women scientists (165 unemployed and 150 employed) have been supported so far. Out of 165 women scientists who were unemployed at the time of getting their respective BioCARe projects, 22 have got permanent employment. 250 Research Scholars have been and are being supported under various projects funded under this scheme. More than 100 papers have been published. 2 patents have been filed. It is a great achievement as though being the first grant as Principal Investigator, 2 patents have been filed. During the period a total of 1475 applications received in seven areas under fifth call were evaluated in phases and 52 were selected for financial support. The number of applications received is getting increased with time.

Presented here like number of unemployed women scientists supported based on the merit indicates that we have talent in India which needs recognition and support so that they can restart their careers as independent researchers and thus the scheme is very important. The data also indicates that scheme has been able to encourage and motivate women scientists to write their first project at the age of 50-55. Young women scientists supported under the program are being invited to participate and present their work at National and International platforms.

Statewise distribution of projects supported under the BioCAR: programe

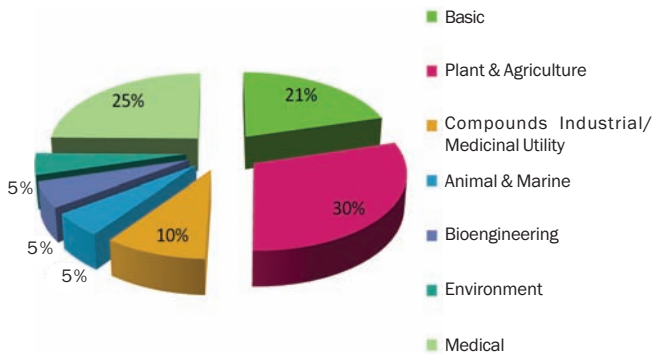
A young women scientist presented her journey and work supported under BioCARe getting felicitated in "Women Scientists and Entrepreneurs" conclave held on 7th and 8th October, 2018 in Lucknow, India

A young BioCARe awardee with SirTim Hunt- Nobel Laureate for "cell cycle regulation discovery" at Future Leaders Programme of 15th Annual STS-forum meeting held in 2018 at Kyoto, Japan. She has now been invited as a speaker in the 16th Annual STS-forum meeting to be held in 2019.

Women Scientists supported so far- Employed/Unemployed

Sl. No	Year of sanction	Employed	Unemployed	Total
1.	2011-12	17	10	27
2.	2012-13	15	17	32
3.	2013-14	29	34	63
4.	2014-15	48	36	83
5.	2015-16	6	4	10
6.	2017-18	37	64	101
	Total	150	165	315

% of supported proposals



Area wise distribution of projects supported has been summarized in the chart below:

Sl. No	Year of Sanction	25-40 yrs	41-50 yrs	51-55 yrs	Total
1.	2011-12	20	15	2	37
2.	2012-13	17	4	-	21
3.	2013-14	32	27	4	63
4	2014-15	62	20	1	83
5.	2015-16	8	2	-	10
6.	2017-18	88	13	-	101
	Total	227	81	7	315

Age wise details of Women Scientists Supported

trimester and also to evaluate the utility and yield of Quantitative Fluorescent PCR in the rapid diagnosis of fetal aneuploidies in the Indian context. 1684 dried blood samples were collected to evaluate the concentration of b-hCG and PAPP A levels in serum and dried blood spots. 2 positive cases of aneuploidy were found and they were suggested to terminate the pregnancy.

The Department organized the First DBT-BioCARe Conclave with the theme “Women Scientists Achieving Great Heights” on 8th and 9th March, 2019 at NIPGR, New Delhi. The aim of the conclave was to bring all the awardees of the scheme at one platform so that they could share their experience and discuss importance of the scheme in their careers. Around 250 women scientists, students, Experts and entrepreneurs from various states across India participated in the conclave. The major highlights of the conclave were various sessions

where the beneficiaries of the scheme shared their success stories before and after getting their first independent BioCARe R&D projects and how it made an impact in their careers. A booklet describing role of the BioCARe scheme providing first independent project as a milestone in careers of the awardees was released. Awardees have penned down their experience about the scheme in the booklet. 60 abstracts were also published in the booklet. Five Best poster awards in 5 areas were given after selection from 60 posters. Janaki Ammal-National Women Bioscientists Awards of the Department of Biotechnology for the year 2017/18 were also conferred in the conclave.

Programmes of Societal Relevance – Rural and SC/ST Population

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 12,900 rural, SC/ST and women population including youth have been benefited through the implementation of these projects during the year.

Programme on Transformation of Aspirational Districts

Govt. of India has identified 117 districts as aspirational districts for overall transformation of the districts using a mass movement approach focusing on health & nutrition, education, agriculture and water resources, financial inclusion & skill development, basic infrastructure including access to road for potable water, rural electrification and individual household toilets. Keeping in view of the aspirational districts programme, department had invited proposals from the institutes/universities and 19 proposals were received. Out of 19 proposals 9 proposals have been recommended for implementation to address some of the pertinent issues related to health and nutrition, agriculture & allied areas using biotechnological tools, techniques and processes for bringing these aspirational districts in the mainstream.

Department has implemented eight projects for setting up of Rural Bio-resource centre/ Technology Demonstration Centre/ Rural Transformation Clusters in identified 11 Aspirational districts in six states namely, Assam, Manipur, West Bengal, Jharkhand, Odisha and Punjab. 6600 people will be benefitted in these 11 Aspirational districts.

Major Achievements of the Projects Supported Under the Programme :

Establishment of Rural Bio-Resource Complex: For the economic empowerment of Himalayan region community Rural Bio-resource Complex (RBC) has been established for ecologically sustainable utilization, covering 26 villages of Almora, and 22 villages of Dehradun. Two rural RBCs have been established at Garhwal and Kumaon (Chokhutiya), Almora District of Dehradun. Farmers have been imparted training on backyard vegetable cultivation, Polyhouse vegetable cultivation technologies, organic farming, mushroom cultivation, processing and preservation techniques of fruits, bio briquetting, poultry farming and vermin composting. 49 training programmes have been conducted and about 3163 participants from 48 villages have been benefited. Some of beneficiaries have started their own agro business and earning Rs. 8000-25000/ month by adopting the project activities.

Biofertilizer and Bio-pesticide: Biofertilizer and Bio-pesticide have been utilized for enhancing the production of rice, potato and maize. More than 1000 farmers have adopted the use of biofertlizers and bio-pesticides and 25-40% of chemical fertilizers have been replaced by biofertilizer.

Application of biofertilizers has increased the yields by 46.66%, 30% and 40% with respect of Potato (variety 3597), rice (variety-motigold) and maize and thereby increased the income of the farmers.

Production of disease free banana (*Musa sapentium*) plants through tissue culture technique has been implemented and 300 beneficiaries have been trained. An efficient and reliable surface sterilization procedure has been optimized for successful establishment of banana germplasm under *in vitro* conditions for clonal propagation. Beneficiaries have adopted banana production for their livelihood generation.

Viral disease management of apple in Kashmir has been implemented and 459 apple growers have been benefited with the trainings in Kashmir valley and Kargil district in Ladakh.

Training programmes on viral disease management in apple

Vermicomposting: Training and demonstration on vermicomposting for empowerment of weaker section was supported and more than 1000 beneficiaries have been trained for their livelihood generation.

Sericulture: Ericulture for upliftment of socio economic condition of rural women has been implemented covering 10 villages of Kamrup and Udalguri districts of Assam. 120 women beneficiaries have been trained for production of Disease Free Laying (DFL) Eri Silkworm and they are generating income of Rs. 2650 per rearing per beneficiary from 10 grams of DFLs supplied under the project. Adoption of this skill development programme has helped in livelihood generation. Enhancement of rural economy through technology intervention for sustainable muga culture has been implemented and 150 beneficiaries have been trained on rearing, reeling and production of DFLs of muga silkworms and farmers are earning about Rs. 34,659.00 per crop/farmer.

Awareness program conducted on Muga culture at Barhoiting, Sivasagar district

Pig Faming: Techno-economic empowerment of rural women through sustainable piglet production has been implemented and 102 women farmers have been trained from 10 villages of Mizoram. 137 weaned piglets produced in the college were distributed among the farmers for rearing as breeding animals to produce weaner pigs in the village level. More than 600 weaner pigs were produced by 102 women farmers and more than 49 lakhs rupees were generated as revenue from selling of pigs.

Breeding Unit of Pig at CVSc&AH, CAU, Aizawl, Mizoram

Cattle Farming: Scientific rearing of cattle for upliftment of economic status of farmer has been implemented and about 1000 beneficiaries have been trained. More than 100 cows were artificially inseminated with semen of Gir breed. Nearly 1000 animals were treated and vaccinated in animal health check-up camps.

Poultry Farming: Poultry Farming for sustainable livelihood generation was supported and more than 300 beneficiaries have been trained on various aspects of poultry production and management. Some of the beneficiaries are earning about Rs. 6000-8000 per month by rearing of poultry through backyard farming.

Fish and integrated farming: Fish and integrated farming system have been supported for Livelihood generation of the rural community and more than 1000 beneficiaries have been trained to adopt the integrated farming system for their livelihood generation.

Women & Child health: Effectiveness of a mHealth (mobile/smart phone) based Preterm Home Care Program on the developmental outcomes of preterms has been implemented. The project mHealth Preterm Home Care Programme (mHealthPHCP) focuses on babies who are born prematurely, which helps in tracking the preterm and their health status through the use of mobile application "NeoRaksha". 25 training sessions have been conducted to empower 600 ASHAs on Preterm Home Care. 140 preterm babies have been admitted in NICU of tertiary care hospital. Out of 140, 70 mothers of preterms in the intervention group were empowered in providing comprehensive preterm homecare and trained in utilizing NeoRaksha. Simultaneously, respective ASHAs from the locality of recruited mothers were individually trained at the research setting on utilization of the NeoRaksha app. At home, mothers entered developmental milestones in NeoRaksha and preterms were monitored remotely.

Training of ASHAs on Preterm Home Care

Genetic Awareness, Diagnostic and Counselling Program on Maternal and Neonatal Health has been implemented and more than 1000 pregnant females, adolescent girls and malnourished kids were benefitted. A 7-day workshop entitled "Maternal and Newborn Care: Issues and Challenges" for medical professionals, research students and faculties was also organised. Hands on training sessions to equip the medical professionals with better understanding, diagnosis and management of pregnancy related issues were conducted.

Prenatal Screening by Dried Blood Spots for Triaging has been supported to design and standardize the values obtained on Dried Blood Spot (DBS) against the serum in the first trimester and also to evaluate the utility and yield of Quantitative Fluorescent PCR in the rapid diagnosis of fetal aneuploidies in the Indian context. 1684 dried blood samples were collected to evaluate the concentration of β-hCG and PAPP A levels in serum and dried blood spots. 2 positive cases of aneuploidy were found and they were suggested to terminate the pregnancy.

08

PROMOTING BIOTECHNOLOGY IN NORTH EASTERN REGION

Promoting Biotechnology in North East Region

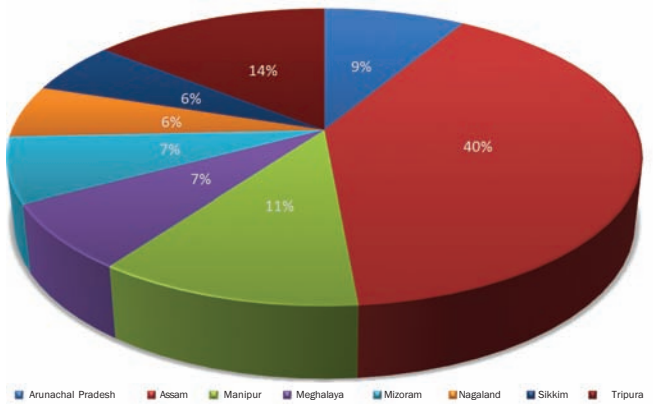
The North East Region (NER) of India is a treasure house of exceptional natural beauty, floral and faunal biodiversity with abundant mineral, water and forest resources. It has been identified as one of the biodiversity hotspots of the world. Rich bioresources spread across NER's diverse ecosystems and nurtured by indigenous communities, provide ample opportunities for furthering economic development of the region. In order to give focused attention for the North Eastern Region, the Department of Biotechnology (DBT), Ministry of Science & Technology, Government of India, has earmarked 10% of its annual budget every year for promoting & strengthening biotechnology activities in the region. Towards this the DBT has also established a North Eastern Biotechnology Programme Management Cell (NER-BPMC).

DBT has proactively launched several region-specific programmes through the intervention of modern biology and biotechnology in NER. These programs are towards flagship R&D programmes, skilling of human resource, establishment of research and training infrastructure with specific network programmes targeting local problems including entrepreneurship development.

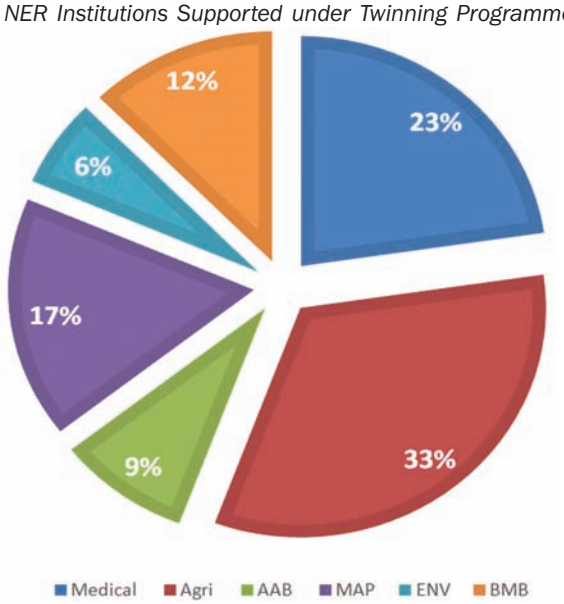
MAJOR RESEARCH & DEVELOPMENT PROGRAMMES

Twinning R & D Programme for NER

This Programme has made a huge impact by catalysing 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. So far more than 600 Twinning Projects have been supported since inception of the scheme in 2010, addressing issues in all areas of Biotechnology with specific relevance to developmental needs of the region; nearly 250 research papers have been published in peer-reviewed journals and more than 2000 young researchers/students of NER have been trained in advanced biotechnology. These projects have been supported in 70 Institutes across NER. State-wise and area wise details of institutions supported under Twinning Programme are as follows:



NER Institutions Supported under Twinning Programme



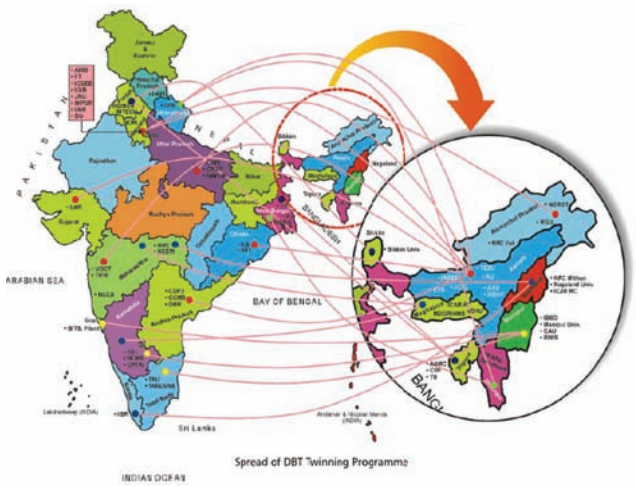
Areawise projects supported under twinning programme in 2018-19

Under NER- Twining programme many good scientific leads have been reported. Important highlights of the leads obtained under the programme are as follows:

- Nanofibrous structure of non-mulberry silk fibroin based mats (scaffold) perfectly mimicked the natural extracellular matrix of skin with biodegradable properties has been developed.
- Eextraction protocol of silk fibroin from the cocoons of *Bombyx mori* and the protein glands of the silk worms - *Antheraea assama* and *Philosomia ricini*, endemic to North East India has been optimised.
- New knee joint by obtaining the equation of motion, which predicts the behaviour of the knee joint has been

developed. Dynamic analysis is under process.

- A technology on improved classical swine virus diagnostic using Newcastle disease virus as a vector
- A novel polyherbal formulation based on extracts of *Gnetumgnemon*, *Elsholtziacommunis* and *Rhododendron arboretum* with anti-stress property has been developed and technology is ready for transfer of technology.



Spread of DBT Twinning Programme

Units of Excellence in NER (U-Excel)

The programme aims to identify and nurture outstanding mid-career scientists with excellent track record in research, who possess innovative ideas and are desirous of pursuing research in frontier areas of biological sciences. Since inception, 34 outstanding scientists from the North East Region have been supported under the programme through funding of their innovative projects across 12 Institutes in NER. 22 research papers were published in peer reviewed journals.

Under U-Excel programme 3 patents have been filed and 45 research papers have been published. Important research leads from various researchers include (i) In-situ forming silk hydrogel for treating 3rd degree burn wounds, (ii) In-situ Bioresponsive Silk Hydrogels for Spinal Disc Degeneration Therapy (iii) Production of antioxidant rich beverage using black rice, (iv) Identification of therapeutically important drug molecule from Indian snake venom; and (v) Technology for development of Protein Charge Transfer Spectra (ProCharTS) concept as useful tool to understand the biodiversity of NER.

MAJOR NETWORK R&D PROGRAMMES

Focussing on the specific relevance to developmental needs of the NER, Department has supported major network programmes in various sectoral areas of Biotechnology.

Agriculture Biotechnology

In the Centre of Excellence established at the Assam Agriculture University, GM chickpea lines have been developed using Bt Cry genes and these have entered into deregulation process. Under the rice breeding programme 3 promising drought tolerant lines in Ranjit background along with 6 QTLs for drought tolerance have been identified. 15 biofertilizer formulations and 10 biopesticides were generated and transferred to five companies/firms for commercialization. Three patent applications have been filed on microbial mass production technologies. 51 workshops for farmers and entrepreneurs in use of biofertilizers and biopesticides have been conducted. During the year, DBT has continued support into Phase-II for the DBT-AAU centre as North East Centre for Agriculture Biotechnology (NECAB) for Agriculture Biotechnology for next three years with the aim to take forward its existing research leads to the next level for the benefit of farmers' community in NE Region.




In Scented Rice programme for NER implemented by 12 NER Institutes and 15 other institutes, a total of 106 aromatic rice germplasm has been collected from different regions of NER, and characterised. They have been found rich in anti-oxidants, polyphenols and flavonoids. It has been found that

rice bran oil from the scented rice (Joha) variety are rich in ù-6 and ù-3 fatty acid and are efficacious to diabetes for which a patent application has been filed before the Indian Patent Office.

A major network programme on NER-Banana has been initiated with 39 institutions including 18 from NER Institutes and 22 other institutes. The programme will focus on banana biodiversity studies, pathogen detection and control, tissue culture, value addition, post-harvest loss and down-streaming & processing studies.

BIO-RESOURCE BASED APPLICATIONS & SECONDARY AGRICULTURE

In network project on value addition from Jackfruit of NER 107 local Jackfruit genotypes for table purpose and 43 local genotypes for vegetable purposehave been identified. Budding technique in Jackfruit for multiplication of elite planting materials has been standarised, technology for preparation of ready to cook (RTC) tender jackfruit for vegetable purpose has been developed.The process protocols for preparation of chips, pulp utilization for jam, squash, peda and ice cream has been standardised.

In the project on value addition from Citrus protocols have been developed for Ready-To-Serve drinks,Fizzy carbonated drinks, squashes and Fruit juice concentrates from NER citrus fruits including Assam Lemon, kachai Lemon, mandarin and sweet orange. The protocol has also been developed for extraction of peel oil and pectin NER Citrus. Pilot testing and up-scaling facility has been established at Medziphema, Nagaland.

BIORESOURCE AND ENVIRONMENTAL BIOTECHNOLOGY

A Centre of Excellence on Bioresources and Sustainable development is being established in Arunachal Pradesh. The centre will focus on documenting the abundant biodiversity and bio resource of Arunachal Pradesh, production of cold enzymes from microbes isolated from high altitude region of Arunachal Pradesh for wide industrial applications and research for sustainable utilization through setting up of fruit processing units, banana fibre extraction & processing unit, mushroom propagation units, vermin-composting units, units for Orchid and Medicinal & Aromatic plants cultivation.

Under the Chemical Ecology of the North East Region (NER) of India, major leads have been obtained. *Laibakcin*, a novel compound has been isolated from the *Artemisia vulgaris* grown in Sikkim. This compound has toxicity against stored grain pests. A promising botanical extract for controlling insect vectors (*Aedesaegypti*) from *Artemisia* spp. has also been

isolated, purified and are being characterized.A novel sugar compound with antioxidant property has been isolated, purified and characterized from the locally available edible berry, *Elaeagnus pyriformis* for use as nutraceutical.

In a network programme on ***Integrating herbal medicine of NER*** with contemporary approaches to develop therapeutic strategies for metabolic syndrome (DDRC), 3 medicinal plants *Premnaherbacea*, *Allium hookeri*, *Lysimachia candida*have shown promising results in controlling obesity and hyperglycemia in animal models of metabolic syndrome and a patent has been filed on herbal composition from *Premnaherbacea*, for its use in prevention of obesity. Well equipped laboratory has been established for "Traditional knowledge based drug discovery" in IASST, Guwahati.

A Phytopharmaceutical Mission for NER of India has been launched for captive cultivation of selected Medicinal plants, development of technology packages for production of GMP grade medicinal plant extracts and production of safe and efficacious phytopharmaceuticals for unmet medical needs using modern scientific tools. Two projects have already been sanctioned under this mission.

A program support on “Fundamental Molecular Investigations in Biotechnology” (Phase-II) has been sanctioned to IIT, Guwahati. Four major projects have been as part of this program.

Animal And Aquaculture Biotechnology

Centre of Fisheries at Tripura has led to the inventorizsation of over 300 fish species, 144 of which have been DNA barcoded. Efficient breeding protocols have been standardized for the food fishes including pengba, pabda and reba. Further, the technology of aquaponic on-farm production of protein-rich wolffia and its utilization as feed ingredient has been developed and leads have been obtained

Infrastructues under the COE-FAB

Wet Laboratory

Fish Museum

DNA Barcode Museum

Major Equipment under COE-FAB

in identifying local feed ingredients for larval feed. During the year, Phase-II of the project has been supported to take these efficient breeding and feed production technologies/ packages developed in Phase-I to the farmer level and to the selected regions of the NER.

Advanced Animal Diagnostic and Management Consortium (ADMaC), a major network programme being implemented with 3 NER Institutes, 4 National Institutes and 8 State Veterinary and Animal husbandry departments. Under this programme following scientific advances have been noted:

- Disease maps of important diseases have been developed based on which real-time in-situ disease outbreaks can now be depicted in NER.
- Important isolates including new pathogens (about 4500), have been deposited in national and regional repository at AAU-Khanapara.
- Molecular epidemiological picture on antimicrobial resistant bacteria in NER livestock and environment has been established.
- Experimental production has been initiated for cell line adopted swine fever vaccine and duck plague vaccines.
- Confirmatory field diagnostic tests have been developed for several diseases like Swine Fever, Duck Plague, Circo virus, goat pox, PRRS, etc.
- Project has resulted in 32 publications and 2 patents so far.

Consortia project on 'NER Duck' has been supported during the year involving 8 NER and 8 other institutes. The programme focuses on breeding of duck production by converging conventional and molecular techniques, developing molecular platform for epidemiology, disease mapping and development of diagnostics for economically important diseases, development vaccine against Duck Plague Virus, analysis of Gut Metagenome of Duck for identification of bacteria having Probiotic potential and value chain on processing of novel Duck meat and Egg for entrepreneurship development in NER.

Medical Biotechnology

MDR-TB has very high prevalence in NER, being the highest in Sikkim. The department has initiated a major network programme on *"MDR-TB in North East India:* a genomic driven approach" involving 22 NER institutes from 8 states and 14 other Institutes, to address various scientific and societal issues of MDR-TB in NER. The programme involves mapping hot-spots of TB and MDR/XDR-TB in NER using genome sequencing approach; population genetic studies to delineate predisposing factors, development/validation of new tools for diagnosis of TB &MDR-TB and non-tuberculosis mycobacterium (NTM); awareness programme on NTMs & Paragonimiasis through training/ seminar/workshop/health camps.

The Department has supported Medical Infrastructure Facility across 21 Government funded Medical Colleges & Biomedical Research Institutes of NER for the development of basic diagnostic facility in the region. Achievements of some of the labs supported under the programme are as follows:

- The lab at Dept. of Microbiology, AGMC, Agartala focuses on TB Diagnostics. The lab is now recognized by RNTCP, Central TB Division, MoH&FW for MDR TB testing in Tripura. Lab upgraded to IRL by RNTCP and has been identified to develop BSL-II facility by Central TB Division.
- Molecular Oncology Lab,has been established at CCHRC, Silchar. The centre provides much needed cancer diagnostic services to the NER region. This is reflected in the increase in patient load from 293 patients (2011-12) to 6478 patients (2018). In the lab at Assam Univ. Silchar Contract Research Service through its RT-PCR for Molecular oncology based diagnosis has been developed in collaboration with CCHRC, Silchar.
- Basic diagnostics Lab at Naga Hospital Authority, Kohima is the only facility for basic Biochemistry, haematology, cytology, histopathology, hormone profiling in the state. The lab is now ISO recognised and receives major patient load of the region and earns a revenue of Rs 3.00 lakhs per month.
- More than 4.50 lakhs diagnostic tests have been conducted by these facilities in NER

A Program support for Research in Biological sciences and Healthcare Engineering in NER(NECBH) has been

implemented through IIT, Guwahati. The purpose of this program is to raise the quality of research in biological sciences and healthcare engineering in the NER through collaboration with IIT, Guwahati. A website has also been created as http://necbhoutreach.ac.in for NE twinning project grants for young faculty members in different NE institutions involving one or more faculties from IIT, Guwahati and already the proposals have been invited through this website.

DEMONSTRATION AND SCALE-UP PROGRAMMES FOR SOCIETAL UPLIFTMENT IN NER

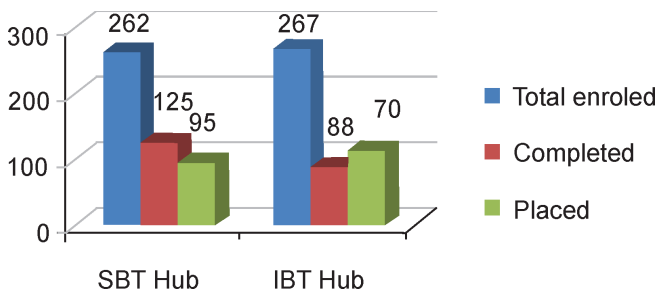
The Mushroom Incubator setup at Bodoland University, Kokrajhar, Assam is working towards the socio-economic upliftment and empowerment of rural entrepreneurs in mushroom culture and farming especially women entrepreneur.

- The Mushroom Incubator has been supporting 11 entrepreneur and helped in setting up of 24 new mushroom Unit at Bodoland region of Assam
- The Incubator has distributed more than 12 quintals of Mushroom spawn and has earned revenue accordingly and as many as 650 families are helped. It has been estimated that a total production of mushroom in Bodoland and adjoining areas has been enhanced by 20 to 25 tonnes annually.
- A total of 1663 people have been trained in mushroom cultivation using modern techniques and 48 small scale entrepreneurs are currently groomed by the centre

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 in universities/ colleges/ institutions and the required training in sophisticated technologies so as 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 Government in NER, spread across all the eight states of NER. Together these hubs have conducted more than 1700 hands-on training programmes and benefitting more than 44,000 participants across the region and more than 1400 research articles/papers have been published by these Hubs both in national and international journals. These biotech hubs have produced more than 210 Ph.D students and 165 such scholars have been placed at various institutions/ organizations across the country.

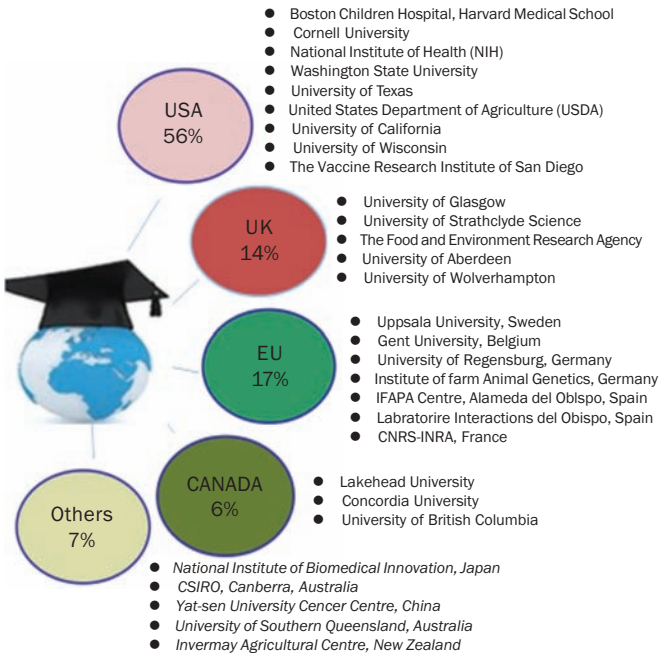


Placement of Ph.D. scholars trained in Biotech Hubs

Overseas Associateship Scheme for NER scientists

The Scheme has provided an opportunity to the 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 in many reputed overseas institutions. A total of 120 students were enrolled for Ph.D. under those awardees and so far, 60 students have completed their Ph.D. 63 Research Associates or research scholars trained by these awardees got placements as faculty/scientists in leading institutions across the country including some overseas laboratories. These

awardees have contributed in publication of 94 research articles in peer reviewed national and international journals besides securing 74 extramural projects from funding agencies. In the previous year, 34 researchers were awarded overseas associateship.



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 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. 16 BLiSS schools are in 6 aspirational districts identified by Government in NER. More than 2000 school students utilized those facility for their science practical during the year and 40 BLiSS school teachers from NER BLiSS schools were trained in New Delhi in August 2018 and given exposure to the laboratories of national institutions.

Visiting Research Professorship (VRP) Scheme

The Scheme was initiated to utilize the expertise of outstanding biotechnology professionals for bringing advancement in the Biotechnology and Life Science related activities in various institutions of research and higher learning in the NER States of India. So far 32 scientists/faculties have been awarded "VRP in NER" including 15 VRPs awarded in 2017-18 and have served NER institutions such as NEHU, AAU, Nagaland University, IIT Guwahati, IASST, Tripura University, Rajiv Gandhi Unvierstiy, IBSD and Mizoram University.

North East Students Conclave (NESC), IISF

A two day North East Students conclave (NESC) was organized as part of IISF 2018 in Lucknow during 7th - 8th October, 2018. A total of 230 participants, both students and teachers have participated in the programme and also performed various competitive events like talks, posters presentations and models. The NESC was inaugurated by the Hon'ble Union Minister, Dr. Harsh Vardhan and Secretary, DBT, Dr. Renu Swarup, gave away the medals and certificates to the winning students during its valedictory function.

Major outcome under the NER programmes of DBT for the year 2018

Personals Trained in NER

- 325 students trained as JRF/SRF under Twinning Programme
- 292 students trained as JR/SRF/RAs under 112 Biotech Hubs in NER
- 34 NER Scientists awarded under Overseas Associateship for training in international laboratories

Publications

- 267 publications in peer-reviewed journals from Twinning, U-Excel and other major Network Projects
- 280 publications in peer-reviewed journals from 112 Biotech hubs

Patents filed

- 5 patent applications filed before the Indian Patent Office

Technologies developed/licenced/commercialised

- 3 technologies developed under the U-Excel Scheme
- 2 technologies developed under the Twinning R&D programme
- 3 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 under process.
- 4 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 1663 people have been trained and 48 small scale entrepreneurs groomed.

09

AUTONOMOUS INSTITUTIONS AND PUBLIC SECTOR UNDERTAKINGS

In order to develop and emphasize on Thematic Area of Biology and Biotechnology, 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 & Emerging Biotechnologies. The institutions offer 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 in Capacity Building, Training and Skilling of Young Scientists, Students and Researchers. During the year, the research outcome of DBT Autonomous Institutions has resulted in about 650 Publications, filing of 50 Patent Applications and support to about 1500 manpower.

1. NATIONAL INSTITUTE OF IMMUNOLOGY (NII), NEW DELHI

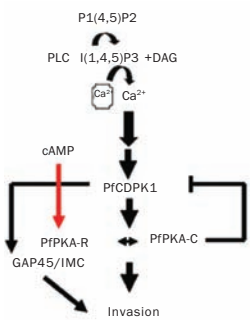
The National Institute of Immunology (NII) is the first autonomous institute of the Department of Biotechnology set up with the aim of promoting research in basic and applied immunology, and also in allied areas of the biological sciences that broaden understanding of the workings of the immune system, as well as of the pathogens responsible for causing disease. Over the period of last three decades, the institute has diversified its research from being engaged majorly in vaccine and reproductive biology to modern emerging biological research areas. The research activities of NII are mostly in the areas of infection and immunity, cell and reproductive biology, molecular design, cancer biology and immunotherapy, nanotechnology and regenerative medicine and chronic diseases and ageing. 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

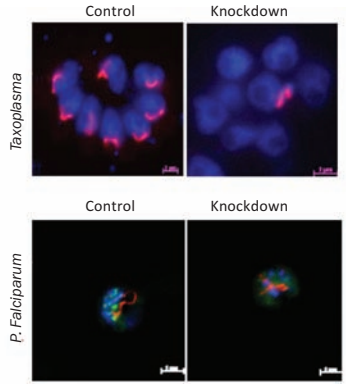
Three major translational activities have been pursued at NII: a) the clinical trials of *M. pranii* in patients of tuberculosis; b) the Phase 2 human clinical trials of a SPAG9-based cancer vaccine in patients of cervical cancer; and c) the technology-transfer to industry for the large-scale refolding of recombinant insulin. Research ideas from various laboratories have culminated in "Centres of Excellence" encompassing the broad research themes viz. vaccine and drug delivery using biodegradable polymeric particles, molecular machinery of Plasmodium signaling, autophagy and ubiquitin proteosome system, investigating the role of BLM helicase as a global tumor suppressor and cancer research program for development of immunotherapies.

Molecular Machinery of Plasmodium:
"Signaling, Autophagy and Ubiquitin Proteasome System (UPS)"

Team Leader: Pushkar Sharma, NII; Co-PI: Debasisa Mohanty (NII) , Akhilesh Pandey , Keshav Prasad (IOB, Asif Mohmmed, Pawan Malhotra (ICGEB), Puran Sijwali (CCMB)



Dissection of PfCDPK1 signaling network in invasion
Kumar, Kumar et al, Nature Comm. 2017



A novel non-canonical function of ATG18 in apicoplast biogenesis in Apicomplexan parasites
Bansal et al. mBio 2017

Dissection of Signaling and Trafficking Pathways in Apicomplexan Parasites: Immunology is a young science, eagerly imbibing the tools and methods of chemistry, physics and mathematics as its horizons expand. The institute is directing its research foreseeing the creation of the field of Immuno Engineering, including within its ambit, immunophysics, artificial immune systems and synthetic immunology; as complexities increase, stringent methods of quantitative analyses will need to keep pace. To begin with, NII is starting activities in developing cell culture platform for the availability of quality immune cells such as T cells, DCs, and MSC for therapeutic applications. Development and novel adjuvant from Indian medicinal plants and new modalities for immunotherapy will be the long term deliverable of the ImmunoEngineering program.

Salient Achievements:

Eighteen students are graduated with PhD degrees during the year, and seventy-two post graduate students hailing from different parts of the country received summer training in niche areas of immunology. The research outcome resulted in 94 publications and filing of 10 patent applications. Being part of the Biotech Science Cluster in the National Capital Region, NII hosted faculty seminars every month as part of its mandate; the high attendance of students and young researchers at these sessions is testament to their popularity.

NII was a nodal agency in the organization of the 4th India International Science Festival 2018 which was held in Lucknow from Oct. 5-8. NII has signed an agreement with Indian Spinal Injury Center (ISIC), New Delhi. An MoU between NII and BIBCOL is also under process. Further, NII has signed a Consultation Agreement with EPR Centre for Cancer Research and Bioinformatics Pvt. Ltd. NII is also actively involved in "Science Setu", an immensely successful initiative which connects scientists at NII to students at the Delhi University, which is in its fourth year. The institute is in the process of expanding our collaborations with Universities of neighbouring states through "Science Setu".

2. NATIONAL CENTRE FOR CELL SCIENCE (NCCS), PUNE, MAHARASHTRA

National Centre for Cell Science (NCCS) has completed thirty successful years of service to the nation this year through carrying out cutting edge research in cell biology and capacity building through teaching, training and outreach activities. The mission and vision of NCCS is to carry out cutting-edge research in cell biology and contribute to national development through capacity building and services which facilitate cell biology research across India. The scientists at NCCS are engaged in research in several areas of cell biology relevant to human health, including the biology of metabolic disorders and diseases like diabetes, obesity, cancer, malaria, tuberculosis and also neurobiology, stem cell biology, immunology and microbiology.

Major initiatives

(a) Pune Bio-Cluster (NCCS and IISER-Pune): A state-of-the-art common research facility is being developed to facilitate shared use of national resources, especially high-end facilities, & to foster academic interactions between various institutions in and around Pune. Members of the cluster will benefit from each other's expertise. The bio-cluster will also help to develop animal models for tacking human disease.

(b) Atal Incubation Centre (AIC): NCCS has been shortlisted to set up an AIC under the Atal Innovation Mission, which will serve to encourage and foster biotechnology-based entrepreneurship. The entrepreneurs availing of this facility, apart from using the facility will benefit from the expertise of NCCS and the mentorship provided by the NCCS faculty.

(c) *Centre of Excellence for National Centre for Microbial Resource (NCMR):* National Centre for Microbial Resource (NCMR) started as Microbial Culture Collection (MCC) in 2009 with a mandate to preserve and catalogue diversity of bacteria collected from different ecological niches from all over India and to make them available for biotechnological exploitation by researchers. With more than 180000 microorgnisms in its collection NCMR is the largest culture collection in the world and single-handedly lifted India to 3rd place among countries having collection of microorganisms. It was recognized as an International Depository Authority (IDA) for the deposit of microorganisms for the purposes of patent procedures under the Budapest Treaty by the World Intellectual Property Organization, Geneva. NCMR also got recognition as a Designated National Repository under the Biodiversity Act of 2002 from the Ministry of Environment, Forests and Climate Change, Government of India. It is an affiliate member of the World Federation for Culture Collections (WFCC) and registered with the World Data Centre for Microorganisms.

The NCMR project of NCCS has supplied more than 20,000 cultures to various research Institutions across the country . In addition, the NCMR scientists are also actively involved in the research in the area of microbial ecology and taxonomy.

a) Manav: Human Atlas Initiative: This initiative aims to develop a proof-ofconcept towards generating a human atlas in the future. Students will benefit from participating in this project by developing important skills such as interpreting scientific literature and critical thinking. NCCS will work with IISER -Pune and Persistent Systems Ltd. to initiate this project and take this forward.

b) An industry -academia meeting was organized to discuss strategies to facilitate technology innovations & scale up in academic institutions .

Salient Achievements

The novel mechanism to rejuvenate aged stem cells from older donors identified at NCCS could help in improving the outcome of stem cell transplantation

(SCT)-based therapeutic approaches for disorders like leukemia, lymphoma, and aplastic anaemia.

Demonstration of the cancer-causing role of a non-coding RNA, identified at NCCS earlier ('Ginir'), has led to the unprecedented discovery that noncoding RNA can be an important player in cancers.

The hitherto unknown, novel role of Interleukin 3 (IL-3) in regulating bone homeostasis revealed through studies conducted in NCCS has relevance to regenerative medicine, especially for important skeletal disorders like osteoporosis, osteoarthritis and rheumatoid arthritis.

Development of patient-derived xenograft (PDX) models and primary culture from Indian breast cancer patients, which could serve as better models to study cancer in the Indian population.

A cell line developed at NCCS from an Indian brain tumour patient (HNGC-2) is in the process of commercialization by Millipore Sigma.

MoU with the Jai Research Foundation, Gujarat signed for collaborative work on 3D cell cultures.

MoU with the King Edward Memorial Hospital and Research Centre, Vadu, Pune: Completed phase-1 of the project by carrying out the evaluation of immunological parameters in healthy Indian adults.

Collaborative project with TATA Memorial Hospital: 'Multi-Omics analysis to decipher mechanisms of hormone resistance in breast cancer'.

MoU with MetaMol Theranostics LLC (Cincinnati, USA) - Initiated work to validate & establish a diagnostic method for detection of cancers, and establish an affordable diagnostic program.

Cell Repository supplied 3420 cell lines to 475 organizations.

Impact : Scientists from NCCS were awarded NASI Platinum Jubilee Chair, J C Bose National Fellowship, DBT TATA Innovation Fellowship, and Swarnajayanti Fellowship. During the year 26 students received Ph.D. and 57 students received research training.

Several hundreds of citizens of all age groups and from diverse backgrounds learnt about the fascinating world of cell biology and research, through the India International Science Festival (IISF 2018) outreach open day at NCCS, and the exhibits displayed at IISF-2018, Lucknow. In the education day program about eighty college and research students availed themselves of this opportunity to learn about the current trends in proteomics and metabolomics, and about getting published in the digital age.

During the year Institute has supported more than 260 scientific and technical manpower through extramural research grants. The other outcomes include 42 publications and filing of 5 patent applications.

Richard Henderson (2017 Nobel laureate) visited NCCS in January 2018

NCCS at IISF 2018

3. CENTRE FOR DNA FINGERPRINTING AND DIAGNOSTICS (CDFD), HYDERABAD, TELANGANA

The Centre for DNA Fingerprinting and Diagnostics (CDFD) was established in the year 1996. CDFD is the first institute in the country to incorporate a "hybrid model" amalgamating services and research, with both components enriching each other. The 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.

Major Initiatives

CDFD is developing an Institutional Flagship Programme to use precision genomics based approaches for development of affordable diagnostics for genetic disorders, and novel DNA marker based forensic tests for identity, ancestry, phenotype, and lineage. This work has direct relevance to Government of India's Sustainable Development Goals (SDG 3 and SDG 9.5), the National Health Mission as well as the Nirbhaya Act 2013. CDFD also plans to contribute towards development of an Indian reference genome based on whole genome sequencing of about 10,000 Indians under the Genome India initiative, an all-encompassing national resource that will serve needs of both the scientific and the medical communities.

Major Activities/Achievements

Services: *Human DNA Fingerprinting:* A total of 127 cases were analyzed in the year 2018 including prominent cases from NIA and Anti-Terrorism Squad involving national security and public safety.

Diagnostics: During the period, 3448 samples were tested for various genetic disorders. The Medical Genetics Department at the Nizam's Institute of Medical Sciences (NIMS), Hyderabad, is functional through an MoU with CDFD to provide services to patients with genetic disorders as well as for training and research.

Plant DNA fingerprinting Services (PDFS): Based on the DNA markers developed in CDFD, this division offers Basmati rice purity testing to rice exporters through *Agricultural and Processed Food Products Export Development Authority (APEDA)*. 152 samples were tested during the year. *PDFS* is also working towards purity testing of different rice varieties as well as other commercially important crops.

Certification of DNA Examiners: Ministry of Home Affairs, Govt. of India has published a Notification dated 25th Oct 2018 in the Gazette of India on 6th Nov 2018, specifying the Director and DNA Examiners of CDFD as Government Experts for the purposes of section 293 of the Cr.PC, 1973.

Other Activities:

Molecular Immunology Forum (MIF) meet was conducted at Leonia Holistic Destination, Hyderabad during 7-9 February 2019.

CDFD Foundation day lecture was delivered by Prof. Seyed E. Hasnain, Jamia Hamdard, New Delhi on 26th January 2019, and this day was also observed as an Open day for school children. **National Science Day** was celebrated on 28th February 2019. Open Day was organized during this celebration for students from different colleges to interact with the scientific fraternity

Research Highlights: The Centre is engaged in high quality research in frontier areas of modern biology, with research

themes including microbiology, cell biology, disease biology, genetics and computational biology.

One of the studies from the centre has discovered nine SNPs (single nucleotide polymorphisms) that could explain 31% of melanin index variations amongst the diverse Indian population.

Scientists at CDFD are working on *M. Tuberculosis* found that a mycobacterial protein kinase interferes with host cellular trafficking by preventing phagosome-lysosome fusion, and favours bacterial survival inside human macrophages, thereby contributing to the virulence of *M. tuberculosis*.

In a separate study, another group has designed novel anti-bacterial peptides targeted against the transcription terminator, Rho.

Transcription activation as well as termination are central to cellular functioning. Work from one of the microbiology groups has shown that in bacterial cells there exists a very large potential for genome-wide synthesis of antisense RNAs that would form toxic RNA-DNA hybrids or R-loops, and that this potential is kept under check by the transcription termination activity of Rho and NusG proteins. Another microbiology group has discovered the involvement of Rho in the DNA repair process.

Uncontrolled cell division gives rise to cancer. Understanding how a cell divides is a prerequisite to understand how cells become cancerous. The E2F family of transcription factors regulates a large number of genes involved in cell division, and their promoters display 'active' histone marks. One of the research groups at CDFD has shown that retinoblastoma binding protein (RBP2) and its partner interact with E2F protein to remove these 'active' histone marks. The results highlight the importance of RBP2 in tightly regulating the process of cell division. Another research group at the Centre has reported the discovery of a new ubiquitin ligase complex ($CRL7^{SMU1}$) that keeps sister chromatids together during cell division. They demonstrated that loss of $CRL7^{SMU1}$ complex proteins in cells resulted in unequal distribution of chromosomes followed by defective cell division and genomic instability.

Impact: CDFD provides DNA fingerprinting services to different law enforcing agencies, diagnostics services to patients suffering from different genetic disorders and basmati rice purity testing. All these services offer a significant benefit to society and most importantly contributes immensely in knowledge generation in molecular biology and highly skilled human resource development. All these services offer a significant benefit to society and nation building.

Human Resource Development

In the reporting period, 13 students were awarded with a PhD degree. CDFD has a summer training programme in collaboration with the Indian Science Academies' Summer Research Fellowship Programme for Students and Teachers, and 16 students were trained in the year 2018 under this programme. Additionally, 12 research trainees were also trained at our centre CDFD imparts training in DNA Fingerprinting and Medical Genetics. An MoU was signed with SVP National Police Academy, Hyderabad on 22nd March 2018, and with Govt. of Uttar Pradesh on 3rd Oct 2018, to impart training in DNA Fingerprinting to IPS officers and forensic personnel. MoUs have been signed with Prasad Research Foundation (PRF), Secunderabad and FSL, Goa. The MoU with NIMS was renewed. In collaboration with Nizam's Institute of Medical Sciences, CDFD conducts a DNB fellowship in Medical Genetics.

Outreach: CDFD is involved in public outreach to educate and engage with common citizens about their research activities. CDFD constantly facilitates visits of school and college students to its laboratories and is also imparting lectures and training at schools and colleges throughout the country. CDFD has initiated a new outreach program called "Jigyasa" with Kendriya Vidyalaya, Uppal where our scientists interact with students and deliver lectures for their benefit. CDFD scientists have actively participated in different outreach activities outside CDFD like in Kendriya Vidyalaya Regional Level National Children Science Congress. Beside, public lecturers by eminent scientists were organized on various scientific topics.

During the year Institute has supported more than 150 scientific and technical manpower through extramural research grant. The other outcomes include 45 publications.

Public Lecture and Open Day during IISF celebrations

Inauguration of CDFD Permanent Campus

Dr. Harsh Vardhan, the Hon'ble Minister for Science & Technology, Earth Sciences, Environment, Forest and Climate Change, Govt. of India, inaugurated the new campus of CDFD on 12th August 2018. The occasion was graced by Dr. Renu Swarup, Secretary, Dept. of Biotechnology (DBT), Govt. of India.

Inaugural ceremony of new campus of CDFD on 12th August, 2018

4. National Institute of Plant Genome Research (NIPGR), New Delhi, 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 and has become well recognized 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 29 scientists, who are leading independent groups covering cutting-edge research in these areas.

Major Initiatives

NIPGR has developed a flagship program in collaboration with seven institutes to tackle the very serious sheath blight disease of rice. The program involves efforts to develop tolerant rice varieties as well as novel anti-fungal formulations that are environmentally friendly.

In terms of infrastructure, with financial support from the Department, the institute is in the process of setting up an advanced research platform for crop sciences with the following three modules:

- Gene function analysis platform for generating

over expression and under expression/knock out lines for specific genes in crops of interest such as rice, chickpea, mustard and tomato.

- An upgraded proteomics facility with a focus on interaction proteomics
- A metabolomics platform with an emphasis on plant hormone estimation and analysis of low abundant molecules.

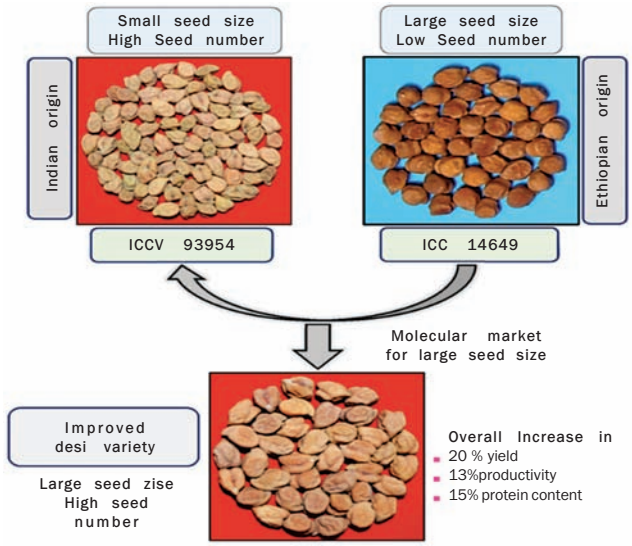
A Plant Genotyping and Genomics platform is being established in a public-private partnership model with support from the Department.

An MoU was signed with Sardar Vallabhai Patel University of Agriculture and Technology (SVPUAT), Meerut, to facilitate joint research activities, training of students, etc.

Salient Achievements

Some of the salient achievements of the research programs of the institute for the year are as follows:

The knowledge gained from genomic studies of chickpea was employed to develop a high yielding variety through molecular breeding approach. A molecular marker was also identified for large seed size in chickpea which was used to transfer large seeded characteristic from an Ethiopian variety of chickpea into a commercially important Indian variety (called ICCV 93954) that has high seed number but small seed size. The newly developed chickpea lines exhibited overall 13-20% enhancement of yield as well as 15% increase in protein content as compared to the parent line ICCV 93954. The newly developed lines are being evaluated in "ICAR-AICRP (All India Coordinated Research Projects) on Chickpea" Advanced Varietal Triai 1 (AVT1) during *Rabi*season 2018-19. If it is found to pass the trial, it will further be evaluated for one more year under Advanced Varietal Triai 2 (AVT2) during rabi 2019-20 prior to release as variety.



Development of a high yielding variety of chickpea.

Fungal pathogens cause devastating plant diseases that result in very significant crop losses. One of these pathogens, called *Rhizoctoniasolani* (RS) causes the serious sheath blight disease of rice. In seminal work, a research group at NIPGR has identified a bacterium that can reside inside rice plants and which can eat the RS fungus. They have discovered a novel secreted protein that is used by the bacterium to kill the RS fungus. Treatment of rice plants with either the bacterium or the antifungal protein will protect rice plants against sheath blight disease. The efficacy of this protein for controlling sheath blight disease under greenhouse/field conditions has been tested at the Indian Agricultural Research Institute and the Indian Institute of Rice Research and the results are encouraging.

RS fungus infected rice Prominent disease symptoms are observed

RS fungus plus bacterium No disease symptoms are observed

Activity of a novel mycophagous bacterium against Rhizoctoniasolani *(RS), causal agent of rice sheath blight disease*

NIPGR scientists have developed genomic resources for lentil and utilized them to map agronomically important traits such as seed size, seed weight and days to flowering. In the long term, the objective is to use these markers for breeding high yielding varieties of lentil.

A master regulator of plant defence responses called RAV1 has been identified in *A. thaliana*. Through network analysis, sixteen key plant defence genes have been identified in *A. thaliana*.

In the area of plant responses to abiotic stresses, the mechanism of formation of aerenchymatous tissue was studied in wheat roots. Aerenchymais characterized by the presence of air pockets within intercellular spaces is a well-conserved response of plant tissues to flooding. The production of nitric oxide was shown to be responsible for the formation of aerenchyma and appears to act upstream to ethylene signal transduction. A novel rice gene called *OsRSM1* (root system modulator 1) has been identified which modulates the response of rice roots to low phosphate. Rice plants overexpressing *OsRSM1* accumulate more phosphate and grow better on low phosphate than wild-type plants. *OsRSM1* is a transcription factor and its overexpression promotes phosphorous uptake from low P soils by increasing lateral root number and root hair length.

Arabidopsis SKP1-like protein13 (ASK13) was found to positively influence seed germination and seedling growth, particularly under abiotic stresses. Further, mutations of the plant-specific FCS-Like Zinc Finger Proteins FLZ6 and FLZ10 lead to slow growth of Arabidopsis plants. It was demonstrated that FLZ6 and FLZ10 are negative regulators of the plant kinase SnRK1 which in turn is a negative regulator of the universal growth promoter TOR1. The FLZ6 and FLZ10 mutants exhibited enhanced expression of SnRK1 and reduced expression of TOR1 causing their slow growth phenotype.

RNAi mediated suppression of a critical regulatory gene was shown to reduce glucosinolate levels in Indian mustard. A collaborative proposal between NIPGR and University of Delhi South campus for performing event selection trials on these lines has received funding from BIRAC. The flanking sequences for insertions in three such transgenic lines have been obtained and found to lie in inter-genic regions. The best line from the event selection trials will be taken forward for translation.

Impact: Publications/Awards& Fellowships

In an Indo-UK collaboration, three papers were published in Nature Communications on the mechanisms of plant adaptation to growth on low phosphate. These papers describe the following findings: 1. Root angle in rice plants in response to external phosphate is under the control of actin-binding protein RMD; 2. The elongation of rice root hairs in response to low phosphate is influenced by auxin influx carrier OsAUX1 and 3. A mechanistic framework to explain the elongation of root hairs in response to low phosphate levels has been provided in the model plant, *Arabidopsis thaliana*.

In terms of awards and fellowships, a number of faculty members, students and technical staff have received awards and recognitions. These include the following: J. C. Bose fellowship to Dr. Manoj Prasad; Fellow of the Indian National Science Academy to Dr. Alok Sinha; Fellow of the National Academy of Sciences, India (NASI) to Dr. Swarup Parida; Prof. B. K. Bachhawat Memorial Young Scientist award of NASI to Dr. Swarup Parida; NASI-SCOPUS award to Dr. Jitender Giri. Besides the above, several Ph.D. students and post-doctoral fellows have received prestigious awards and recognitions.

Conferences/Symposia/Workshop/Training: The 8th Conclave of Ramalingaswami Fellows was organized by NIPGR during Feb 15-17, 2018. 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, the Institute had organized an Open Day/Public Outreach Day on 26th October 2018. In this event, more than eleven hundred students from thirty different schools and three colleges participated along with their teachers and the NIPGR community presented 31 posters and 18 exhibits on plant science. To give students the real laboratory experience, a demo lab was set up to show them the basic molecular biology experiments. Additionally, on behalf of the

Department of Biotechnology, the Institute organized the Young Scientists Conclave (YSC) during October 5 - 6, 2018 as part of the India International Science Festival held during October 5 - 8, 2018 at Indira Gandhi Pratishthan, Lucknow. Almost 1000 delegates and speakers from all over the country participated in the deliberations of the YSC. Further, NIPGR joined hands with Shiv Nadar University (SNU), IIT Delhi and the Inter University Accelerator Centre (IUAC) to organize the first Delhi Youth Science Camp for high school children on 15th November 2018. These students had impactful interactions with eminent scientists of NCR region and were provided hands on training in basic molecular biology experiments such as isolating plasmid DNA, visualizing DNA using gel electrophoresis, analyzing microbes using foldscope and experiments related to physics using ion accelerator. Besides, the institute has been providing high quality training to doctoral students and post-doctoral fellows in the area of basic and applied plant molecular biology and a number of MSc/BTech and BSc students are undertaking project work in the institute as part of their educational training/fulfilment of degree requirement.

NIPGR has filed 6 patent applications, published 81 research articles and supported 134 PhD students and 66 Postdocs. During the year Institute has supported more than 100 scientific and technical manpower through extramural research grants.

5. NATIONAL BRAIN RESEARCH CENTRE (NBRC), MANESAR, HARYANA

The National Brain Research Centre (NBRC) continues its focus on research with significant impact on the well-being of the society, while carrying out basic research in the frontier areas of neuroscience to understand mechanisms of brain functioning in health and disease. NBRC is mandated 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.

Major Initiatives

Research focus during this year are on: Japanese Encephalitis; Zika; Down Syndrome; Spinal Cord injuries; prion infection; age related brain diseases; epilepsy; and brain development.

Zika virus, which causes babies born with microcephaly (small brain) if the pregnant mothers are infected, has emerged as a global health issue, with cases showing up in India as well. NBRC initiated work on understanding mechanisms of Zika virus infection using neural stem cells. The knowledge will lead to development of vaccines and drugs for Zika virus infections.

A major national level program 'Dementia Science Programme' initiated by NBRC. Goal of this program is to determine the lifestyle and genetic factors that result in a subset of people converting from Mild Cognitive Impairment (MCI) to dementia, so that possible intervention could be developed. There will be four hospital based sites and three community based sites in north, south and east India, where rural, urban and tribal cohorts will be setup and followed up long-term.

Collaborative program on Epilepsy with AIIMS, New Delhi, moved into the second phase after successful completion of the first phase which resulted in direct benefit to the patients and as well as high quality publications. Goal of this program is to understand basic mechanisms as well as to better localise foci of epilepsy in patients for better management including surgical management.

Salient Achievements

Scientists at NBRC have identified receptors (host protein) in neurons, which facilitates the entry of Japanese Encephalitis Virus into cells. They have also shown that IL-1, a pro inflammatory cytokine, plays a critical role in regulating neuro-inflammation via the NLRP3 inflammasome pathway. Further, they have shown the importance of inflammatory pathways in neuro degeneration which follows infection of the brain by the Chandipura virus.

Another team of scientists have discovered that envelop (E) protein of zika virus affects proliferation rates of human neural stem cells that would have consequences on brain development and play an important role in Zika Virus-induced microcephaly in babies.

Signalling changes in a mouse model of Down syndrome (DS), a developmental disorder that results due to an extra copy of Chromosome 21 and leads to several abnormalities including cognitive deficits in humans have been examined using hippocampal cells derived from the trisomic mice and it is found that the aberrant status of signalling molecules

that play critical roles in long-term potentiation and memory.

A nematode worm *Caenorhabditis elegans* is an excellent model system to understand the molecular mechanisms of repair of damaged neurons after an injury. Scientists at NBRC have shown that axon regeneration in C elegans declines with age, which can be overcome either by loss of conserved *let-7* miRNA or by loss of insulin signalling. They also established PVD neurons in *C. elegans*as a model system for studying the regenerative responses to dendrite injury and have showed that the DLK-1 MAP kinase pathway, which is essential for axon regeneration is not needed for dendrite regeneration.

Role of an ubiquitin ligase, Rnf2, that regulates synapse maturation via non-degradative function of protein ubiquitination was identified. Loss of Rnf2 function leads to development of "silent synapses" or synapses which fail to send electrical signals - an abnormality linked to a neuro developmental disorder known as Angelman Syndrome.

Work on spinal cord injuries has revealed that somatomotor system is composed of a complex of region specific networks rather than a single network as believed previously. Major similarities between the human and non-human primate systems were also found opening a way to extend results from an animal model system to humans.

NBRC scientists also unraveled mechanisms of how viruses are able to infect neurons, the cells of the brain. Scientists identified host receptor proteins that are essential for Japanese Encephalitis Virus in the neurons, which could become a target to block the infections. Work on Zika virus showed that the viral envelop protein is essential for its infection of neural progenitors cells, thus providing a therapeutic target for this infection that causes micro-encephaly in babies of infected pregnant mothers.

Impact

Identification of host proteins important for Japanese Encephalitis Virus entry into neurons would provide candidate molecules which may be targeted to block the viral infection in diseases such as Japanese Encephalitis and thus reduce disease severity.

Work on dementia and epilepsy will lead to better understanding of the disease and improved interventions.

Research on the Zika virus and its effects on the developing brain provides scientific basis for understanding how microcephalyin infants is caused.

Research on unravelling cell signalling molecules and pathways in hippocampal cultures obtained from trisomic mouse models would provide insights into cognitive impairment observed in Down's syndrome.

Studies on molecules such as ubiquitin ligases which regulate synapse maturation will provide insights into cognitive deficits observed in neurodevelopmental disorders such as Angelman Syndrome.

Studies on spinal cord injuries will provide better means of therapeutic interventions to induce plasticity for better recoveries.

During the year Institute has supported more than 50 scientific and technical manpower through extramural research grants. The other outcomes include 24 publications.

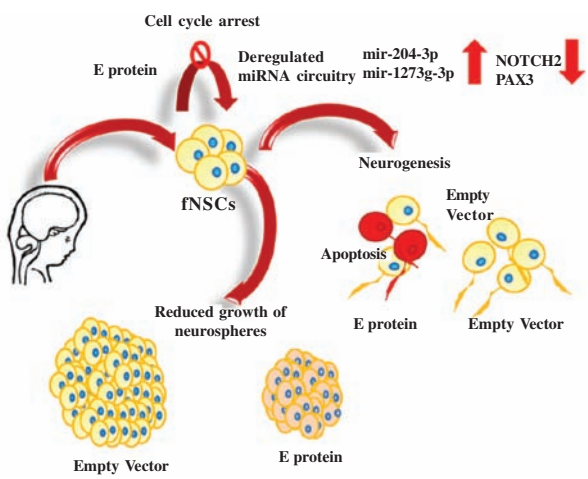


Figure showing how envelope protein affects proliferation of neurons inneurosphere cultures.

6. INSTITUTE OF BIORESOURCES AND SUSTAINABLE DEVELOPMENT (IBSD), IMPHAL, MANIPUR

The IBSD is focusing its activities on medicinal plants and horticultural resources, microbial resources, animal resources, and bioresource database and bioinformatics. During the current year, IBSD has made significant contributions in plant, animal and microbial resources. The

medicinal and horticultural resources include five research programmes: (i) Bioenergy and Bioresources management (ii) Plant Systematic (iii) Plant Tissue Culture (iv) Molecular Genetics and Genomics, and (v) Natural Product Chemistry. In Bioenergy programme, bio-refinery approach in conservation and sustainable utilization of Bioresources in Loktak lake is being studied. Production of biofuel from lignocelluloses-based biomass could be an alternative sustainable solution to minimize dependency on fossil fuels. IBSD has standardized pretreatment steps for bioconversion of *Phragmites* for the production of bioproducts. IBSD has also launched a floating laboratory in Loktak Lake, Manipur.

Orchid cultivation units were established in the rural areas of Manipur for demonstration and training of farmers and unemployed youths. Till date, 950 farmers and unemployed youths have been trained in orchids bio-entrepreneurship programme. The Plant Systematic and Conservation programme has led the discovery of seven new species, exploring the unexplored region of North East India. The new species are: i) *Nymphaea manipurensis* Asharani & Biseshwori ii) *Nymphaea manipurensis.* var.*varsicolor* Asharani & Biseshwori iii) *Zingiberpherimaense* Biseshwori & Bipin iv) *Caulokaempferiadinabandhuensis* Biseshwori & Bipin, and v) *Zingibercaudatum* Biseshwori & Bipin.

North East India is rich in different traditional fermented foods, which are unique in taste and their methodology of production. IBSD has developed starter cultures for production of fermented soybean and fermented milk products. Metabolite profiling of fermented food extracts is in progress with the aim of developing bioprocess and products. IBSD has a North East Microbial Repository, which has a total collection of 27,466 microbial cultures originated from various ecological niches such as freshwater lakes, traditionally fermented foods, caves, hotsprings, high altitude, low temperature mountains, forest area, plant endophytes etc. A total of 15,000 cultures have been characterized using different methods such as MALDI-TOF MS and DNA sequencing and phenotypic characterization.

Insect Resources Group has identified plant-derived compound having insecticidal properties that is less toxic to animals including human beings. Its unique properties offer an inherently eco-friendly alternative to current fumigants. This compound can potentially serve as fumigant and kill stored grain insect pests such as rice weevil, pulse beetle and flour beetle and having potent grain protectant properties. Notably, its discovery on the street of Ima market at Imphal reveals the importance of ethno botanical knowledge in discovering herbal pesticides for human use and further understanding of mechanism in biology. The potable Fiber glass Reinforce Plastic Carp and Magur hatchery facilities were established to serve the fish farmers of the state for the skill development training, demonstration as well as revenue generation through breeding.

During the year, research activities of IBSD have resulted in publication of 46 research papers in peer reviewed Journals. IBSD has also trained several women in silk production and unemployed youth in bamboo entrepreneurship. A large number of school and college students have visited IBSD for the outreach programme. IBSD has expanded its activities to several North Eastern States and has now presence in Sikkim, Meghalaya, Mizoram and Manipur.

Dr. Harsh Vardhan, Hon'ble Minister for S&T presenting orchid plantlets to potential entrepreneurs in Shillong, Meghalaya.

7. INSTITUTE OF LIFE SCIENCES (ILS), BHUBANESWAR, ORISSA

Institute of Life Sciences (ILS), Bhubaneswar is an autonomous institute under the Department of Biotechnology, Govt. of India. ILS mandate is to conduct and promote basic as well as translational research in the frontier areas of life sciences, for the betterment of human health and welfare. The Institute undertakes cutting-edge research in the core disciplines of Infectious Diseases, Cancer Biology, Genetic & Autoimmune Disorders and Plant and Microbial Biotechnology. Following are some of the significant accomplishments

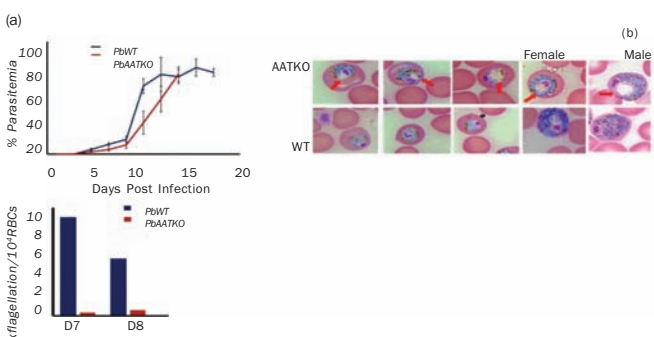
achieved during the year.

Major Activities

Infectious Diseases Biology: The life cycle of malarial parasite *Plasmodium* spp. is being studied using *Plasmodiumfalciparum* as an *in vitro* model, and *P. berghei* as an *in vivo* model. Growth curve analyses of amino acid transporter knockout *P. berghei* (PbAATKO) in mice have indicated a delay (2-3 days) in blood parasitemia levels. AATKO parasites showed drastic decrease in male gametocyte exflagellation. The blood stage parasites show swollen vacuole phenotype prominent in the asexual stages and in gametocytes (Fig 1). Notable parasite factors associated with parasite virulence and disease outcome have also been identified.

Studies on the Chikungunya virus (CHIKV) have revealed two novel host factors MK2 and its isozyme, MK3, whose activation is essential for CHIKV progeny release. The investigation established a significant decrease in MK2 and MK3 expression with a concurrent increase in CHIKV nsP2 expression while, the P38 MAPK, an activator of MK2/3, was found to be sequestered in viral inclusion bodies in CHIKV-infected cells.This may be a plausible explanation for the decrease in MK2/3 expression during infection.

In another investigation conducted to comprehend the mechanism of bacterial cell division, MinCD protein was recognized to oscillate between the poles of the cell and interact with FtsZ, a bacterial cytoskeletal protein, thereby perturbing it and eventually inhibiting the formation of the Z-ring. The MinD interaction site was discerned as the H10 helix on FtsZ, in *E.coli*. It was further found that FtsZ level in *E. coli* affects Min oscillation.



Characterization of AATKO in P. berghei. *a) Growth curve analysis of* Pb*AATKO and its comparison with* Pb*WT. b) Giemsa stained smears of* Pb*AATKO showing swollen vacuole phenotype. c)* In vitro*exflagellation analysis of* Pb*AATKO. Exflagellation data represents the results obtained from a single experiment.*

Cancer Biology: In breast cancer studies carried out in ILS, NEDD8, an ubiquitin-like protein which mainly regulates progression through the cell cycle, has been reported to be highly up-regulated in estrogen receptor alpha positive breast cancer patients as well as in breast cancer cell lines. The elevated expression of NEDD8 in ER alpha-positive breast cancer results in the recruitment of a co-activator and abrogates the degradation of EGFR leading to Tamoxifen resistance in breast cancer. A number of studies have been undertaken on host gene expression and regulation associated with cancer at ILS. Differential gene expression using microarray analysis and subsequent confirmation by RQ-PCR and chIP revealed TIMP2, a gene involved in metastasis, to be regulated by EVI1 in colon cancer. Cells that did not express EVI1 showed tight and compact colonospheres whereas those cells expressing EVI1 exhibited loosely packed colonospheres.

Genetic & Autoimmune Disorders: There are five well-studied subsets within $CD4^+$ T helper cells, wherein Th1, Th2, and Th17 cells have been implicated as effector cells of the adaptive immune system. Scientists at ILS were successful in establishing the role of chronic antigen presence in Ocular tuberculosis as the main inducer for pathogenic "Th1Th17" cells. Th1Th17 from RA established as the inflammatory bone degrading cells with high RANKL expression, while DM Th1Th17s were recognized as the inflammatory cells terminating Th2 cells with TNF-α.

Otosclerosis is a conductive hearing loss resulting from abnormal bone growth in stapes bone. SERPINF1 and BMPs are known to be involved in several bone disorders and mutations in SERPINF1 gene are inherited only in the affected members of otosclerotic families of Europeans. At ILS, the whole coding regions of all the multigenerational families were examined in the Odia population in India, and occurrences of SERPINF1 mutations were found to be lacking.

Plant and Microbial Biotechnology: Plant biologists at ILS have successfully characterized the full-length transcript promoter MUASCsV8CP of CsVMV and used this chimeric promoter to study the effectivity of *totiviral* KP4 expression to restrict the growth of devastating foliar fungi. Transgenic

lines expressing KP4 were tested for their resistance against two fungi namely, *Alternaria alternate* and *Phomaexigua* var. *exigua,* and found substantially restricted fungal growth using the *in vitro* agar-based killing zone assay. This may open new avenues in the field of plant protection against phyto-pathogens.

Phragmites karka, an invasive plant species, has been chosen as a candidate for multiple stress tolerance and also as a potential bioenergy crop. Core set of germplasm have been established for little millet (*Panicum sumatrense)* based on their resistance to water stress and nutritional quality. Transcriptome analyses in response to drought and salt tolerance have identified several transcription factors with differential expression to salinity and drought stress.

An environmental isolate *Bordetella bronchiseptica* strain HT200 was characterized based on comparative genomics and cellular approach. Both infection- and heat-inactivated whole cells induced anti-HT200 antibodies thus, conferring effective protection against pathogenic *B. bronchiseptica* strain RB50 in C57BL/6 mice model. *In vitro* and *in vivo* experiments are underway to understand the efficiency of strain HT200 as a whole cell vaccine.

Salient Achievements

Dr. Nrisingha Dey was elected as a Fellow for West Bengal Academy of Science and Technology, and Dr. Ajay Kumar Parida has been awarded the Prof. G. K. Menon Lecture Award (2018) by the National Academy of Sciences, Allahabad. Scientists at ILS are also members and life members of many societies such as the American Society of Immunology, American Society of Molecular Biology, American Society of Microbiology, Electron Microscopy Society of India (EMSI), Indian Virological Society and Indian Association for Cancer Research (IACR) etc. Research groups within ILS are moreover actively collaborating with institutes and research centres at both national and international levels. The stakeholder engagement centre of ILS was dedicated by Shri Naveen Patnaik, Chief Minster, Odisha and the Guest House & Research Scholars Hostel was inaugurated by Dr. Renu Swarup, Secretary, Department of Biotechnology, GOI.

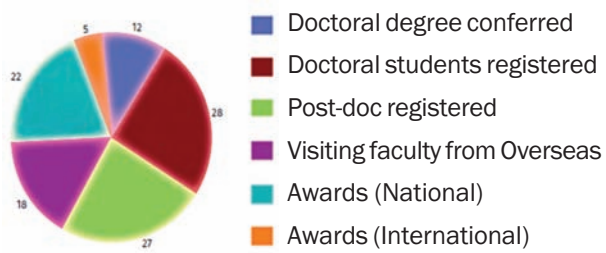
Impact: The Institute has also successfully conducted international conferences, symposiums, workshops and training programmes. A 3-day International India-EMBO Symposium on Autophagy was organised with support from India-EMBO and Wellcome Trust-DBT-India Alliance. ILS was also host to the 9th Annual Meeting of Proteomics Society, India (PSI) and International Conference on Proteomics in Health and Disease, 2017. Other workshops and training programmes include the International conference on Plant Development Biology organized in association with NISER, the 3rd Orientation Workshop on Laboratory Animal Sciences, and hands-on training on Ultra-Microtome. ILS actively participates, and is committed to reaching out to school and college students, teachers and the public at large to captivate and nurture a general understanding of science among all. As part of this outreach programme, Science Summer School, symposium for science teachers, Refresher course for Biology faculties teaching in school, colleges and universities and visit of schools by ILS faculties were organised. ILS organised the science exposition and open day which was participated by more than 800 school and college students. During the year Institute has supported more than 15 scientific and technical manpower through extramural research grants. A total of 45 research articles were published, 2 patents were granted and 2 patents were filed during the period. Two technologies developed by ILS were licensed to industry partners

8. RAJIV GANDHI CENTRE FOR BIOTECHNOLOGY (RGCB), THIRUVANANTHAPURAM, KERALA

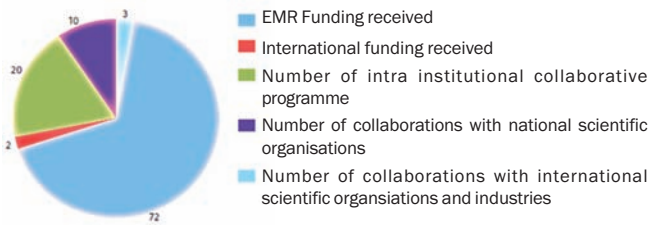
The mandate of RGCB is Discovery, Innovation and Translation in Biotechnology and Disease Biology. India's engagement with biotechnology, life sciences and medicine is dynamic and constantly evolving. RGCB sees itself as a key player in this development process. Research is focused on understanding disease 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.

Salient Achievements

RGCB has major emphasis on human resource development as shown in the figure.



Research Grants



Scientific achievements of RGCB includes: 89 scientific research papers; 1366 citation; 8 Indian/International patents filed; and 1 patent has been granted.

Impact

The Molecular Forensics and DNA Fingerprinting (MFDF) division helped the investigation agencies to identify victims of cyclone Ockhi. The MFDF also receives numerous samples for identification, maternity/paternity and relationship disputes forwarded by courts from different districts of Kerala and the Women's Commission. This year alone, a total of 204 samples forwarded from various forest range offices through courts related to animal poaching were identified.

Health and Science education to schools: RGCB has made efforts for spreading awareness on good health and imparting science education to schools students have led us to initiate several outreach programs in government and private schools across Kerala. Research laboratories at RGCB are always open to schools and colleges of Kerala for short term and summer training, as part of its commitment to human resource development. National Science Day was celebrated in RGCB on February 28, 2019 where excited young students from various schools of Thiruvananthapuram actively participated. Science day Lecture was delivered by Dr. Jinesh KB, Associate Professor, Indian Institute of Space Science and Technology, Trivandrum on “Seeing and playing with atoms: the evolution of microscopes”.

During the year Institute has supported more than 100 scientific and technical manpower through extramural research grants.

RGCB - Medical Laboratory Services: Application of RGCB's Translational Capability For Better Health Care:

RGCB Medical Laboratory Services (MLS) is an indispensable clinical laboratory professional partner that provides clinical laboratory information and services by use of optimal but advanced levels of health care resources. This permits maximizing effective delivery of care in today's complex healthcare system by accurate test results that enable providers to make the right diagnostic and therapeutic decisions

BioNest: BioNest is jointly run by Rajiv Gandhi Centre for Biotechnology (RGCB) [under the aegis of Department of Biotechnology, Government of India] and Kerala Start up Mission (KSUM) [the implementing agency of Government of Kerala for entrepreneurship development and incubation activities]. There are 4 broad business verticals: molecular biology, fermentation technology, phyto-technology/herbal medicines and micro propagation. 17 incubatee companies are operating as start-ups from BioNest.

AqueSense is a coliform detection kit product marketed at Rs.200/- compared to the competitor's price of Rs. 2200/- was developed (A BioNest Product).

Foldscope to Schools: *RGCB has conducted an outreach workshop on the assembly and use of Foldscope.*

9. REGIONAL CENTRE FOR BIOTECHNOLOGY (RCB), FARIDABAD, HARYANA

Regional Centre for Biotechnology (RCB) is an academic institution established by the Department of Biotechnology, Govt. of India with regional and global partnerships synergizing with the programmes of UNESCO as a Category II Centre. The primary focus of RCB is to provide world class education, training and conduct innovative research at the interface of multiple disciplines to create high quality human resource in disciplinary and interdisciplinary areas of biotechnology in a globally competitive research milieu. In 2016, RCB was recognised as an Institution of National Importance by the Indian Parliament.

The vision of RCB is to produce human resource tailored to drive innovation in biotechnology, particularly in areas of new opportunities and also to fill 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 programmes of the Centre are designed to create opportunities for students to engage in multi-disciplinary research to provide solutions for human and animal health, agriculture and environment.

Research-based-learning is the hallmark of the RCB academic program. The Centre provides education and training in the biotech sciences at the pre-doctoral, doctoral, and post-doctoral levels. Currently, RCB is offering an integrated MSc-PhD program in Biotechnology, and PhD programs in Biotechnology, Biostatistics, and Bioinformatics. Regional Centre for Biotechnology and GlaxoSmithKline (GSK) Pharmaceuticals Ltd. are collaborating under their 'Trust in Science" program to offer novel doctoral programmes in the area of Bioinformatics and Biostatistics. The Centre conducts domain-specific short-term training programs that are designed to create a cadre of highly specialized scientists for high-end research and technology development.

At the international level, RCB has a partnership with the Advanced Institute of Science and Technology (AIST) of Japan under which joint research programs are run at two places. RCB also has a partnership with the European Synchrotron Radiation Facility (ESRF) in France through which we are training Indian researchers on their advanced beamline for research purpose. This collaboration has benefitted more than 200 Indian researchers so far.

Major initiatives

Following the approval of the RCB statutes, ordinances and regulations, an integrated MSc-PhD programme in Biotechnology was launched where students with a graduate degree will be admitted through a nationally-competitive process.

The RCB Act 2016 empowers the Centre to recognize institutions of higher learning for their various academic programs and in this direction, after the due diligence, RCB granted academic recognition to the PhD programs at the Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad; National Institute of Animal Biotechnology (NIAB), Hyderabad; National Agri-Biotechnology Institute (NABI), Mohali; and Centre for Innovative and Applied Biotechnology (CIAB), Mohali.

RCB provides opportunities for young scientists by offering short-term innovative education and training programmes that contribute to the human resource development in the advanced areas of life sciences and biotech sciences. In this direction, the first RCB Bioimaging School was conducted during March 2018. The school highlighted popular imaging systems that have been extensively used in biology and biomedicine. Twenty-one participants from across the spectrum of research scholars, postdoctoral fellows and faculty were selected for the school from across India. The instructors and speakers included experts from prestigious academic research institutions and universities in India and Japan.

The Biosafety Support Unit (BSU) of the Centre trained Biosafety regulators from different African countries on

'Food/Feed & Environmental Risk Assessment-as part of the Biotechnology and Biosafety study tour to India for African nationals in February 2018 in association with TERI. The third meeting of the India-US Strategic Dialogue on Biosecurity was organized in February 2018 where experts from both the countries reviewed the Biosecurity issues, potential biological threats and our preparedness.

Under the auspices of the Department of Biotechnology (DBT) of Government of India, and the European Synchrotron Radiation Facility (ESRF) Council, RCB signed a three-year arrangement for the medium-term scientific use of synchrotron radiation for non-proprietary research, with focus in structural biology, to provide access to the ESRF to Indian scientists. The program was launched by the Honorable Minister for Science and Technology Dr. Harsh Vardhan in May 2017. This programme has provided tremendous support to the Indian structural biologists and has benefited a large number of young research students.

Regional Centre for Biotechnology organized an International Conference on 'Structure assisted development of novel therapeutics' during February 12-16, 2019. The workshop provided insights on the protocols and infrastructure regarding structure-based drug design. Several training programmes are regularly conducted with partnership from academic and industry to enrich the career path of students and young scientists.

Additionally, RCB continues to participate in a multi-institutional research programme aimed to understand the biology of pre-term birth to identify possible biomarkers to predict the outcomes. A large cohort of pregnant women has been established by THSTI at the Gurgaon Civil Hospital and the scientists at RCB are conducting a comprehensive study on the proteome of the various tissue samples from these women.

Major Achievements

RCB scientific achievements in terms of quality of publications and the ability of our faculty to attract extramural grants has shown considerable growth as can be seen in graphs below. Besides, information on industrial consultancies and collaborations is provided below.

Also, with respect to the academic program, a large number of PhD students were admitted to RCB during the reporting period. Several honors and awards were received by the RCB faculty and these are listed below.

Societal Impact

Through its academic and training programs, RCB has been contributing to the human resource development in the high-tech area of biotechnology thereby impacting significantly to India's growth story and societal development. Besides, their research is focused on areas highly relevant to human health, especially in the context of India, such as mosquito-borne infectious diseases, and cancer therapy.

During the year RCB filed 2 patents applications, published 28 research articles and supported 8 PhD students and more than 75 scientific and technical manpower through extramural research grants.

10. 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. 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

For the BMGF-funded project '*Building the clinical research ecosystem in India*'. THSTI has entered into a subaward agreement with the University College London. THSTI along with ICMR, WHO and other partners to develop tools to strengthen the clinical research ecosystem, indispensable for translation of basic discoveries with potential of clinical utility into usable products.

Half of the snake-bite related deaths occurring globally are reported from India. THSTI has ventured into this challenging area along with Tezpur University, with a newly sanctioned project by BIRAC to develop aptamer-based rapid test to differentiate venomous snake bites from non-venomous and dry snake bites. Also, in aptamer-based diagnostics development, THSTI and her start-up M/s Aptabharat Innovation Pvt Ltd have entered an agreement with AIIMS, New Delhi for facilitating development of aptamer-based diagnostics.

The institute signed a sub award agreement with National Institute of Biomedical Genomics (Kalyani) for the BMGF-funded project '*Maternal micronutrient and genetic associations with pregnancy outcomes in North India*'.

THSTI has started deciphering neonatal, maternal, and child health data stored in its Garbh-IN-i Biorepository in collaboration with IIT Madras in the project "Preterm Birth risk in pregnant women-prediction using machine learning models".

THSTI initiated a project for establishing anti-diabetic potential of young shoots of Wendlandia glabrata D.C. and fruits of Phoebe cooperiana with North-East Institute of Science and Technology and Institute of Advanced Study in S & T.

The Drug Discovery department of THSTI started formulating a manufacturing process of near expiry patented API Sorafenib IP in collaboration with Penam Labs.

A non-disclosure and facility due diligence agreement has been signed with BioBridge for ascertaining suitability of facilities at THSTI and Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL) for Oral Cholera Vaccine assay/ manufacturing.

Subaward Agreement between THSTI and CDSA for the project titled "Indian Surveillance and Impact Studies: New State Roll-out".

NDA between THSTI, Medanta Hospital Gurgaon, Cohesive Labs Pune, Baby Memorial Hospital, Kozhikode, and St. Johns Research Institute for the project entitled "Development of an affordable McCoy Video Laryngoscope".

International Meetings/Symposia:

The International Vaccine Institute (IVI) and the Translational Health Science and Technology Institute (THSTI) of India organized a joint symposium at IVI headquarters in Seoul, Korea on November 22. More than ten speakers, including four from THSTI and other participants from the Korea Health Industry Development Institute (KHIDI) and India's Department of Biotechnology (DBT), participated in the one-day symposium to share an overview of current research and development projects at THSTI and IVI, as well as to discuss common interests while exploring collaboration opportunities.

National Meetings/Symposia:

THSTI hosted the 45th Annual Meeting of the Indian Immunology Society at its premises in the NCR Biotech Science Cluster, Faridabad from 1st-3rd November 2018. The theme of Immunocon 2018 was Immunotherapy and Advances in Immunology.

The NCR Biotech Science Cluster partners host a seminar series every month and the November's NCR Cluster Seminar Series was organized by THSTI at the

NCR BSC Auditorium on November 19, 2018. A series of three lectures were organized on the theme Diagnostics: Recent Advances and Perspectives

Achievements:

THSTI filed 9 patent applications during the period April-December 2018 and published 37 scientific papers.

Students of the Faculty of Applied Sciences, Manav Rachna International University visited THSTI on 25th July 2018 and interacted with scientists and PhD students.

Faculty from the Drug discovery group at THSTI visited Shaheed Rajguru College of Applied Sciences for Women, University of Delhi on 14thSeptember 2018 for delivering lectures.

THSTI organized its second open day on September 28, 2018 as a pre-event to the 4th India International Science Festival. The event was co-hosted by NIPGR. The highlights of the Open Day were laboratory visits by school and college students, a popular lecture and poster session.

THSTI has signed a MoU with Indian Council of Medical Research (ICMR) for building the basic, clinical, translational and implementation research ecosystem in India.

THSTI and Tata Translational Cancer Research Centre, Kolkata entered into collaboration for:

a. Creating Integrated Electronic Platforms to Aid Research Application.

b. Development of a Small Animal Facility.

c. Development of Joint Research Academic and Training Programs.

THSTI and Bharat Immunological and Biological Corporation limited (BIBCOL) entered into funding agreement with BIRAC for the project entitled "Production of safe and effective oral cholera vaccine of global GMP standards in India through Industry Academia partnership to meet India supply needs".

Societal Impact

From the work ongoing at THSTI, based on the leads so far, it is expected that in the short-term (3-5 years), the direct impact on the population will come from products such as the diagnostic tests (blood borne viruses, dengue, bacterial pathogens, TB) developed at THSTI. In the next 4-7 years, it is envisaged that the prediction tools (for diabetes mellitus and NAFLD) and the vaccine development process supported by THSTI (for dengue, Chikungunya, typhoid and influenza) will be beneficial for the society. In the long term (6-10 years), the TB reagent repository will lead to new understanding of disease and potential interventions. Research in the field of microbiome and leads from NAFLD research may result in new treatment approaches for large-scale health problems in India. Additionally, the outputs from the maternal child health program will have a direct positive influence over major components of at least two Sustainable Development Goals (3 and 9) in the National Mission. During the year Institute has supported more than 240 scientific and technical manpower through extramural research grants.

11. INSTITUTE FOR STEM CELL SCIENCE AND REGENERATIVE MEDICINE (INSTEM), BENGALURU, KARNATAKA

The Institute for Stem Cell Science and Regenerative Medicine (inStem) at Bangalore, is India's first stem cell institute committed to accelerating advances in stem cell biology & regeneration to understanding disease. 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. Efforts are focused on building core strengths in stem cell biology and manipulations, in areas such as repair from injury or wounding, disorders of the brain and heart disease in the groups at inStem.

The thrust on interdisciplinary, thematic research with translation emphasis has allowed inStem to tackle complex questions in ways that cannot be addressed in individual investigator-driven efforts. inStem has also engaged with various international universities/institutes to enhance its technical and scientific capabilities. Significant amongst these have been partnerships in the clinical setting, which have led to large centre grants with well-defined mandates in the area of translational neuroscience as well as in

chemical biology. Other initiatives, which began more as more opportunistic interactions have consolidated activities in the following broad areas: Tissue specific regulation of renewal and repair; analysis of stem/ progenitor cells to understand specific programs and genes; delineating mechanisms governing self-renewal/repair and alterations during ageing, inflammation or disease.

Major Initiatives

Inauguration of National CryoEM facility:

The National CryoEM Facility which was inaugurated by Bharat Ratna Prof. C. N. R. Rao in the presence of Prof. Richard Henderson, the Nobel laureate in Chemistry (2017) is now well equipped with a 300 kV Transmission Electron Microscope (TEM), capable of high-resolution structure determination of macromolecules in solution as well as *in situ* in cells by tomography. This facility is now open and hosting researchers from laboratories across India and has already conducted saveral workshops to initiate new users.

Inaugural Symposium of the Tata Institute for Genetics & Society, Centre at inStem

inStem held the inaugural symposium of the TIGS - Centre at inStem, which is a partnership between the Tata Institute of Genetics and Society India (TIGS India), The inaugural conference was held on 24th and 25th of October, 2018.. The symposium, entitled "New Tools and Technologies for Health and Agriculture", hosted scientists from India, the USA and the UK as well as over 100 students and postdocs from institutes across the country.

Achievements

The overall objective of the Centre for Inflammation and Tissue Homeostasis (CITH) is to decipher the regulation of tissue development, regeneration and repair and the increasingly critical role that inflammation plays in these processes. One of the highlights of this theme's efforts has been a partnership with clinicians at the Bangalore Medical College and Research Institute to investigate the efficacy of human hair follicle stem cell grafting on the repair of chronic non-healing ulcers

The Accelerator Program for Discovery in Brain Disorders (ADBS), is on track to meet its targets with a recruitment of 1015 donors. Neuropsychological assessments are completed for 394 individuals, MRIs completed for 392 individuals; EEG completed for 317 individuals; amongst other assays. DNA has been extracted and sequenced from 746 individuals and 225 LCLs, a first step to generating iPSC completed. The ADBS Biorepository currently has a total of 61 lines, of which 43 are from affected individuals and 18 are from control individuals. The clinical protocol was published earlier in the year. A system is in place for live entry of patient information. LIMS platform is set up to record the outcomes from clinical assessments, neuropsychiatric assessments, brain imaging, clinical-electrophysiology and biochemical assessments.

The related programme at the Centre for Neuro developmental Synaptopathies has established protocols for the generation of functional cortical neurons, astrocytes, microglia and oligodendrocytes to study: 1) cell autonomous consequences of FXS mutation on cortical neurons, by analyzing how FMRP regulates spontaneous bursting in hPSCs derived cortical neurons.2) Role of astroglia in the pathogenesis of neurodevelopmental disorder like FXS and 3) The molecular, cellular and functional cell and non-cell autonomous consequences of FXS mutation on cortical OPCs and OLGs. The centre has been characterizing the biochemical, electrophysiological and behavioral consequences of a range of mutations in several newly generated genetic rat models of ASD/ID.

The Centre for Chemical Biology & Therapeutics recently completed the first phase of the development of Bractoppin, a drug-like inhibitor of phosphopeptide recognition bythe human BRCA1 tandem (t)BRCT domain, which selectively inhibits substrate binding withnanomolar potency *in vitro*.This work illustrates a new approach to selectively interrupt intracellular signaling pathways initiated by protein kinases using drugs that block the molecular recognition of phosphorylated proteins.

A team of researchers from the Technologies for Advancement of Science atinStem has developed a nucleophilic polymer, which formulated into a topical gel can be applied on the skin before spraying of pesticides. This gel can deactivate pesticides on the skin through nucleophilic mediated hydrolysis, thereby preventing pesticide-induced toxicity and lethality. inStem's nucleophilic catalytic gel is

active against a wide range of pesticides, insecticides, and fungicides including commonly used commercial pesticides in India.

The Centre for Stem Cell Research (CSCR), inStem's translational group, located in CMC - Vellore, continues to focus on translational research in cell and gene therapy to bring stem cell science and other novel therapies to the management of patients with unmet needs. The concept of teams working on specific themes through multidisciplinary collaborations is being further enhanced to move closer to this goal. A major enhancement of some of the existing efforts at CSCR have come through the program on Novel Applications in Haematological Diseases (NAHD) under the multi-institutional Indo-Japan program on Accelerating Applications of Stem Cells to Human Diseases (ASHD).

A novel pilot study of scaffold-based autologous mesenchymal stromal cells for correction of large segment bone loss in children has been completed; two phase I/II clinical trials have been initiated for the treatment of physeal bars and osteogenesisimperfecta. Two preclinical studies are in progress for osteochondral and segmental bone repair using functionalized scaffolds

Farmers are exposed to toxic pesticides, through skin contact and inhalation, during the spraying of pesticides. This is a severe health hazard. A team of researchers from in Stem has made significant advance in the development of a topical gel can be applied on the skin before spraying of pesticides

Located within the Bangalore Life Sciences Cluster campus in Bangalore, inStem recently moved its own building equipped with state-of-the-art infrastructure. On 24th February, 2019, the new building of the Institute for Stem Cell Science & Regenerative Medicine (inStem) in Bangalore was formally inaugurated by Dr. Harsh Vardhan, Hon'ble Union Minister for Science & Technology; Earth Sciences; Environment, Forest and Climate Change, in the presence of Dr. Renu Swarup, Secretary, DBT. The Minister marked the occasion by planting a tree and naming the building, Atal Anusandhan Bhawan. The Minister accompanied by scientists from the three institutes of the Bangalore life Science Cluster and visitors, toured the National CryoEM Laboratory Facility, Stem Cell facility, and other inStem laboratories at the event.

Impact

Researchers at inStem are advancing understanding and thereby contributing to improving technologies for skin grafts used for healing burn injuries or diabetic wounds. The research results led to 26 publications and 04 patent applications. inStem participated in the India International Science Festival held at Lucknow in October, 2018. Hundreds of people of across age-groups visited the kiosk and learned about the thematic areas of research pursued at inStem. Multiple posters of core and collaborative activities at InStem and its partnering institutions (NIMHANS, CMC-Vellore, and others), demonstrations, and interactive spaces showcasing regeneration were on display.

inStem is a member of the Bangalore Life Sciences Cluster, and on November 16th, 2018 the institutes on campus opened their doors to the public to share their science. Different research groups from the campus showcased their work through posters, live demos, exhibits, scientific experiments, and interactive modules. More than a thousand people visited the Bangalore Life Sciences Cluster to learn more about the research performed on the campus.

inStem PIs participated in the Bangalore life science cluster's public engagement nitiatives such as the BLiSc Science Café and the Jigyasa Project. During the year Institute has supported more than 80 scientific and technical manpower through extramural research grants.

12. NATIONAL INSTITUTE OF BIOMEDICAL GENOMICS (NIBMG), KALYANI, WEST BENGAL

NIBMG was established in the year 2009. The mandate is to create necessary physical infrastructure for principles and practice of Biomedical Genomics. NIBMG intends to conduct and promote cutting edge research on biomedical genomics for better understanding of public health need and also like build Capacity in Biomedical genomics. The vision of NIBMG is to enhance knowledge on human health and disease through genomics and translate the knowledge using appropriate technologies for promotion of well-being and improvement of genetics based health care in India. The institute is mandated to create necessary physical infrastructure and build capacity to serve as the expert base for the establishment of principles and practice of medical genetics and to conduct and promote cutting edge research in biomedical genomics for better understanding and containment of public health burden.

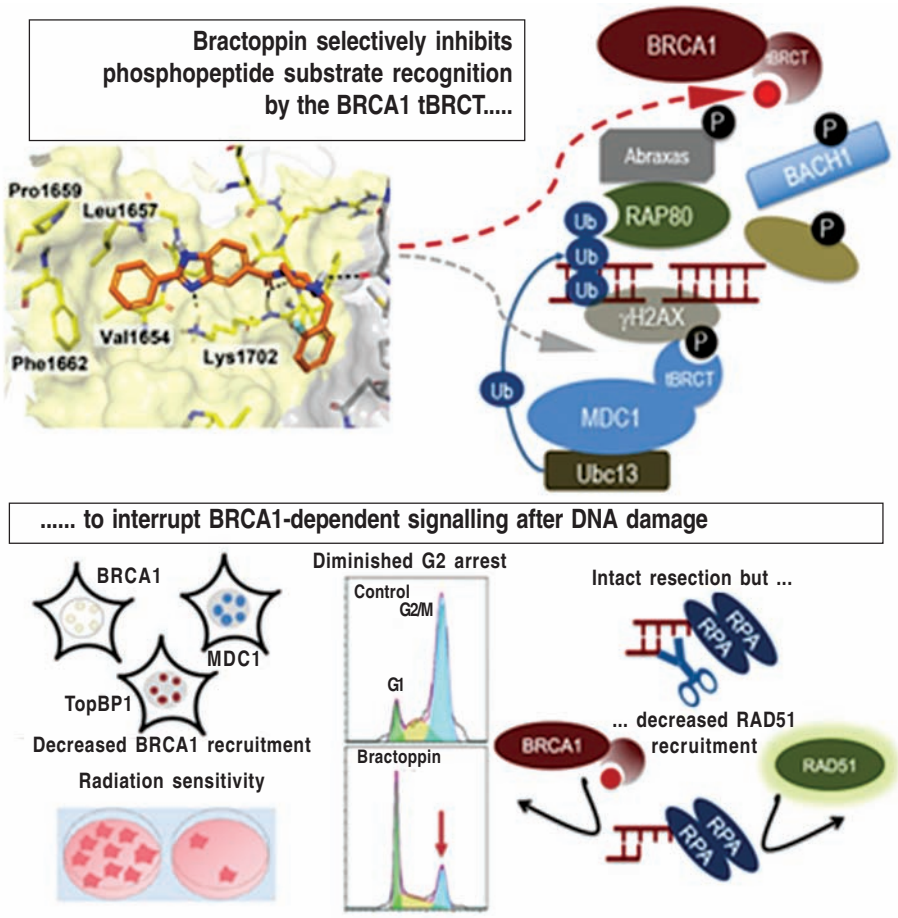
Major Initiatives

Setting up a Zebrafish facility at the NIBMG for functional genomic studies. This facility will help in confirming the functionality of genes and regulatory elements underlying human disease biology with high efficiency and generation of relevant animal models that uphold in-depth studies of disease mechanisms or potential drug discovery;

Interim animal holding facility at NIBMG for experiments that require constant monitoring or applications that require freshly dissected tissues;

Imaging facility for High sensitivity multichannel imaging, Macro and micro imaging at super resolution and High speed time-lapse imaging;

Benchtop NGS platform (MiSeq) for small scale amplicon & targeted sequencing (to validate and expand on our



A new inhibitor developed by scientists at inStem

Nobel laureate Prof. Richard Henderson, Bharat Ratana C. N. R. Rao and Prof. Satyajit Mayour Director inStem, NCBS at the inauguration of the National Cryo-EM facility at inStem Bangalore.

whole genome & exome sequencing hits) - this will also help identify possibilities of translation of our genomics findings on various cancer types;

Developing a patient derived three-dimensional model of solid tumors which will be used as tools for mechanistic understanding of variable clinical responses to a given treatment and may also be useful for pre-clinical drug testing and suggesting novel targets;

Developing a diagnostic panel for rapid detection of early onset sepsis and anti-microbial resistance in high-risk neonates;

Introduction of Integrated MS PhD on Biomedical Genomics;

Doctoral program on Biostatistics and Bioinformatics, jointly with Regional Centre for Biotechnology (RCB) and GlaxoSmithKline Private limited (GSK);

Achievements

Dr. Bornali Bhattacharjee was awarded the 2nd prize in the 4th Agar Art contest organized by the American Society for Microbiology. The goal of Agar Art is to provide a venue for the creativity of ASM's scientist members and to highlight the beauty and diversity of the microbial world and had 156 entries from 23 different countries and 22 US states.

NIBMG Summer School on Systems Biology, July 17-23. The workshop was attended by 49 participants from all over India. The workshop was spanned over 40 hours in 5 days with approximately 25 hours of hands on practical session.

Third Advanced North-East Region (NER) Research Training Workshop on "Understanding Human Disease and improving Human Health Using Genomics-Driven Approaches" was held in NIBMG from 23 to 31 July 2018. Participants of this Workshop were from various organizations located in NER.

A workshop was organised in NIBMG in collaboration with EMBL titled "Analysis of genome scale data from bulk and single-cell sequencing" to train researchers in India who are engaged in genomics research on applications in statistical and bioinformatic analyses of data generated by massively-parallel sequencers using nucleic acids isolated from bulk cells or a single-cell.

Impact

The National Institute of Biomedical Genomics (NIBMG) organized the outreach program on September 28, 2018. 110 students from 8 schools near Kalyani and Kanchrapara area visited NIBMG accompanied by their teachers. This outreach program provided a run-up for the upcoming IISF-2018 held in Lucknow during Oct 5-8, 2018. This outreach program was immensely beneficial for students and definitely made them interested towards research in biomedical genomics as evident from their sharing of experiences.

NIBMG published 20 research articles and supported 2 PhD students during this year. During the year Institute has supported more than 70 scientific and technical manpower through extramural research grants.

India International Science Festival: Public (IISF) Outreach & Open Day Program, held on September 28, 2018

Nobel Laureate Harold E. Varmus was delivered a lecture on The Transformation of Cancer on November 11, 2018

13. NATIONAL AGRI-FOOD BIOTECHNOLOGY INSTITUTE (NABI), MOHALI, PUNJAB

National Agri-Food BiotechnlogyInstiute (NABI) was established with the objective of promoting and coordinating research of high calibre in basic and translational aspects at the interface of Agriculture, Food and Nutrition. The Mandate of NABI is to be a centre of excellence and provide leadership in agri-food biotechnology research Insititue to ensure food and nutritional security for all through agri-food biotechnology research and innovation. Overall aim is to improve nutritional quality and availability of affordable agri-food and food products through innovations.

Major initiatives

Metabolic engineering of triacylglycerol metabolism pathway to trigger oil content stability in plant leaves and seeds have been undertaken.

Understanding and improving nutrient partitioning during rice gain filing has been initiated. In this regard transcriptome based approaches were also integrated to find the novel genes that could serve as a good candidate for micronutrient transport.

Novel strategies have been undertaken to address the antinutritional component like ODAP like marginal crop like *Lathyrus* spp.

New avenues of nutritional biotechnology are being addressed by recombinant production of Omega-3 polyunsaturated fatty acids of bacteria from high altitude lakes of Indian Himalayas

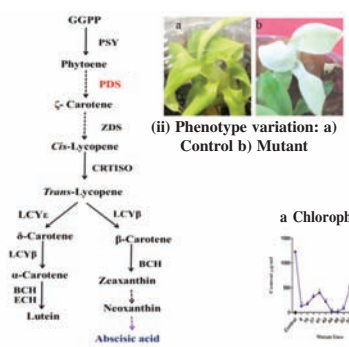
NABI was recognized as a center for pursing Ph.D. degree in Biotechnology as well as NABI scientists are now recognized as adjunct faculty of The Regional Centre for Biotechnology, Faridabad.

Anthocyanin biofortified wheat seeds were sown at 30 acres in NABI farm and 81 acres in farmer's field in the states of Punjab, Haryana, MP, UP, Rajasthan, Chhattisgarh and Gujrat with 85% average yield in comparison to check.

Salient Achievements

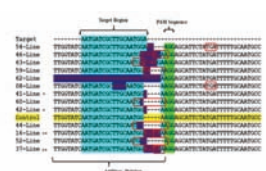
During the last one year, considerable progress has been made to characterize the wheat TILLING population at the candidate gene level to modify the starch content in grains.The improved varieties of anthocyanin rich coloured wheat were taken to the commercial level and multiple MoU's were signed with different companies to extend the work for product development. Researchers at NABI have also demonstrated proof of concept in Banana for the feasibility of carrying out CRISPR based genome editing. This technology is now exploited to develop trait in Banana as well as in crops like wheat, rice and *Lathyrus. P*utative probiotic bacterial strains that could prevent low protein, moderate fat and high sucrose diet induced metabolic, inflammatory and behaviour abnormalities were identified. A proof of concept has been developed for the usage of sweet prebiotics such as isomalto-oligosaccharides in combination with antioxidant/anti-inflammatory agents such as cinnamaldehyde and cranberry extract in protecting against high fat diet induced obesity and associated complications to develop novel class of functional foods as "Cobiotics".

Some of the major research highlights are represented with the pictures shown below.

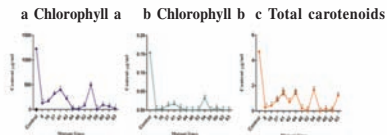


(i) Carotenoid biosynthesis pathway

(ii) Phenotype variation: a) Control b) Mutant



(iii) Mutations observed in mutant lines



(iv) Pigment quantification in mutant lines

Phytoene desaturase editing using CRISPR/Cas9 (i) Carotenoid biosynthetic pathway (ii) Phenotypic variation among control and mutant. (iii) Indels observed in *RAS-PDS* targeted region. (iv) Quantification of chlorophyll (a, b) and total carotenoid content in mutant lines.

Impact: With the developing landscape of the institute three Ramalingaswamy fellows and six DST-Inspire faculties have joined at NABI during the last one year. NABI and Center of Innovative and Applied Bioprocessing (CIAB), Mohali jointly organized one day national meet of science oriented Social Organizations by the Vibha-Vani Chapter of Haryana, Punjab, Himachal Pradesh and Chandigarh. The event was attended by about 100 NGOs from Haryana, Punjab & Himachal Pradesh.

NABI conducted Industry-Academia meet in August 2018. Primary goal of this meet was to interact with various Food Processing Industries and Entrepreneurs across Punjab State to identify the unmet need and possible gaps in their processes as well as to explore the possible opportunities with respect to infrastructure and technologies of both CIAB & NABI institutions. More than 20 industrialist/ entrepreneurs attended this meeting and interacted with scientists of CIAB, NABI, and PSCST.

Multiple training programs at the level of Scientist, Masters student and Project mode are been regularly taken by researchers at NABI. A total of 39 numbers of people have been trained in the area of Agri-Food and Nutritional Biotechnology. NABI also conducted computational workshop in March 2018 for the training students/faculties from all over the India. During this training program approximately thirty researchers participated in the program.

NABI conducted Open Day for school and college students in the month of September 2018. More than 180 students from various school and colleges participated in the event. The students were exposed to the different ongoing research activities at NABI. Students also participated in the interaction sessions by means of debate and model making competition.

NABI developed two technologies, commercialised one product, transferred one technology, filed 2 patents, published 26 research articles and supported 4 PhD students and 5 Postdocs during this year.

14. NATIONAL INSTITUTE OF ANIMAL BIOTECHNOLOGY (NIAB), HYDERABAD, TELANGANA

National Institute of Animal Biotechnology (NIAB) is working on important issues of farm animals using modern tools of animal genomics and genetics, transgenic technology, reproductive biotechnology, bioinformatics and nutrition enrichment with an aim to enhance productivity and improve animal health. The emphasis is given to both applied and basic research for development of novel vaccines, diagnostics and improved therapeutic molecules for farm animals. NIAB is also doing research to address farm level problems faced by dairy farmers like inability to detect animal in heat as well as early pregnancy and presence of antibiotic and pesticide in milk etc. NIAB has initiated a program to understand the existence and spread of Anti Microbial Resistance (AMR) in microbes associated with poultry birds. NIAB is committed to understand problems of the marginal farmers and resolve them in collaboration with appropriate partners so that benefit of research is directly translated. The major emphasis is to use modern biotechnological tools to find a better and easy as well as cost effective measure as a solution to existing problems of farmers.

MAJOR ACHIEVEMENTS

Livestock genomics programme was initiated in a mission mode to find out breed specific signature of indigenous cattle. In this project, cutting edge technologies such as NGS, array based genotyping etc. are being used to decipher the genetic makeup of all registered cattle breeds for conservation of indigenous cattle. The data generated from NGS will help in making chip for identifying relatively pure individuals in herd of specific breed.

NIAB is establishing testicular transgenesis in farm animals for generating animals producing therapeutic protein in milk. Expression of the construct was validated for expressing marker protein (EGFP) in the sperm surface for easy separation of the transgene bearing sperm from the whole ejaculate.

In order to study the complex life cycle of *Toxoplasmagondii*, a parasite of medical and veterinary importance, NIAB has systematically identified two cyclin and CDK pairs to understand their role in gene regulation related to its survival. Six immunodominant antigens were also identified in *T.*

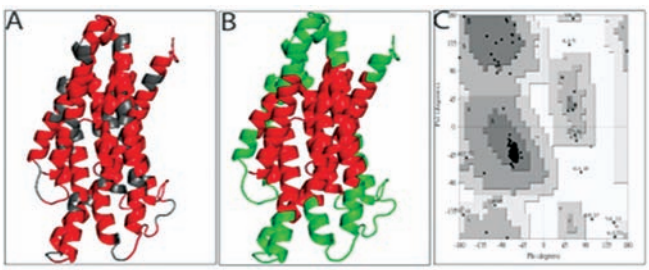
gondii, which may be used for development of diagnostics.

Molecular epidemiology and genomics of bovine mastitis-associated are being carried out to know its genetic diversity and to build a repository of mastitis associated bacteria.

In India, brucellosis in livestock and its impact on public health causes a huge economic loss. NIAB has undertaken a High throughput siRNA screening which led to identification of host proteins supporting the invasion and intracellular multiplication of *Brucella*. Two immunodominant protein antigens (BM-5 and BM-7) of Brucella are being used at NIAB to develop ELISA based diagnostic. Work on validation and improvement of BM-5-based Lateral Flow Assay (LFA) device is also under progress.

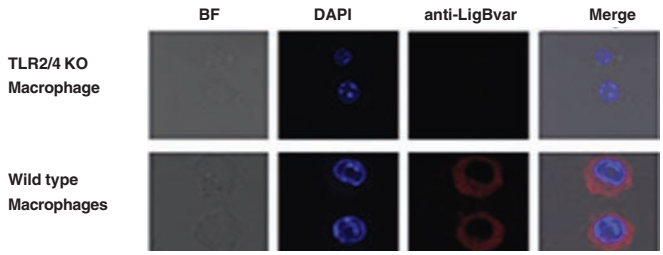
Newcastle disease (NDV) is a highly contagious respiratory, neurological and/or enteric disease in chickens which is endemic and episodes of outbreaks despite strict vaccinations are common. NIAB has successfully cloned the RNA dependent RNA polymerase complex proteins and tested their functionality using EGFP reporter minigenome system. Work is ongoing to rescue the recombinant virus by CMV based system. A novel subgenotype (XIIIe) of NDV in NDV vaccinated birds that had succumbed to NDV infection in Tamil Nadu has also been identified.

Theileriosis causes huge economic losses to the farmers. The current vaccine has lots of drawbacks such as need to maintain a cold chain, high cost, and short shelve life. Using *in silico* approach, novel vaccine candidates have been identified in NIAB and a novel multi-epitope construct containing vaccine candidate have been designed that effectively binds with TLR4, increasing possibility of developing cell mediated response. Real-time PCR assay based diagnosis has also been developed at NIAB for theileriosis.



Model of multi-epitope vaccine candidate for Theileria annulata*: A. Multi-epitope vaccine candidate in red and linker in black, B. Predicted B-cell epitopes in multi-epitope vaccine candidate is shown in green, C. Ramachandran plot of multi-epitope vaccine candidate.*

Current vaccines for leptospirosis provide limited protection and are unable to prevent the shedding of bacteria in urine. Leptospira immunoglobulin like proteins (Lig A and Lig B) as ligand for Toll like receptors (TLR2 and TLR4) were identified at NIAB. Further, the domain involved in signalling through these receptors were also been identified and characterized which can be tested for development of vaccine/diagnostics. Novel emulsion adjuvant AS007, which induced superior immune response than Alum, Freunds and Montanide adjuvants has been developed and work is under process to evaluate its efficacy.



Recombinant Leptospira *immunoglobulin like proteins (Lig B) were purified and the figure shows the Interaction of its variable region with TLR2 and TLR4 receptors of mouse macrophages.*

NIAB is reaching out to the farmers and discussing the problems being faced by them in livestock rearing across the country. The outreach program called MILAN (Meeting of Indian Livestock farmers and Agriculturists with NIAB scientists) is initiated by NIAB to understand the burning and pending issues of farmers and veterinary clinicians related to livestock rearing and health care. Under this program, NIAB scientists have reached-out to eighteen (18) states including eight states of North-Eastern region. While organizing MILAN program, inclusion of aspirational districts was given preference. So far, a total 22 aspirational districts in different states have been covered. The outreach programmes conducted so far indicates that livestock farming is facing region specific problems and need special attention accordingly. During the year the research outcomes resulted in 12 publications.

Inauguration of NIAB campus:

Dr. Harsh Vardhan, the Hon'ble Minister for Science & Technology, Earth Sciences, Environment, Forest and

Climate Change, Govt. of India, inaugurated the new campus of NIAB on 11th August 2018. The occasion was graced by Dr.Renu Swarup, Secretary, Dept. of Biotechnology (DBT), Govt. of India.

Inaugural ceremony of new campus of NIAB on 12th August, 2018.

15. CENTRE OF INNOVATIVE AND APPLIED BIOPROCESSING (CIAB), MOHALI, PUNJAB

Center of Innovative and Applied Bioprocesing (CIAB) functions as 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.

The mission of CIAB is to test, validate, translate, innovate, improve, up-scale and integrate approaches and technologies related to bioprocessing of agrifood/agri-mass for promotion of secondary agriculture. To generate bioresources related knowledge and advance R&D leads and potential for the growth of research and innovation systems towards products development, technology translation, product quality assurance in the sectors of agri-food and secondary agriculture including technology demonstrations, training, clustering of entrepreneurs/stakeholders etc. in the lab-to market chain.

CIAB is working in four mandate areas of research. a): Value addition to primary processing residues or wastes for edible products; b): Valorization of crop wastes for specialty products and chemicals; c): Nutritionals, nutraceuticals, and upgradation of value or use of primary processing bioproducts; d): Biosynthetic technology/ synthetic biology for low volume-high value products and industrial enzymes.

Major Initiatives

Institute is partner in two very important international R&D programs with UK under Newton Bhabha Fund on 1) Development and optimization of fresh produce supply chain and storage systems; 2) Enhanced rice milling and maximized valorization of rice milling co-products.Institute is also partner in two very important national R&D initiatives on 1)Setting up of Secondary Agriculture/ Food Processing Entrepreneurial Network (SAEN) sponsored by BIRAC, GOI, 2) Setting up of Rural Biotech Innovation and Application Centre (RBIAC) in Kandi Area of Punjab sponsored by DBT, GOI and 3) CIAB has also initiated a flagship research project on Utilization of rice residues for value added product development sponsored by DBT, GOI.

Major Achievements

Oligosachharides production from agro-biomass:

Standardized process for bacterial cellulose production on whey medium

Developed process for the synthesis of rose oxide from â-citronellol via radical peroxidation using iodosylbenzene (PhIO).

A scale up process (120 g) for production of rose oxide value added citronella oil was developed.

A semi-synthetic process was been developed for preparation of an oil having significantly higher amount of rose oxide (~ 30%) content than any known essential oil occurring in nature.

Simple and cost effective process was developed to prepare a Prebiotic ready-to drink (RTD) whey beverage with fibers which were produced from fruit processing byproducts waste.

A titania-based catalyst was developed for large-scale isomerization of glucose to fructose.

A method was developed for isolation of lignin from lignocellulosic biomass in acidic deep eutectic solvent through organic solvent extraction.

An improvised, sustainable and economical process has been developed for the synthesis of biomass derived lignin coated metal nanocomplexes for use as nanotherapeutic and nanodiagnostic.

Lab scale to bench scale process for nanocellulose production from rice straw with low lignin content has been developed.

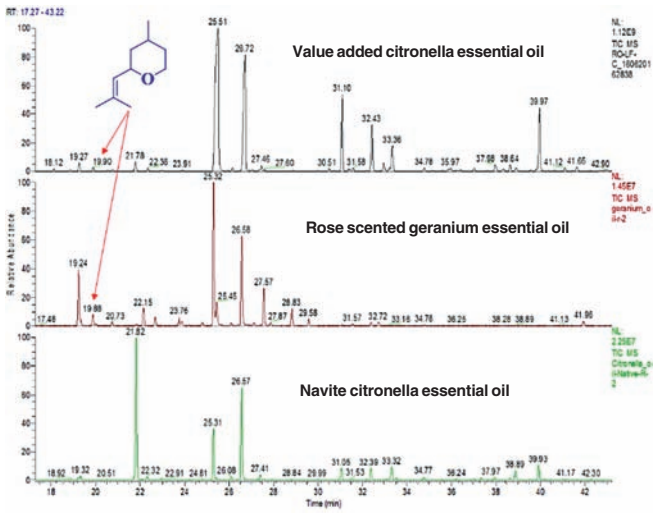
Process recovery of nano-silica and lignin from paddy straw was developed.

A special beverage based on tomato fruit juice, coconut water and other additives was developed.

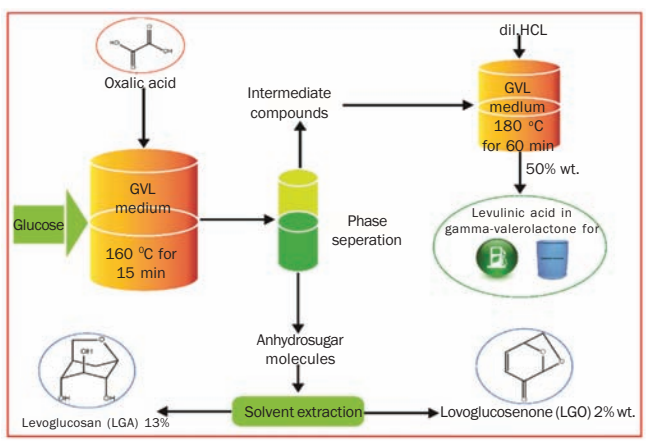
A process for production of fructooligosacharides and levan from plant biomass or fully or partially processed products or by-products or residues by employing levansucrase has also been demonstrated

Societal impact:

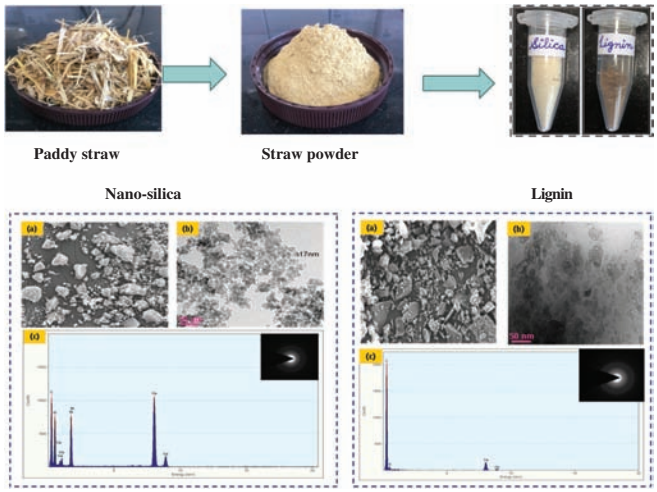
CIAB is the only institute in the country which works mainly on Bioprocessing Technologies and Value addition to Secondary Agriculture and waste biomass of Agro-industries. Mandate of institute fits well with the of Govt. of India's programme on Doubling the Farmer's Income, Waste to Wealth, and Swachh Bharat. Around sixty young research scholars are working, documenting the impact of institute on skilled professional development. Societal and industrial needs are being prioritized and positive mechanisms are being evolved to ensure rapid and effective translation of knowledge, to provide incubation space/ infrastructure and skilled professionals. Thrust is being given to create start-ups and entrepreneurs in the bioprocessing areas; students from schools and colleges are being given opportunities to acquaint with advance technological platforms, industries are being invited to address their problems and attempts are being made to find solutions to their unmet needs.Realizing the need of bioprocessing in agriculture based countries like India, CIAB can prove to be an asset institutions to create vibrant and coherent environment between academia knowledge to the transferable research outputs and skilled individuals. 35 students have been trained. The research outcome resulted in 132 publications, development of 7 processes/products and filing of 117 patent application.



GC-MS of value added citronella oil, native citronella and rose scented geranium oil



Process for bioderived glucose valorization to value addition chemicals through homogeneous integrated approach



A direct process for recovery of nano-silica and lignin from paddy straw agro-waste

16. INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY

ICGEB New Delhi encourages innovative research in the field of life sciences with special emphasis to fulfill needs of the for the benefit of developing countries. During 2018, the ICGEB New Delhi Component has made major advances in all aspects of its mandate, maintaining its focus on three macro areas of research, namely Molecular Medicine, Plant Biology and Integrative Biology. Not only the Component continues to be extremely active in research and maintains a high annual publication output, covering a wide spectrum of scientific investigations. but also participated in policy making meetings such as Science, Technology and Innovation (STI) Forum of the United Nations, held at the UN Secretariat in New York.

During the period, two national and six national Phases of one international patent application were filed, and one international patent was granted. ICGEB New Delhi conducted four ICGEB supported advanced training programmes to fulfill its commitment towards Member States. Approximately more than 100 researchers have attended these training programmes. At present, over 10 international (including Ph.D. students) personnel are on board participating in various research activities at New Delhi Component.

The year 2018 witnessed active involvement of ICGEB in outreach activities. It has participated in the IISF, 2018 at Lucknow. Around 440 students from 20 school and colleges visited ICGEB and learnt about latest trends in science.

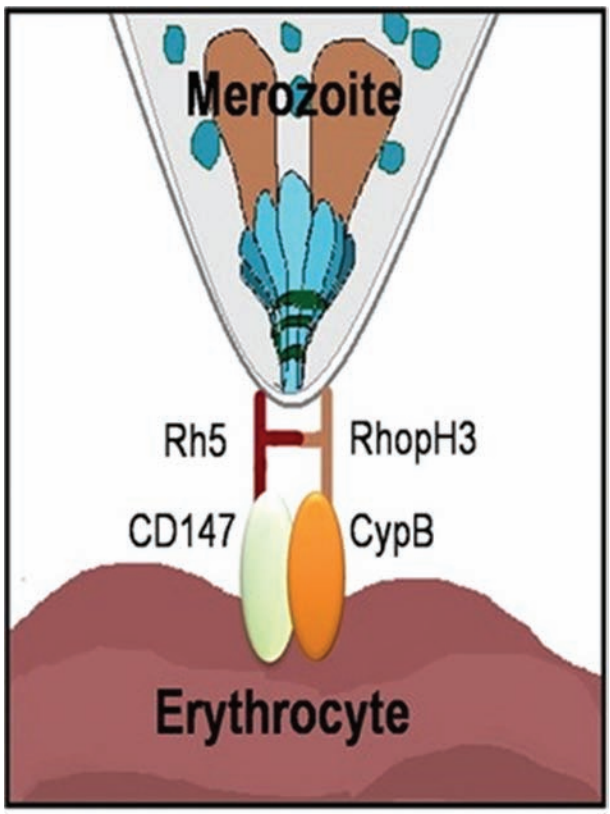
Salient Achievements

a. **Molecular Medicine:** The major focus of Molecular Medicine group is on Tuberculosis, Malaria, Dengue and Chikungunya diseases. Significant progress was made in all focus areas of Molecular Medicine. The tuberculosis group characterized macrophage response to Mtb infection using microarray experiments. One of the major findings was to identify changes in alternate splicing in macrophage transcriptome upon Mtb infection. Subsequently, it has been demonstrated that by specific alterations of splicing pattern of target genes, Mtb modulates stoichiometry of proteins involved in host innate defense functions. In Dengue research, it has been displayed that domain III of dengue envelope proteins induces multi-serotype neutralizing antibodies in mice and macaques which confer protection against antibody dependent enhancement in AG129 mice. In the basic biology study on Dengue, major comprehensive analysis of T cells from dengue patients from India is the most notable achievement. The evolution of CHIKV in India is being studied by Vector Borne Disease group at ICGEB since 2010. In this initiative, clinical samples along with their clinical records and details of arthralgia have been collected and correlated to disease progression and severity. The study done on around 600 patients shows a strong correlation between initial viral load to disease severity.

Malaria researchers have recently described two novel erythrocyte receptors; Intercellular Adhesion Molecule 4 (ICAM4) and Cyclophilin B that seem to play important role(s) at different steps of merozoite invasion of human RBCs. Dual inhibitors for falcipain-2 enzyme and heme-detoxification protein were also identified; these inhibitors have effective parsidicidal activity and are proved much more potent than the artemisinin.

Structure-based targeting of orthologous pathogen proteins (STOPP) was also attempted. This approach is based on enzyme-drug complexes from malaria parasite tRNA synthetases and applicable widely. During the year, series of 11 crystal structures were determined that decipher the structural basis of

Vitamin-C recycling which is conserved in plant and human. This knowledge has potential to be used for developing newer therapeutics and crop improvement



Proposed model for Cyclophilin B associated Multi-protein complex involved in erythocyte invasion

b. **Integrative Biology:** In the field of structural immunology, the major focus is in two areas. Towards understanding immune escape of influenza viruses, several human scFvs were made and screened for cross-reactivity with different clades of the viral protein, to find that all of them exhibit pluripotency. On the other front, crystal structures of different plant seed proteins facilitated identification of bound metabolites providing indications of physiological functions. ICGEB took a leap in the field of artificial intelligence and systems biology techniques with development of Altered Pathway Analyzer. This is a gene expression dataset analysis tool for identification and prioritization of differentially regulated and network rewired pathways. The tool performed far better than existing tools for such analysis. The work on biofuels to identify novel and efficient enzyme producing fungal and bacterial platform, for saccharification of biomass is going on at full swing. The Biofuels group has also successfully collaborated with Oxford Brookes University for reconstruction and analysis of the largest genome scale metabolic models of a thermophilic bacterium (Geobacillus thermoglucosidasius). Progress has also been made in work on Artimisinin. A proof-of-concept demonstration of the functionality of tobacco-biosynthesized complete artemisinin in double transgenic alternative plant was provided by in vitro and in vivo methods using the antimalarial efficacy studies.

c. **Plant Biology:** In the direction of developing herbicide tolerant rice crops, success was achieved to develop transgenic lines with significant tolerance for two broad-spectrum systemic herbicides glyphosate and sulfonylurea without introducing any foreign gene into the crop plant. In addition, transgenic strategy was developed by overexpressing phosphite dehydrogenase encoding in rice plant and then application of phosphite as a fertilizer to reduce the weed infestation and prevent the pathogen infection. To understand the failure of conventional transformation methods for North-East rice cultivars, methods to overexpress Sub1A1 or Sub1B genes in Taothabi and Khongan varieties , two prominent deep water cultivars of Manipur were developed. It is found that the transgenic progeny derived from transgenic lines where sub1A1 is over expressed, grew shorter as compared to their parents under submergence suggesting that up regulation of sub1 pathways can counter SNORKEL (SK) pathway to some extent.

Impact

The research outcomes resulted in 114 publications and 4 patent applications. The institute has set up two DBT centers of national importance; Mission Innovation India unit and Apex Biotechnology Information centre at its premises and has also collaborated with several industries and institutions for translation of leads. Examples include collaboration with SUN Pharmaceutical limited for Botanical Drug for Dengue, DBT-ICGEB-Cambridge joint fellowship program, Hindustan Petroleum Corporation Limited (HPCL) etc.

Public Sector Undertakings

Bharat Immunologicals and Corporation Limited (BIBCOL):

Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL) is a Central Public Sector Unit (PSU) in India promoted by the Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India with primary objective of eradication of polio from the country.

Financial Status:

S. No	Year	Turnover (Rs Crores)	Profit Before Tax (PBT)(Rs crores)
1	2015-16	128.03	(7.07)
2	2016-17	124.18	9.45
3	2017-18	34.80	(7.96)

In addition to Oral Polio Vaccine in vaccine segment, BIBCOL has been manufacturing and marketing dispersible zinc tablets and Diarrhoea Treatment Kit in pharmaceutical segment and now has launched Ready to Use Therapeutic Food (RUTF) BIBPOSHAN and table top Sweetener BIBSWEET.

With continuous support from Department of Biotechnology, BIBCOL has achieved the vision of polio eradication of Government of India and now the Company is in diversification mode to include another vaccines and pharmaceuticals. Further to its diversification plan, BIBCOL has submitted project proposals to BIRAC under National Biopharma Mission for development of oral cholera vaccine and plasma derived medicines and expecting the work to start from the beginning of next financial year.

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. The company came into existence after a joint venture was signed on 1st February 1989 between Reliance Industries Limited and PMSV.

The main objective of the company was to manufacture Injectable Polio Vaccines (IPV) to be incorporated in the mass immunization programmes of Govt. of India. However, since IPV was not approved by W.H.O., the project was put on hold in February 1992. Thereafter P.M.S.V exited from the joint venture in 1998 by selling its shares to DBT.

Share holding of IVCOL at present is as under:

Government of India (DBT)	66.67%
Reliance Industries Ltd (RIL)	33.33%

IVCOL is presently being controlled by a Board of Directors, with two Directors representing GOI (DBT) and two Directors representing RIL. The Company has been incurring losses for the last two years (Rs.208.22 lacs for 2015-16 and Rs.20.31 lacs 2016-17) and has accumulated losses of Rs.1149.19 lacs as on 31.03.2018.

Biotechnology Industry Research Assistance Council (BIRAC)

Biotechnology Industry Research Assistance Council (BIRAC) is a not-for-profit Section 8, Schedule B, Public Sector Enterprise, set up by the Department of Biotechnology (DBT), Government of India as an interface agency to strengthen and empower the emerging Biotech enterprises specially the start-ups and SME's to undertake the strategic research and innovation, addressing nationally relevant product development needs. BIRAC has been taking into consideration the recent scientific advances and commercial successes which have captured the attention and aspirations of policy makers, business people, and investors consequently. This in turn has further propelled the growth of biotechnology sector by supporting factors responsible for entrepreneurship activity, productivity, and sustainability.

BIRAC's vision is primarily to act as a boon for the bio-economy of India as well as its global partners. There are three main verticals in which BIRAC operates to accomplish its mission viz.:

- *Investment: Providing risk capture across the Product Development value chain*
- *Entrepreneurship Development: Nurturing the ecosystem by providing the enabling environment*
- *Strategic Partnership group: Leveraging and fostering global and national partnerships*

BIRAC provides funding support to entrepreneurs, start-ups, SMEs and Biotech Companies for all stages of the product development value chain from discovery to proof of concept to early and late stage development, taking forward to its validation and scale up, and then right up to pre-commercialization. There are also special product development missions. The *Entrepreneurship Development* domain of BIRAC focuses not only on the funding support, but also on making available the right infrastructure, mentoring and other networks for technology transfer and licensing, IP and business mentoring including regulatory guidance. BIRAC's *Strategic Partnership group* works closely with all the national and international partners including government departments and concerned ministries both Central and State, industry organisations, international bilateral agencies, philanthropic organisations and corporate sector, to leverage the strength and expertise and mobilize resources and extend the outreach of its activities.

BIRAC's Impact

Since its inception BIRAC has created an ecosystem which supports affordable product development by empowering and enabling Indian biotech companies. Through its various funding schemes, BIRAC has been able to create the following impact:

3Nethra-New-Retinopathy of prematurity screening device

VAPCare-Intelligent Secretion Management system for ventilator patients to prevent infections

Anupath-Multi-Analyte device with non-enzymatic strips for diabetes management

RhinoDigester-Compact Anaerobic Digester for decentralized food waste management

Mobile-Lab-A compact, portable clinical diagnostic laboratory in a box for use in remote settings

Dozee- A contactless health monitoring device for tracking sleep patterns, heart rate, respiratory rates etc.

yeggMore-Poultry feed supplement from silk worm pupa waste for nutrient enriched eggs

Poorti-Post mastectomy breast prosthesis kit

New products commercialized during the year

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:

Investment Schemes: The Backbone

(i) **Biotechnology Ignition Grant (BIG):** BIG is the flagship early stage funding program of BIRAC, which has motivated and ignited more than 400 ideas over last 7 years of its operationalization. BIG has facilitated creation of more than 100 new start-ups, supported more than 60 women entrepreneurs, and generated more than 800 high skilled workforces. More than 100 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 further 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 $125 Million through other sources.

(ii) **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, 271 projects involving 206 sole companies and 65 collaborative projects have been supported through SBIRI. 38 products/technologies have been developed/ validated through the scheme. From January 2018 – December 2018, 3 call for proposals were announced. A total of 211 projects were received in these calls; out of which 35 have been recommended/supported. A challenge based call for proposals was announced in February 2019. A total of 69 proposals were received which are under advanced stage of evaluation.

(iii) **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, 203 projects involving 142 sole companies and 61 collaborative projects have been supported under BIPP. 47 Products/technologies have been successfully developed and 8 facilities have been created as research resources.

In the year 2018, 3 calls for proposals were announced. A total of 132 projects were received in these calls; out of which 19 have been recommended for support. 2 more proposals received under follow-on mode have also been recommended for financial support. A challenge based call for proposals was announced in February, 2019. A total of 50 proposals were received in this call which are currently under technical evaluation.

(iv) **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 2018-19, two calls have been announced.

So far, 17 calls have been launched and 71 projects have been supported involving 61 unique academic institutions and 31 companies. 7 technologies/ products have been developed under the scheme that has achieved TRL7 and 2 IPs have been generated and few are under process of generating new IPs. From January 2018–December 2018, 3 calls for proposal were announced. A total of 359 projects were received in these calls; out of which 47 have been supported/ recommended for funding. A challenge based 17th call for proposals was announced in February 2019. A total of 123 proposals were received in this call and out of which 7 have been recommended for further support which are under consideration.

(v) **Initiative on Synthetic Biology:** BIRAC has announced a call for proposals in the area of 'Synthetic Biology' on 15th May 2018 to stimulate and promote translational research in this area. A total of 63 proposals were received out of which 7 have been recommended/supported.

(vi) **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, 46 projects have been supported and 13 products/prototypes/technologies have been developed.

7th Call of SPARSH announced in October 2018 focussed on *"Soil & Plant Health and Human Health"*. A total of 126 projects were received in these calls; out of which 4 have been recommended/supported.

A theme based call (Waste to value, Livestock health and Improvement, New and improved agricultural tools, Reducing post-harvest losses and Combating environmental pollution) was announced in January, 2019. A total of 66 proposals were received in this call, which are currently under technical evaluation.

The Social Innovation Immersion Program (SIIP) of SPARSH has supported 33 social innovators who are trying to develop solutions for most pressing problems in the field of 'Maternal and Child Health (MCH)', 'Ageing & Health' and 'Waste to Value'. So far, 10 Social Innovators have been successful in raising follow-on funding.

(vii) **BIRAC SEED Fund:** The SEED (Sustainable Entrepreneurship and Enterprise Development) Fund is aimed at providing capital assistance to start-ups with new and meritorious ideas, innovations and technologies. The SEED support is positioned to act as a bridge between promoters' investment and Venture/ Angel investment. BIRAC operationalized the SEED fund in 2016 and implements it through the Incubators, wherein startups are provided up to INR 30 lakhs in lieu of equity held by the incubators. Till now, two rounds of Seed Fund have been completed, under which 14 incubators have been supported.

(Viii) **LEAP Fund(Launching Entrepreneurial Driven Affordable Products)** will enable potential startups to pilot/commercialize their products/Technologies. BIRAC's LEAP fund is aimed at providing next level funding support of up to INR 1 Cr/start up against equity and equity linked instruments through implementing incubator i.e. LEAP fund partner. Six Leap Partners have been rolled out in 2018-19.

(ix) **Product Commercialization Program:** Advanced startups facing a challenge in their last mile journey to commercialization, can be facilitated through Product Commercialization Fund. This new scheme can provide upto INR 5 Cr/ startup to facilitate manufacturing, marketing, scale up etc considering case by case

bottlenecks. Four Startups were recommended for facilitation under this fund in 2018-19.

(x) **BIRAC AcE Fund:** The novelty of AcE Fund policy is to create a fund of fund to support daughter funds including Early Stage Angel Funds & Ventures in the area of Biotechnology and Life Sciences. The core focus of daughter funds would be to develop domestic innovation & manufacturing capabilities. A call to invite potential AcE Fund partners was initiated in Dec 2017.Till date 6 Ace partners have been identified and a commitment of 82.Cr. has been made through the partners. The signing of the Agreements is in the process and the fund would be operationalized in FY 2019-20. 2nd Call for AcE Fund was launched in January 2019 to identify additional AcE Fund Partners.

The Entrepreneurship Development: Fostering Innovation

In order to foster innovation, BIRAC has taken several initiatives to promote entrepreneurship and has achieved considerable success.

(i) **BIRAC BioNEST (BIRAC-Bioincubation: Nurturing Entrepreneurs for Scaling up Technology):** Under the BioNEST programme, BIRAC has established 41 world-class bio-incubators across the country and has created around 441349sq. ft. of incubation space. Through these Bioincubator facilities, BIRAC has supported skilled manpower for the smooth management of these incubators. A total of about 120 jobs have been generated through these incubators and more than 350 start ups have been supported. BIRAC has supported 10 Bio incubators during 2018-19.

(ii) **SITARE (Students Innovations for Advancement of Research Explorations):** BIRAC has partnered with Society 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 and schools. As on date, we have 49 projects running under GYTI category and more than 160 students have been awarded under Appreciation award category. In addition, BIRAC and SRISTI also organized three 21 days long workshops for students called as Biotech Innovation-Ignition School (BIIS), wherein 40-50 students were provided hands on training in the areas including phytochemistry, microbiology, basic biotech techniques etc. One of these workshops was conducted for female students only.

(iii) **eYUVA (Encouraging Youth for Undertaking Innovative Research through Vibrant Acceleration):** The University Innovation Cluster (UIC) programme of BIRAC has helped in creating pre-incubation space where innovators (students with a Master/Ph. D degree) with entrepreneurial ideas can perform preliminary studies and bring the same to (pre) proof-of-concept stage. The programme has been running successfully since 2013.Through BIRAC support, five UICs have created a dedicated incubation space ranging from 2500 to 3000 sq. ft. each. 23 fellows have benefitted from UICs, of which 8 Fellows incorporated start-ups.

Mentorship: The Capacity Building

(i) **BRIC (BIRAC Regional Innovation Centre) at IKP Knowledge Park, Hyderabad:** BIRAC Regional Innovation Centre (BRIC) at IKP Knowledge Park, Hyderabad has conducted an extensive regional innovation system (RIS) mapping in South India. Till now, BRIC has organized 16 tech showcase events and 30 half day workshops to create awareness among startups and entrepreneurs on funding, regulatory and IP related issues. Phase 3 has been initiated to cover additional 12 clusters of NE India taking the total cluster coverage to 22 pan India.

(ii) **BREC (BIRAC Regional Entrepreneurship Centre) at C-CAMP:** The Regional Entrepreneurship Centre at CCAMP, Bangalore has been set up as an extended arm of BIRAC and is mandated to carry out various activities with an aim to spread a wave of entrepreneurial culture in the biotech sector across the country. So far BREC has conducted 8 awareness workshops addressing more than 900 students, 8

workshops impacting more than 350 start-ups and entrepreneurs through focused learning on topics such as Biodiversity Act, Costing-Pricing Issues, Understanding Term Sheets etc. BREC has also organized 8 rounds of "Meet the Investor series", which connected more than 300 startups with investors. BREC also organized two 3-day long boot camps for entrepreneurs involving international faculty.

(iii) **BRBC (BIRAC Regional Bioinnovation Centre) at Venture Centre, Pune:**

Third regional centre - BIRAC Regional Bioinnovation Centre (BRBC) has been set up in March 2018. The BRBC aims to provide bioentrepreneurs with necessary regulatory guidance; knowledge and skills required for converting innovative ideas into successful ventures; training to incubation managers, mentor match services etc.

During the year, 120+ entrepreneurs were connected with mentors through mentor mixer program, 80+ participants were provided domain knowledge, 9 incubation managers trained through immersion program100+ students/entrepreneurs were provided insights into essentials of scientific entrepreneurship through city camps and 50+ starts up were assisted for solving regulatory queries

(iv) **BIRAC Regional Techno-Entrepreneurship Centre for East & North East Region (BRTC-E&NE) at KIIT-TBI:** BRTC, launched in March 2019, aims to develop the biotech entrepreneurial ecosystem especially in East and North East Regions including Odisha, Chhattisgarh, Jharkhand, West Bengal and Bihar and the North East including Assam, Meghalaya, Guwahati, Imphal, Manipur and Tripura.

(v) **IGNITE Boot Camp:** BIRAC has channelized the participation of 5 BIG grantees (every year) for last 6 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 from the same and build relevant connects.

(vi) **Roadshows and IP Management Workshops:** 04 IP & Technology Management workshops have been conducted so far at KIIT, Bhubaneswar, C-CAMP Bangalore and IIT, Kanpur & IKP Hyderabad. In addition to this, BIRAC organized two IP Clinics to provide a solution-based approach on IP & Technology Transfer related matters by engaging the BIRAC supported entrepreneurs and Start-ups.

(vii) **Regulatory Facilitation:** Regulatory Facilitation is one of the challenges faced by many entrepreneurs and remained unaddressed since long. To address these challenges, structured regulatory workshops are organised pan India by BIRAC. 02 Such workshops have been conducted.

(viii) **Hands on training workshops:** BIRAC's main aim is to enhance the research and innovation capabilities of the Indian biotech industry particularly start-ups and SME's for creation of affordable products by providing mentoring support. BIRAC organizes hands-on training workshops for upgrading the technical skills of the industry personal. BIRAC has organized two workshops in the area of 'Synthetic Biology' and three workshops in the area of 'Biopharmaceuticals'.

(ix) **FIRST Hub (Facilitation of Innovation and Regulation for Start-ups and Innovators)**

BIRAC has set up a Facilitation unit namely FIRST HUB to address the queries of start-ups, entrepreneurs, researchers, academicians, incubation centres, SMEs etc. and to promote government initiatives on Start-up India & Make in India. The FIRST HUB was launched on 10 August 2018 and the first meeting was conducted on 07th Sep 2018 at BIRAC. First Hub is open on every first Friday of the Month at BIRAC office from 3:00 pm to 5:00 pm. Officers from DBT, BIRAC, ICMR, CDSCO and other relevant government organisation are available for taking queries related to regulatory pathways and regulation, funding opportunities, mentorship, investment opportunities, market access, industry academia partnerships and intellectual property.

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 with an aim to give Indian economy global recognition. Make in India Facilitation Cell at BIRAC had organized a Strategy Meet in July 2018 to discuss the road map for achieving $ 100 Billion Bioeconomy of India.

- Product launch during BIRAC 7th Foundation Day- 9 products were launched namely- Poorti; ArmAble; amouth-dissolving thin-film platform which is an alternate to tablets, capsules, liquids syrups for the delivery of food supplements, medicines; AUM; a process for Enhancing Vitamin D content of Mushrooms through a natural organic process, Mush D+; GOsteri; PurVital Minis; Smart Scope®; and RICEL & RISIL.
- Lab To Market: Compilation of 32 commercialised products/ technologies was released on the 7th foundation Day of BIRAC. Pitches resulted in 8 Startups successfully gaining commitment from Stakeholders forforward traction.

(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 and SMEs.

(iii) Swachh Bharat: BIRAC has taken many initiatives in promoting the Swachh Bharat mission. In continuation to the efforts made through the "Re-invent the Toilet challenge- India" program, BIRAC has been instrumental in announcing calls for supporting technology development in this area. A special call for Technological interventions for conversion of fecal sludge and MSW to energy and other product was also launched and 4 projects have been funded which range from development of granulated sludge, use of caffeine containing agricultural residues for pharma and cosmeceutical applications and pressurized reactors for wastewater treatment

(iv) SOCH (Solutions for Community Health): BIRAC launched an Innovation Challenge Award SoCH-Solutions for Community Health (SoCH) Award'17 on the MyGov portal with an aim to propel the Indian innovators towards combating the challenges of community health sector. SoCH 2017-18 was announced based on two themes: 1. Platform technologies for reducing the burden of Diseases (Communicable and Non-communicable diseases). 2. Sanitation and Waste Recycling. A total of 10 early winners were selected in both themes (5 in each). These early winners were then assessed on the basis on their MVP and 2 winners (1 from each theme) were awarded INR 50 lakhs each. The names of winners were announced on 26th Jan, 2019.

National and International Alliances

(i) 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), and the Wellcome Trust. Till now this partnership and the PMU-BIRAC supported 5 open calls, 2 graduate programs and 5 specialised programs.

(ii) MeitY-BIRAC Industry Innovation Program on Medical Electronics (IIPME): The project 'Industry Innovation Programme on Medical Electronics' is a collaborative project between the "Ministry of Electronics and Information Technology", Government of India and BIRAC. One of the product from IIPME scheme, Sohum (Hearing screening device), has been commercially launched. Six projects (Jeevtronics- hand-cranked Defibrillator, Panacea Medical Technologies-Hexapod Couch for LINCA machine and Dr.Vikas Karade-Tabplan X-ray to 3D software), Opto-glucometer from Aries Biomed, Transvaginal Digital Colposcope from Periwinkle and Artificial Larynx from Tuhin Subhra Sengupta have

reached TRL-6/7. Industrial Design registration has also been done for Jeevtronics defibrillator.

(iii) **SAEN (Secondary Agriculture Entrepreneurial Network):** BIRAC has initiated Secondary Agriculture Entrepreneurial Network (SAEN) with an aim to promote new enterprises and to support existing industry in the secondary agriculture sector in the state of Punjab. SAEN is led by 'The Punjab State Council & Technology (PSCST)' and other partners are 'National Agri-Food Biotechnology Institution (NABI)', 'Centre for Innovative and Applied Bioprocessing (CIAB)' and BioNEST–Panjab University (BioNEST-PU).

Portable digital X-ray

Laparoscopy Surgical Simulator

(iv) **TiE Delhi NCR:** BIRAC has partnered with TiE-Delhi NCR to leverage each other's strengths for mentoring biotech startups and providing continuous platform for BIRAC supported startups to interface with funders and investors. The MoU was signed at the TiE Global Summit 2016 at New Delhi. In 2018, BIRAC and TiE together have announced 2nd edition of "BIRAC-TiE WInER award" to recognize Women Entrepreneurs in Biotechnology. The award includes a prize money and mentoring through a residential 7-day accelerator programme exclusively for Women entrepreneurs at one of the BIRAC supported Bioincubators i.e., Golden Jubilee Biotech Park in Chennai. BIRAC in collaboration with TiE also organized 6 entrepreneurship awareness workshops for students and young entrepreneurs in Tier II cities. More than 400 participants benefitted from these workshops.

(v) **New Partnerships:** BIRAC continued its efforts for establishing partnerships with like-minded organizations and culminated following collaborations:

CARB-X: LoI between BIRAC & CARB-X was signed on 19th March 2019. CARB-X,headquartered in Boston University is a non-profit public-private partnership dedicated to accelerating antibacterial research to tackle the global rising threat of drug-resistant bacteria. It provides financial, scientific, business support to accelerate the development of products focused on the most serious drug-resistant bacteria identified by the WHO and CDC. BIRAC-CARB-X partnership is aimed at establishing a collaborative framework to carry out activities related to the exchange of best practices and setting up of coordinated support measures to foster technology and knowledge transfer and innovation cooperation for enhancing Indian R&D in the area of Antimicrobial resistance

Perkin Elmer: BIRAC and Perkin Elmer both have common objectives in the promotion of innovation research and development, and enhancement of international linkages. To fulfill their missions, the LoI was signed. The goal of partnership is to promote the portfolio of 'Indian led revenue based innovations/start ups' in multidisciplinary areas comprising of medical devices, point of care, algorithms and information technology/software, to help scientists/doctors/public health experts/related fraternity who are dealing/ delivering the issues related to maternal health, newborn health and food.

BIOCUBAFARMA: LoI was signed between BIOCUBAFARMA and BIRAC and Kalam Institute of Health Technology on 21st June, 2018. Bio Cuba is a biotechnological & pharmaceutical business organization producing drugs, equipment and service with high technology to improve the health of population, production of exportable goods and service. The objective is to promote cooperation, between two countries in area of health technology with focus on exchange of technologies, products & innovations.

ALEAP(Association of Lady Entrepreneurs of India): BIRAC signed MoU with ALEAP (Association of Lady Entrepreneurs of India) to support Women Entrepreneurship at the International Women Entrepreneurship Summit organised by South Asian Women Development Forum (SAWDF) in Kathmandu. The objective is to 'encourage biotech innovation ecosystem' further involving countries from SAARC, ASEAN, and MENA region.

- **Technology Development Board, Department of Science & Technology (TDB):** BIRAC has signed a MoU with TDB (Technology Development Board, Department of Science & Technology) to further strengthen the innovation ecosystem and bridge the gap between innovation and commercialization & facilitating scale up.

- Dept. of Economic Affairs, WorldBank and BIRAC signed the Loan & Project agreement for implementing the "Innovate in India for Inclusiveness" programme, a major initiative of DBT to promote Make in India.

- MoU on extension of existing partnership was signed between **DBT & Vinnova,** with BIRAC as an implementing agency including Bio-incubators, Test beds in the scope of collaboration. Vinnova is the Swedish government agency similar to BIRAC & DBT that administers state funding for research and development.

Dr. Renu Swarup, Secretary DBT and Chairperson BIRAC along with BIRAC representatives at Vinnova, Sweden

Industry-Academia Interaction: Bridging the Gap

(i) **BIRAC's 6th Foundation Day:** BIRAC celebrated its 6th Foundation Day on March 20, 2018 at India Habitat Center, New Delhi by organizing a knowledge and networking event with the theme "Sustaining Innovation: A Market Driven Pathway". The event was attended by a large number of dignitaries from scientific & industry sectors, The event also saw the felicitation of Prof. G Padmanabhan, Former Director and current Honorary Professor of the Indian Institute of Science, Bengaluru, on the occasion of his 80th birthday and the release of the second volume of his memoirs, titled 'Doing science in India: My second innings'.

(ii) **7th Innovators' Meet:** The 7th Innovator's Conclave of BIRAC was held at Heritage Village, Manesar on 19th-20th September 2018. The theme for this event was 'VIGYAN SE VIKAS'. The Innovator's Conclave witnessed the confluence of around 300 Scientists, Entrepreneurs, Academicians, and Industry Experts. The event was inaugurated by Dr Renu Swarup, Secretary DBT, Ministry of Science & Technology and Chairperson, BIRAC.

BIRAC's 7th Foundation Day-

The 7th Foundation Day of BIRAC with a theme 'Nurturing Innovations: Empowering India'was

celebrated on 19-20thMarch, 2019. The event was attended by 300+National & International experts,Entrepreneurs, Scientists, Academicians and representatives from Hospitals, Industry.

The event was inaugurated by Dr. Rajiv Kumar, Vice Chairman, NITI Aayog, Govt. of India.

Lamp lighting ceremony

10

REGULATION, INTELLECTUAL PROPERTY AND LEGISLATIONS

Regulation And Intellectual Property

The programme on Biosafety Research and Regulations emphasizes on the implementation of the provisions of Rules, 1989 of Environment (Protection) Act, 1986 for the manufacture, use, import, export and storage of hazardous microorganisms, genetically engineered organisms or cells and products thereof in research and development. The Rules, 1989 delegated the Department to administer the 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) which monitors & reviews all ongoing research projects involving high risk category and confined field experiments and ensure the compliance of biosafety rules & regulations. Framing and implementation of safety measures and guidelines, while conducting research on high risk group microorganisms and GE organisms have also been entrusted upon RCGM.

Biosafety Research

During the year, the RCGM evaluated more than 1300 applications from public and private institutions in the areas of agriculture, healthcare and industrial products specifically for authorization to import, export & exchange of high risk group microorganisms and recombinant DNA research (rDNA) related materials including seeds, gene constructs, plasmids, vectors and genetically engineered (GE)/living modified (LM) organisms; to conduct pre-clinical toxicity studies; for evaluation of pre-clinical study reports; to conduct confined field trials on GE crops viz. cotton, corn, rice etc. for generation of biosafety data; and to conduct rDNA research in pharmaceutical & agriculture sectors.

Four Central Compliance Committee (CCC) teams with more than 20 experts with expertise in plant breeding, physiology, plant biotechnology, entomology, pathology, silkworm biology etc., along with agriculture and silkworm experts were constituted and they visited the containment facilities as well as biosafety research trial sites and monitored the compliance of biosafety rules & regulations while conducting the trials on GE crops and silkworm.

During the year under report, 12 rDNA products were permitted by RCGM for conducting pre-clinical toxicity studies by 8 private/public institutions/companies. Based on the evaluation of pre-clinical study reports, 11 rDNA products were recommended to Drug Controller General of India [DCG (I)] for appropriate phase of human clinical trials.

The Field Inspection & Scientific Evaluation Committee (FISEC) constituted by the Department, as per the directives of Prime Minister Office (PMO), to assess the veracity of spread of unapproved herbicide tolerant (HT) cotton in the country based on deliberations and interactions with various stakeholders during these meetings, committee submitted its report with six immediate, five short term and four long term strategies and measures to be implemented by different stakeholders such as Ministry of Environment, Forest and Climate Change (MoEF&CC), Department of Agriculture Cooperation and Farmers Welfare (DAC&FW), DBT and concerned state governments.

The Biosafety Support Unit (BSU) established in partnership with Regional Centre for Biotechnology (RCB) evaluated all applications submitted to RCGM for approval, and provided support for conducting scheduled RCGM meeting. The BSU has also supported Genetic Engineering Appraisal Committee (GEAC) providing Risk Assessment and Risk Management Plan (RARMP) documents for various applications considered in GEAC meetings. BSU has done the technical evaluation and provided RARMP documents on specific request of other government institutions for proposals related to GE Mosquito, *Wolbachia* infected *Aedes aegptii* and *Anopheles* mosquito and GE silk worm.

As a measure to observe strict compliance of biosafety guidelines for rDNA activities by various colleges, universities, institutions, laboratories, and industry through their Institutional Biosafety Committees (IBSCs), 65 new IBSCs have been constituted, while 38 old IBSCs were renewed.

Foreign Trade, In-House R&D recognition and Other Issues:

Trade plays an indispensable role and always been a decisive parameter in country's economy. The Department had communicated Input/output norms for 07 biotechnological products. Comments on export/import of 05 restricted items were also shared with Directorate General of Foreign Trade

(DGFT) to facilitate trade in biotechnology. Keeping in view of the technical expertise, merit & essentiality of the projects, resources & manpower established, and intellectual property (IP) generated, the Department had recommended 52 R&D units of biotechnology firms under in-house R&D recognition scheme to the Department of Scientific & Industrial Research.

Patent Facilitation and Capacity Building

The Biotechnology Patent Facilitating Cell (BPFC) provides single window awareness-cum-Patent facilitation to scientists and researchers for filing of Patent Co-operation Treaty (PCT) and National phase applications on inventions pertaining to Life Sciences and Biotechnology through empaneled IPR firms. During the period under report, 5 new patent applications were filed and 6 Indian patents and one US patent have been granted /out of the applications filed earlier.

Legislations

The DNA Technology (Use and Application) Regulation Bill:

Recognising the need for the regulation of the use and application of DNA technology in the country, the Department has formulated "The DNA Technology (Use and Application) Regulation Bill" with the aim to establish the identity of certain category of persons including the victims, offenders, suspects, under trials, missing persons and unknown deceased persons. The Bill has the provision to establish a DNA Regulatory Board to carry out the functions and exercise the power assigned to it under the proposed Bill. It also has the provisions to establish National and Regional DNA Data Banks for the maintenance of the national forensic DNA database for the purposes of identification of the aforementioned category of persons. The Lok Sabha has Passed "The DNA Technology (Use and Application) Regulation Bill" in January 2019.

National Guidelines for Stem Cell Research:

"National Guidelines for Stem Cell Research" has been jointly formulated by the DBT and ICMR to lay down standards for stem cell research and ensure that research with human stem cells is conducted in a responsible and ethically sensitive manner in the country. The guidelines states that any stem cell use in patient is investigational and it must only be done within the purview of an approved and monitored clinical trial and not offering it as therapy. The guideline is available on DBT website: http://www.dbtindia.nic.in/wp-content/uploads/National_Guidelines_StemCellResearch-2017.pdf.

11

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. In order to enhance the beautification and aesthetic value of the premises, quality tribal art works from TRIFED were procured and have been displayed in the conference rooms and other vantage points. 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. Modern Audio Visual System have been installed in Conference Rooms at R.No.816, Block No.2 and 503, Block 3.

Swachh Bharat Abhiyan: The Swachhta Action Plan (SAP) 2018-19 in respect of the Department,its PSUs and Autonomous Institutes was finalized at an estimated amount for Rs. 18.71 crores. Swachhta Pakhwada 2018 was organized from 1st to 15th May 2018. Swachhta Hi Seva (SHS) was celebrated from 15th September to 2nd October, 2018, re-intensifying the Jan Andolan to realize the vision of the clean India. Some of the activities undertaken during this period are: drawing competition on cleanliness, awareness campaigns on hygiene and sanitation, proper disposal of garbage and toilet etiquettes etc.

The use of plastic folder and water bottles have been completely banned during the meetings and these were replaced with handmade paper folders and paper glasses. Also, Water Dispensers were provided in the conference rooms and other such places. All plastic dustbins were replaced with stainless steel dustbins. A large number of old/obsolete e-waste items long piled up were taken up for disposal and auctioned, as per rule.

Two unisex toilets for Divyangjan have been completed through CPWD at Block No.3 (4th & 5th floors).

e-Office: e-Office is a Mission Mode Project (MMP) under the National e-Governance Programme of the Government. The product is developed by NIC and aims to usher in more efficient, effective and transparent inter-government and intra-government transactions and processes. It is being progressively used by the Administration and other divisions of the department. Recently, the Leave Management Module has also been activated in e-Office mode. For smooth handling of e-Office, digital signature certificates were procured from NICSI for all the officers of the Department.

IISF - 2018: India International Science Festival (IISF) 2018 was successfully organized from 5th to 8th October, 2018 in Lucknow, for which, the Administration provided all the logistics and other technical support to organizers.

Government e-Market Place (GeM):

During 01-01.2018 to 31st March, 2019 the department has made most of its public procurement of goods and services for an amount of Rs.2,04,94,394/- through GeM as per GOI Instructions.

Establishment: Establishment Section in the Department is entrusted with the following functions :-

Recruitment and promotion to various posts:- This is an ongoing process. Process for filling up of vacant posts of Scientist 'H' and Scientist 'C' on direct recruitment basis as well as promotion cases under Modified Flexible Complementing Scheme are being carried out from time to time.

Recruitment Rules: The Department of Biotechnology (Group 'A', Scientific Posts) Recruitment Rules, 2018 have been notified in the Gazette of India.

Training:- A total 18 officials were deputed for various training programmes conducted by the Institute of Secretariat Training & Management (ISTM), National Institute of Financial Management (NIFM), Faridabad and Indian Institute of Public Administration, New Delhi to enhance their skills in relevant fields.

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.

Parliamentary Matters: The meeting of the Parliamentary Standing Committee on Science and Technology, Environment & Forests was held on 13.02.2018 in the Parliament House Annex, to consider the Demands for Grants (2018-19) of

Department of Biotechnology. Replies to about 48 Parliamentary questions pertaining to the Department were duly replied within the prescribed timeframe.

Grievance Redressal : 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 362 grievances were received by the Department, from 01.01.2018 to 11.12.2018, through the CPGRAMS portal, out of which 301 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 29th October, 2018 to 3rd November, 2018. 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 "My Vision - Corruption Free India", which was adopted by the Central Vigilance Commission (CVC) as theme for the year 2018.

RTI Cell : RTI Cell is functioning in the Department & quarterly reports are filed timely on the RTI portal.

FINANCE: Department of Biotechnology has been allocated an amount of Rs. 2411.53 Crore of Budget Estimates(BE) in FY 2018-19. There was no change in the total BE allocations in the Revised Estimates (RE) 2018-19. The Financial Statement showing the details of Actual Expenditure during 2017-18, B.E. & R.E. for 2018-19 and B.E. 2019-20 in respect of various Programmes/Schemes are given in **Annexure I.**

Status of C&AG Audit Paras: The Status on Action Taken Notes (ATN) on pending C&AG Paras pertaining to the Department is as per **Annexure II.**

Annexure - I

Details of Actual Expenditure during 2017-18, B.E. and R.E. of 2018-19

(Rs. in crores)

SL No.	Name of the Programme/Scheme	Actual 2017-18	BE 2018-19	RE 2018-19	BE 2019-20
1	2	3	4	5	
	REVENUE SECTION				
1	Secretariat Economic Services				
1.01	Secretariat	26.86	32.31	31.61	32.31
2.01	Biotechnology Industry Research Assistance Concil (BIRAC)	30.00	31.00	31.00	31.00
2.02	Support to Autonomous R&D Institutions*	724.51	748.98	749.68	761.86
3.01	Biotechnology Research and Development, Human Resource Development & Research Resources Facilities	1239.11	1350.00	1350.00	1474.97
4.01	Industrial and Entrepreneurship Development	210.94	249.24	249.24	280.20
	TOTAL	2231.42	2411.53	2411.53	2580.34

** Institute includes 16 Autonomous Bodies namely National Institute of Immunology, New Delhi, National Centre for Cell Science, Pune, Centre for DNA Finger Printing & Diagnostics, Hyderabad, National Brain Research Centre, Gurgaon, National Institute for Plant Genome Research, New Delhi, Institute of Bioresources& Sustainable Development, Imphal, Institute of Life Sciences, Bhubaneswar, Translational Health Science & Technology Institute, Faridabad, Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram, National Institute of Biomedical Genomics, Kalyani, Regional Centre for Biotechnology, Faridabad, National Agri-Food Biotechnology Institute, Mohali, Institute for Stem Cell Research and Regenerative Medicine, Bengaluru, National Institute of Animal Biotechnology, Hyderabad, Centre of Innovative and Applied Bioprocessing, Mohali, International Centre for Genetic Engineering and Biotechnology, 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. 3 of C&AG Audit Report No. 5 of 2003	One (Containing 157 sub-paras)	135 Sub Paras	Final ATN vetted by the Audit has been furnished to Monitoring Cell.
2.	Para No. 3.1 of C&AG Audit Report No.12 of 2016 (Irregular administrative and entitlements operations)	One	One	Closed
3.	Para No. 3.1 of C&AG Audit Report No. 17 of 2017 (Irregular expenditure on premises transferred to another organisation).	One	One	Closed
4.	Para No. 3.2 of C&AG Audit Report No. 17 of 2017 (Unauthorised expenditure due to excess appointment and grant of advance increments to employees)	One	One	Closed
5.	Para No. 3.3 of C&AG Audit Report No.17 of 2017 (Overpayment of transport allowance).	One	One	Closed
6.	Para No. 4.1 of C&AG Audit Report No. 2 of 2018 (Activities of Institute of Bio-resources and Sustained Development,Imphal".	One	One	Closed
7.	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 has sought further information. Revised ATN is being furnished shortly.

8.	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 has been furnished.

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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