

Annual Report Compilation Committee 2022-23

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2022-23

Government of India

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01

OVERVIEW

1

Overview

The mandate of the Department of Biotechnology (DBT), Ministry of Science & Technology is to make India globally competitive in biotechnology research, innovation, translation, entrepreneurship and biotech industrial growth with an aim to achieve National Development Programmes (NDPs) and Sustainable Development Goals (SDGs). DBT funds extramural research projects in Biotech R & D across the country to address pertinent issues with respect to health care, clean energy, agriculture, bioresource development and sustainable utilization, infrastructure etc. at various levels including policy framework, creating institutional infrastructure, forging industry partnerships, instituting regulatory capacity, developing talent pool, spearheading cutting edge research, supporting key missions, & driving international collaborations. DBT also functions through 14 Autonomous Institutions, one statutory organization - Regional Centre for Biotechnology (RCB), International Centre For Genetic Engineering and Biotechnology (ICGEB) and three Public Sector Undertakings - Biotechnology Industry Research Assistance Council (BIRAC), Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL) and Indian Vaccine Corporation Ltd (IVCOL).

Biotechnology, recognized as a sunrise sector, is a key enabler driving bio economy of the country. In past 8 years, India's bio-economy has grown 8 times from \$10 billion to \$80 billion, leading to the increase in number of Biotech Start-ups from 50 to 5300. India is presently ranked at 12th position in Biotech sector worldwide; 3rd in Asia pacific region; and is the largest vaccine manufacturer in the World. The Government through Aatmanirbhar Bharat is

promoting biotech innovation missions and entrepreneurship, leveraging the strength of strategic partnership and building capacities across the country. The goal is to support and nurture the bio economy towards the goal of 300 billion USD by 2030. Hon'ble Prime Minister inaugurated the Biotech Startup Expo 2022 on 9th June 2022 which showcased 150+ biotech startups and their products, and was attended by 5000+ delegates comprising academicians, researchers, scholars, budding entrepreneurs SMEs, investors, policymakers, start-ups and industrialists.

To achieve centralized and unified governance for maximizing the impact of biotech research, a policy decision has been taken to subsume its 14 Autonomous Institutions to create one Apex Autonomous Body - Biotechnology Research and Innovation Council (BRIC). The restructuring of DBT institutes is based on the "Minimum Government and Maximum Governance" principle to enhance the scientific character and science outcomes at the institutes by building research synergies, new education programs in line with National Education Policy, improving human resource structures across cadres and effective management and monetization of assets emanating from the research being carried out.

Sector-wise achievements/Success stories during the year 2022 are summarized below:

Building Capacities

Biotechnology is a multi-disciplinary and rapidly advancing area wherein well trained human resource

is a pre-requisite for meaningful R&D and production. The Human Resource Development (HRD) Programme of the DBT is aimed at providing holistic development and support to students, young researchers and scientists working in the multidisciplinary areas of Biotechnology. The HRD programmes of the Department include teaching programmes (Star College Programme and Postgraduate Teaching programme), national and international fellowships.

The DBT HRD Division supports teaching programmes at undergraduate and postgraduate levels. 675 candidates have been admitted in DBT supported postgraduate programmes in Biotechnology in 63 programmes running in 56 participating host universities/institutes. In all, there are ~1400 DBT supported Post Graduate students studying in first and second year of DBT supported PG Programmes in the year 2022-23. At undergraduate level, colleges are supported to strengthen the teaching and research infrastructure for better hands-on exposure. 23 new colleges have been supported under Strengthening Component and 02 Colleges have been supported under Star Status of the Star College Programme.

Under DBT-Junior Research Fellowship (JRF) programme, a total of 998 ongoing students have been supported and 178 new fellows have joined. A total of 142 research articles and reviews in journals of national and international repute have been published by DBT JRF fellows.

In year 2022-23, several ongoing fellowship schemes viz., DBT-Research Associate (RA) programme, Distinguished Biotechnology Research Professorship, Janaki Ammal Fellowship, Tata Innovation Fellowship, DBT Ramalingaswami Re-entry Fellowship (DBT-RRF), MK Bhan Young Researchers Fellowship, and BioCARE continued their support for fellows and scientists.

Apart from the national fellowships, DBT also funds international fellowships, internships and partnership programmes. This includes PhD Fellowship Programme under Indo-Australia Collaboration and DBT TWAS fellowship.

Three Biotechnology Research Cancer Programme (BRCP) fellows under the DBT-Wellcome Trust Partnership have received Shanti Swarup Bhatnagar Award (2021); one fellow each received Sun Pharma Science Foundation Research Award (2021) in Medical Sciences; CDRI Award for Excellence in Drug Research (2022); SERB Women in Excellence Award for Chemistry; and Merck Young Scientist Award (2021).

The Skill Vigyan activities are under implementation in nine states viz., Arunachal Pradesh, Himachal Pradesh, Meghalaya, Odisha, Punjab, Uttarakhand, Karnataka, Telangana, and Andhra Pradesh.

Further, during the year 2022-2023, the Department organized two hands-on training workshops on the use of Foldscope at Visakhapatnam, Andhra Pradesh and Washim, Maharashtra wherein 112 school teachers from 17 Aspirational Districts have participated.

Under the Research Resource Service Facility Platform (RRSFP) scheme, infrastructure facilities are established through DBT-BUILDER and DBT-SAHJ. DBT-BUILDER supports establishment of high-end research infrastructure in Universities for enhancing post-graduate teaching and research; whereas DBT-SAHJ supports establishment of national level facilities for very high-end equipments supporting cutting-edge research. The facilities thus created, continue generating revenue through extensive usage by research community.

Research and Development

Through the Research and Development scheme, the Department is addressing key challenges in

agriculture, health care, energy, environment, food and nutrition security etc. Technological interventions are being made to be future ready through the development of climate resilient crops, efficient and affordable vaccines and diagnostics, vegan protein alternatives and clean energy technologies. Investments are also being made on precision medicine, data analytics and digital health etc. A summary of efforts is given below:

Agriculture Biotechnology and Allied Areas

The research infrastructure and trained manpower in cutting-edge areas of agricultural research (crops, livestock, and fisheries) has been strengthened across the country. Department extends support to basic research to address the complex problems, and applied research that will provide improved crop varieties, livestock, fish brood stock, and other products to farmers and other stakeholders. A major attention is being given to the development of efficacious veterinary vaccines and diagnostics which can be easily deployed at the field level.

A Centre of Excellence (COE) was established at G.S.Khush Institute of Genetics, Plant Breeding and Biotechnology, Punjab Agricultural University, Ludhiana in the honor of Prof. G.S.Khush. The COE will deliver new varieties with new value added traits and nutrition improvement in wheat etc. Genetically Modified Organisms (GMO) matrix of 22 GM food crops with over 130 GM events approved globally was developed and Multiplex PCR based GE diagnostics was validated for GM detection in seeds/food derivatives. Further, a CRISPR activation and inhibition toolkit was also optimized for Solanaceous plants. On the other hand, an eco-friendly slow-release sustainable urea fertilizer was developed using jute grafted silica nanoring for controlling the release of urea and enhancing the productivity in rice with egg white acting as a binder. The following plant varieties were released in 2022:

Crop	Varieties	Trait
Rice	ADT 46-Sub-1	Submergence tolerance variety
	MTU-1293	Salinity tolerant version
	HUR 105-Sub-1	Submergence/flooding tolerance
	KR16024 (IET-28791)	Submergence tolerance
	IR 64-Sub1-DTY2.2 (CR Dhan 804)	Submergence tolerance
	Shalimar Rice -6	blast disease resistance
Pea	HIM Palam Matar-2	Powdery mildew resistance
Mungbean	HUM 27	Early maturing, medium dwarf, green seed, resistant to MYMV

One Health Initiative with National Institute of Animal Biotechnology, Hyderabad as the coordinating institute and 27 research/ academic institutions and state government laboratories has been initiated with an aim to assess simultaneous country-wide prevalence of ten zoonotic and 5 transboundary diseases and to make us ready for future pandemics. On the veterinary vaccine front, live attenuated *Theileria annulata* vaccine technology was transferred to Hester Biosciences Pvt Ltd, Ahmedabad. Further, a single nanotechnology based dipstick has been developed for instant detection of multiple adulterants in milk.

A dedicated laboratory for marine fish larval microbiome and nutrigenomics research has been established at Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi by the Department. A full length *R. canadum* (Cobia) transcriptome is reported for the first time. Two bacteriophage formulations namely Coliphage Cocktail and Vibriophage (xLV6) formulation have been developed for controlling antimicrobial resistant (AMR)

Escherichia coli, luminescent vibrios in shrimp culture respectively.

Bioenergy, Bioresource, Environment and Forests

The Bioenergy Program aims to make available cost effective and sustainable biofuel technology by improving or developing feed stock and also through improvement of biofuel production technologies. Demonstration plants were commissioned to convert municipal solid waste to organic fraction and energy in various forms. DBT is also supporting bioenergy waste to value technologies to address the municipal sewage waste treatment. The 5 Bioenergy Centers supported by the Department are the main fulcrum of the programme. Three demonstration projects were supported to produce energy in the form of Biogas from Organic Waste at 1Tn-10Tn waste/day. Other major achievements include Cellulase Enzyme Technology for 2G Ethanol Production and its scale-up process; and Marine algae cultivation demonstration at 1,00,000 L scale (spanning across 220 sq. meter area) in outdoor (Mumbai coast) using a custom made sunlight-distributed (with improved productivity) algal growth system (20 gm/m²/day algal productivity).

Environmental Biotechnology is providing biotechnology-based innovative clean and green solutions for the management of environmental issues of National and Global concerns in the area of climate and environment. Forest Biotechnology program was initiated in 2018-19 to facilitate application of biotechnology for forest conservation, resource utilization, and scientific management of invasion, studying ecosystem services, and climate change. Some of the significant leads include miniaturized gas sensors developed to monitor the emissions (CO, CH₄, NH₃, and N₂O) from the soil for precision agriculture; patent for Nutrient rich biomanure; a bio-restoration technology is being demonstrated by West Bengal State University in about 163 acres (~65 hectares) comprising 31

degraded mangrove sites at Indian Sundarbans and successful genotyping of four populations of *C. acanthospathus* (15 SSR loci) and *C. nambariensis* (15 SSR loci) along with three populations of *C. brandisii* (25 SSR loci), six populations of *C. andmanicus* (10 SSR loci).

Medical Biotechnology

The major focus is on Biomedical research & innovation for understanding the causes of human diseases such as non-communicable diseases, emerging infections, anti-microbial resistance, genetic disorders, pregnancy complication, diseases of early childhood, challenges in public health & nutrition, development of vaccines, innovative tools and therapies, healthcare delivery systems and development of products for medical applications.

Data Driven Research to Eradicate TB – “Dare2eraD TB”, was launched as an umbrella TB program which includes setting up of Indian TB Genomic Surveillance Consortium in line with the Governments vision of *TB Mukht Bharat*. An enzyme immunoassay with PPE17 (Rv1168c) as candidate antigen was developed with potential to serve as a serodiagnostic marker for primary screening of latent TB infected subjects. Also, a strategy to harness the power of CRISPR/Cas9, for modulation of gene expression in the Tuberculosis (TB) pathogen *Mycobacterium tuberculosis* (Mtb) has been developed. A taurine and acridine containing electrospun-nano fibrous-sheets (Tau-AcrNFS) efficiently scavenged damage-associated molecular patterns from stored human and mice RBCs ex-vivo, which may lead to the development of novel blood bags or medical devices.

On the other hand, for the first time, a novel therapy using cutting-edge biotechnology has been developed wherein Phase-1 clinical trial of Lentiviral vector-based gene therapy of hemophilia A was initiated at CMC, Vellore with first subject recruited in May, 2022. Mission Program on Pediatric Rare Genetic Disorders spanning diagnostics, research and counselling for

pediatric rare genetic disorders was also launched with an aim to analyse a total of 6000 individuals (2000 patient-parent trios) over 5 years and to identify the cause of undiagnosed genetic disease.

The GenomeIndia project, one of the major initiatives of the Department, has been implemented to catalogue the genetic variations by whole-genome sequencing (WGS) of 10,000 Indians. The project, spanning across 20 national institutes in the country, has enrolled 13803 participants for the study and completed their blood sampling, socio-demographic assessment and blood biochemical investigations. So far 6221 samples have undergone whole genome sequencing and genome-wide genotyping completed for 8063 samples.

GARBH-Ini: Inter disciplinary Group for Advanced Research on Birth outcomes -DBT India Initiative has enrolled over 10,000 pregnant women in order to study growth and development in different phenotypes of preterm birth, small for gestational age and low birth weight as compared to the normal babies. For the first time pre-term birth rates, still birth rate and small for gestational age has been systematically documented using ultrasound dating.

UMMID Initiative: The Unique Methods of Management of Inherited Disorders Initiative has established comprehensive screening facilities in the Government healthcare system, which have provided screening services to more than 1,90,000 beneficiaries and identified genetic abnormalities in over 13,000 cases, facilitating appropriate medical intervention.

India's 1st indigenously developed quadrivalent Human Papilloma Virus (qHPV) vaccine against cervical cancer supported by DBT and BIRAC received market authorization from DCGI in July, 2022.

Knowledge Generation, Discovery Research, New Tools and Technologies

The major goals of this programme is to perform research in advanced methods of computer based

information processing for analyzing the structure and function of biologically important molecules and also to evolve and implement programmes on education of users and training of information scientists. Projects are also being supported on AI applications for affordable and accessible healthcare in the area of cancer, tuberculosis and pulmonary diseases, diabetes and cardiovascular disease, ophthalmological and neurological disorders. These projects are being supported to develop mainly AI based diagnostics for different types of diseases.

Indian Biological Data Centre (IBDC), 1st national repository for life science data in India was established for archiving all life science data generated from publicly-funded research in India (ibdc.rcb.res.in). It is envisioned to usher in a new age of biological data analytics in the country. The Biotech-PRIDE (Promotion of Research and Innovation through Data Exchange) guidelines will be implemented through IBDC. The data center has started its operation by providing nucleotide data submission and analysis services. Presently, 55 datasets amounting to 195.6 billion bp have been submitted. These include RNA seq data, eukaryotic whole genome sequences as well as individual gene sequences etc. Further, more than 2 lakh viral genome sequences amounting to 6.1 billion bases have been submitted by INSACOG labs. IBDC has also developed and maintains an online dashboard for INSACOG aimed towards the real-time monitoring of SARS-CoV-2 variants in different states of India.

A machine-learning tool "MP4" that predicts and functionally classifies pathogenic proteins into their respective pathogenic classes and an algorithm that is capable of designing drug molecules for any protein from scratch were developed. On the other hand "PTPAMP", the first plant-based approach for predicting Anti-Microbial Peptides (AMPs) web server was developed (<http://www.nipgr.ac.in/PTPAMP/>) to provide a platform for peptide categorization among four defined activities and a module to generate their

mutated sequences in the hope of getting better bioactive peptides.

DBT's role in fight against COVID-19

The Department played a key role in the mitigation of COVID-19 pandemic through development of vaccines and diagnostics utilising its network of academia, startups, and institutes. It is a matter of pride that DBT has developed the following Vaccines for 'Swasth Bharat' and also established INSACOG:

- World's 1st and India's indigenously developed DNA Vaccine (ZyCoV-D), supported by DBT-BIRAC under Mission COVID Suraksha, received EUA for use in 12 years and above;
- India's 1st intranasal vaccine for COVID-19 received EUA for use in primary series (18 years & above) and for use as homologous & heterologous booster.
- Protein subunit vaccine, CORBEVAX™; and mRNA vaccine GEMCOVAC-19™ also received EUA.

Indian SARS-CoV-2 Genomic Consortium (INSACOG) was established to ascertain status of new variants of SARS-CoV-2. DBT is coordinating this Consortium along with other National Agencies. This consortium consists of 57 labs and 300+ sentinel sites and has sequenced >3.0 lakh COVID-19 positive samples so far.

Two Autonomous Institutes of DBT, National Institute of Animal Biotechnology (NIAB), Hyderabad and National Centre for Cell Science (NCCS), Pune, have been upgraded as Vaccine Testing Facilities (VTFs), with support from PM-CARES Fund, for enhanced testing and batch release of vaccines. Additional parallel testing of 6 batches of Covaxin and Covishield, has been completed by the facilities.

Building International cooperation and partnership

The DBT is committed through multifaceted approaches of International collaboration

programmes and partnerships such as bilateral collaboration, multilateral collaboration, International NGOs and partnerships with non-profit organizations in the mutually agreed areas to encourage science diplomacy essentially to bridge the gap of technology and capacity building in frontier areas of natural sciences.

Bilateral partnerships are ongoing with USA, Canada, Australia, UK, Spain, Sweden, Switzerland, Netherlands, Denmark, Belgium, Finland and Germany. Multilateral partnerships have been established via BRICS, QUAD, G20, TaSE, and Global Stars (EUREKA) along with organizations like HFSP and EMBO. Department collaborates with Bill & Melinda Gates Foundation (BMGF), Wellcome Trust (WT), Cancer Research UK (CRUK), Philanthropic Organizations as well as NGOs Nobel Media, Prakash labs for fostering capacity building and complementary research facilities with training in diverse translational research in basic science across the globe.

During the year, DBT renewed (through Cabinet approval) the cooperation with the Bill & Melinda Gates Foundation (BMGF) to support and initiate R&D cooperation for development of innovative and novel approaches, therapies and interventions needed to solve challenges concerning health food and nutritional equities. The Indo-U.S. Vaccine Action Program (VAP) which is a bilateral program, under implementation since 1987, has been extended till 2027 to support novel vaccine research, human immunology, vaccine-related technologies, translational research, and other activities of shared scientific interest supported jointly by both sides. Under the Ind-CEPI Initiative of DBT, bioassay lab at THSTI, Faridabad has been recognized as one of the 7 labs, globally, for centralized assessment of COVID-19 Vaccines.

Promoting Entrepreneurship and Industrial Growth

The Department of Biotechnology has established

Biotechnology Parks/Incubators to translate research into products and services across the country by providing necessary infrastructure support. So far, the Department has supported 11 Biotechnology Parks in various States for 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.

BIRAC, an industry-academia interface of DBT, has implemented a number of schemes and programmes to promote and support public private partnership in biotech sector across the country. More than 4000 Start-ups have been supported by BIRAC in all Biotech sectors which has enabled development of several affordable biotech products and technologies.

BIRAC has established a vibrant ecosystem comprising 75 Bioincubators across 21 States and UTs in the country supporting over 1800 incubatees. More than 2500 Companies have been supported by BIRAC. This has enabled over 1200 IP filings, 800 biotech products/technologies reaching to the market. More than 500 regulatory queries from Startups/entrepreneurs supported through BIRAC's FIRST HUB and about 250 through Regulatory Information Facilitation Cell. INR 4000 Cr follow-on funding have also been generated by 125 biotech Startups.

Societal Programme

The Department is supporting special projects in aspirational districts and rural areas through Biotech Based Programme for Societal Development and Biotech- Krishi Innovation Science Application Network (Biotech-KISAN) is empowering farming Community.

Through Biotech Based Programmes for Societal development, 32 projects were supported in aspirational districts benefitting more than 5000

persons. Women constituted 65% of the total beneficiaries, about 56% belonged to SC/ST communities.

Biotech KISAN programme has provided solutions to local farming problems across 15 agro-climatic zones of the country. Programme is aimed to work with small and marginal farmers especially the woman farmers for better agriculture productivity through scientific intervention and evolving best farming practices by linking available science and technology to the farm. So far more than 3 lakh farmers have been benefited through this programme.

Promoting Biotechnology in the North East Region of India

The Department has been allocating 10% of its annual budget every Year for the implementation of special Programmes for North Eastern Region (NER) since 2010.

The Twinning Programme for R&D has catalyzed collaborations between 65% institutions from NER and those from the rest of India. About 200 NER researchers as well as over 500 NER Students were benefitted. Eleven major network projects have been initiated to strengthen the citrus research in NER. DBT also supported a programme on "Fundamental Molecular Investigations in Biotechnology (Phase-II) at IIT, Guwahati. An improved and hygienic process for mass production of fermented foods of Meghalaya chubitchi (fermented rice beverage) and Fungrymbai (fermented soy bean) has been standardized. 250 beneficiaries were given training on package of practice including starter culture.

Biotech Hubs were established across NER for providing necessary infrastructure in universities/ colleges/ institutions and the required trainings in sophisticated technologies to support and promote biological sciences / biotechnology education and research. Advanced-level State Biotech Hubs with Leadership role (ALSBH-LR) and Advanced-level State

Biotech Hubs focuses on research addressing local issues, conduct advanced and specialized training for students, researchers and local entrepreneurs, provide mentoring to Advanced-level Institutional Biotech Hubs, work on micro-grants with young researchers in other NE Institutes, conduct awareness programmes and Popular Lecture series. Further, state-of-the-art Orchidarium with modern technologies have been developed for conservation and cultivation of important orchids at Kimin. A total of 75 species of the endemic orchids have been collected and maintained in the conservatory. Database of around 50 species of orchids has been created and important information was documented.

Data Monitoring

Department of Biotechnology (DBT) implements Output-Outcome Monitoring Framework (OOMF) as formulated by NITI Aayog. The DBT has set annual targets against each output and outcome indicators to monitor the progress of each of its programmes and schemes through OOMF. The progress is updated both quarterly & annually by DBT on OOMF dashboard developed and maintained by NITI Aayog.

Autonomous Institutions and Public Undertakings

The Department has established 14 theme based Autonomous Institutions, one statutory organization (RCB), one International centre (ICGEB) and three PSUs - BIRAC, BIBCOLD and IVCOLD, which are undertaking research in line with the National Development Programmes (NDPs) and Sustainable Development Goals (SDGs).

National Institute of Immunology (NII), New Delhi: The specific mandate of NII is to conduct advanced research in basic and applied immunology for studying the body's defense mechanisms and developing modalities of immune system manipulation that can intervene with disease processes. The research programs are focused on unravelling immune pathways that help preserve

organismal homeostasis, deciphering mechanisms of pathophysiology that operate in infectious and noninfectious diseases, elucidation of the structure and function of biomolecules and development of novel diagnostics, therapeutics and vaccines. NII provided the first evidence on the traits of immune memory generated in response to inactivated whole-virion vaccine BBV152/Covaxin. Biosynthetic mechanisms of a novel class of compound that sequesters zinc from the host and contributes to pathogenesis of *Mycobacterium tuberculosis* (Mtb) have been dissected. Studies towards vaccine development for malaria have delineated the minimal protective antigenic regions of several newly identified antigens. NII has published a total of 54 research articles in highly reputed peer reviewed international journals and four patents have been granted. Also, three scientists received major honours & awards this year. It has also filed a trademark (ASPAGNII) for a SPAG9 recombinant protein cell-based immunotherapeutic vaccine component for the treatment of various types of cancer. Technology developed at NII for using a collagen-based formulation for treatment and management of osteoarthritis has been transferred for commercialization.

Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad: The mandate of CDFD is to provide services and conduct trainings in the area of human & plant DNA fingerprinting, diagnosis of various genetic disorders; and carry out basic research in various disciplines of modern biology. One of the major initiatives of CDFD during this year was launching of "Mission program on Pediatric Rare Genetic Disorders". During the year, CDFD has solved a total of 58 forensic cases, including identification of deceased army officials of helicopter crash near Coonoor, Tamil Nadu; diagnostic test for 3795 individuals of various genetic disorders; and analysed a total of 506 Basmati rice samples and provided certificate about their purity for export. CDFD has published a total of 52 research articles

in highly reputed peer reviewed international journals. During the year, two scientists received JC Bose fellowship and one each received fellowship from INSA and NASI.

Center of Innovative and Applied Bioprocessing (CIAB), Mohali: CIAB, mainly works on Secondary Agriculture and development of value added products from different types of bio resources. CIAB licensed a technology on 'Production of food grade dye from *Butea Monosperma* Kuntze (Indian Patent <http://Appl.No.202211005755>)' to Vexcel Upkram Pvt. Ltd., Ranchi via Biotech Consortium India Limited (BCIL). A total of 12 new patents have been filed in Indian patent office (IPO) while 10 new processes have been developed for products related to the area of hydrogels, coatings, catalysts, enzymes, and functional food. In the year 2022-23, a total of 31 publications have been published in different journals of international repute and one patent has been granted by IPO. Also, three scientists have been awarded by different scientific societies.

Institute of Bioresources and Sustainable Development (IBSD), Imphal, Manipur: IBSD is working with the mission for "Bioresources development and their sustainable use through biotechnological interventions for the socio-economic growth of the North Eastern Region". Towards this end, IBSD has setup Bioincubators for Nurturing Entrepreneurship for Scaling Technologies (BioNEST) at IBSD, Node Meghalaya to develop women entrepreneurship through orchid floriculture in Meghalaya. More than 30 progressive women bio entrepreneurs from different villages have been enrolled for providing hands on training on horticulture practices, up keeping, harvesting, packaging, marketing and industry linkage for the selected orchids, through this program.

Institute for Stem Cell Science and Regenerative Medicine (inStem): DBT-InStem is leading stem cell research and application in India and a major contributor on the international stage

in stem cell biology. While facilitating increased translation of the benefits of stem cells to society through regenerative medicine, inStem also carries out extensive research training and social outreach. inStem has contributed new conceptual insights into the basic biology of stem cells and indigenous tools for application. Current research at inStem is broadly focused on lifestyle and metabolic disorders such as hematopoietic, cardiac, epithelial, endothelial and neural diseases. Their DBT funded institutional programs, have developed a strong foundation in iPSC generation and related methodologies, and setup repository and distribution pipelines. inStem has also developed strong capabilities in drug design and screening through programs. Recent highlights include the first phase I clinical trial on gene therapy for haemophilia, enhancing the quality and shelf life of stored blood, potential therapy for psoriasis, testing over 3 lakh samples for COVID-19, novel nanobody inhibiting SARS-COV2 entry, germicidal masks and many more.

International Center for Genetic Engineering and Biotechnology (ICGEB), New Delhi: The ICGEB New Delhi component has made significant progress in research during the year 2022. The centre has made around 76 publications and filed 02 National Patent applications. During the year, 01 National and 01 US Patent have been granted. Recently, an Italio-India one-day joint symposium was also organized on Pandemic and Post Pandemic responses. Novel insights were provided into the classification, evolutionary conservations, and functional divergence of the members of the CDS domain containing (CDCP) family across different *Oryza* species; transgenic plants overexpressing *E. coli* gene, hchA showed enhanced tolerance against salinity stress; increased glyoxalase and antioxidant enzyme activity that resisted the accumulation of excess magnesium and reactive oxygen species (ROS) during stress. Fermentation bioprocesses were developed using a robust *Saccharomyces cerevisiae*, NGY10 strain with paddy

straw hydrolysate and molasses as substrate for higher ethanol production.

Institute of Life Sciences (ILS), Bhubaneswar: The ILS applies basic, applied, and translational approaches in an interdisciplinary mode. There are 28 faculties supported by 150 research fellows, 25 post-doctoral fellows, and women scientists, as well as more than 100 project staff. Significant findings from the cancer biology group include identification of biomarkers involved in the invasion and metastatic pathways of Oral Squamous Cell Carcinoma (OSCC), role of fluvastatin in pancreatic cancer, significant tumor reduction after treatment of EVI1-positive cells with kinase inhibitors, development of mucins for promoting bone regeneration, and nano-formulation for cancer therapy. In the infectious diseases group, scientists have established that IRGM induces antiviral immune response, the MK2A inhibitor, CMPD1, abrogates chikungunya virus infection, and curcumin acts as an adjunct drug for standard therapy. The Institute has also established eukaryotic proliferating cell nuclear antigen as an ideal therapeutic target. Further, the reference grade genome of nutritionally-rich *Moringa* species was elicited by the Plant Biotech group which has also developed synthetic promoters for viral diseases and have characterized them in transgenic system.

National Agri-Food Biotechnology Institute (NABI), Mohali: NABI has been established to promote and coordinate research of high calibre in basic and translational aspects at the interface of Agriculture, Food and Nutrition. The major areas of research at the institute comprise improving cereals for nutrition and processing quality, improving fruits for post-harvest quality and nutrition, basic biology for crop improvement, diet and health, and computational biology approaches for marker and gene discovery. Main achievements at NABI include the development of wheat lines containing high amylose, biofortified colored wheat with high

anthocyanin content, pro-Vitamin A (PVA) enriched banana, microfluidic-chip based detection from a mixture of bacterial strains and edible coating material from agricultural and food processing by-products. The National Gene editing and training centre (NGETC) has also been established this year at NABI.

National Brain Research Centre, Manesar: The mandate of NBRC is to pursue research to understand brain function in health and disease, generate trained human resources to carry out interdisciplinary research in neuroscience, and promote neuroscience in India through networking among institutions across the country. NBRC is a NAAC accredited Deemed to be University and awards M.Sc. and PhD degrees. NBRC has also been recognized as an Institution of Excellence by the Government of India. Zika Virus E protein affecting the expression of tight junction proteins such as ZO-1, Claudin and Occludin, novel role of YAP1 in regulating mitochondrial dynamics with clinical relevance pertaining to their sensitivity to oxidative stress inducers and the possible role of innate antiviral response in the deterioration of motor functioning and pathogenesis of flaccid paralysis upon neurotropic virus infections are some of the research highlights.

National Center for Cell Science (NCCS), Pune: Within its tripartite mandate, NCCS functions as a National Cell Repository, conduct basic research in diverse areas of cell biology and train human resources. NCCS provided over 6000 cell cultures to around 540 organizations in India for research purposes. NCCS currently hosts 116 PhD students and awarded the doctoral degree to more than 25 students. NCCS also trained about 200 students in advanced cell biology research domains with specialized training using the state-of-the-art facilities. Research findings have been published in around 100 reputed society Journals and 06 national and international patents filed during the year. The Human

Microbiome Initiative of select endogamous populations of India initiative is the flagship programme of NCCS, wherein, a strong association of diet with the microbiome as compared to age and geography was observed. The institution also established the Centre of Excellence “National Center For Microbial Resource (with more than 2,00,000 microbial cultures)” and Anti-Microbial Resistant (AMR) repository (with 1000 cultures) as an invaluable national research resource. Several NCCS scientists received prestigious scientific recognitions.

National Institute of Biomedical Genomics (NIBMG), Kalyani, West Bengal: The mandate of NIBMG is to enhance knowledge of human health and disease through genomics and to translate the knowledge for promotion of well-being and improvement of genetics-based health care. Research efforts on genomics of gingivobuccal oral cancer in India have resulted in the comprehensive identification of major genomic alterations which drive this cancer from precancerous lesions. Further, a public database of these alterations (dbGENVOC), have designed a cost-effective sequencing gene panel for early diagnosis and developed novel buccal mucosal cancer cell lines. Additionally, NIBMG has delineated genomic signatures and cross talks in HPV16 positive CaCx, ER+ breast, pancreatic and gastric cancer.

National Institute of Animal Biotechnology (NIAB), Hyderabad: NIAB's mission is to contribute to a sustainable and globally competitive livestock-based economy through cutting-edge research & development. Its vision is to demonstrate excellence in science, and to develop technology and solutions in animal biotechnology, leading to eventual commercialization. NIAB has set up vaccine testing facility with PM CARES fund and started testing different batches of COVID vaccines. It has launched a project on “One Health” with a consortium of 27 partners from veterinary, medical and wildlife disciplines, located throughout the country, including the northeast regions. Lateral flow-based diagnostic kits for detection of Japanese encephalitis; and

reagents and assays for the detection and differentiation of snake venoms have been developed. LFA-based technology is developed for detection of *Toxoplasma gondii* infection in farm animals and humans. Four technologies have been transferred to industry, including a subclinical and clinical mastitis kit, an antibiotic sensitivity testing device and a diagnostic assay which can not only detect antibodies to Brucella in humans and animals, but also differentiate vaccinated and naturally infected animals. Other technologies as well as potential therapeutic applications to improve the health and productivity of the animals are on the anvil.

National Institute of Plant Genome Research (NIPGR), New Delhi: NIPGR's mandate is to undertake high-quality research in frontier areas of fundamental and applied plant molecular biology and biotechnology. To utilize molecular biology, genomics and integrative omics along with tissue culture, genetic engineering, gene-editing and molecular breeding to identify and understand the structure, expression, regulation and function of important genes/proteins/metabolites and manipulate them for developing climate resilient and high nutritional value crops. Further, institute is engaged in knowledge dissemination for human resource development and providing effective linkages between various scientific and research agencies in India and abroad. A major genetic locus associated with sheath blight disease resistance has been identified in rice and transferred to elite rice cultivar by Marker Assisted Breeding (MAB). A high yielding chickpea line NC7 (ADVIKA) under drought condition has recently been approved by ICAR for cultivation in India. Using gene editing technology low glucosinolate mustard lines have been developed. Under the Mission mode program, 2400 Pan Genebank Core chickpea germplasm accessions have been re-sequenced and field phenotyped.

Regional Center for Biotechnology (RCB), Faridabad: RCB is an Institution of National Importance established by the Department of

Biotechnology (DBT), Govt. of India, under the aegis of UNESCO with a mandate to impart education and training, and conduct research in the frontier areas. RCB offers structured degree programs as well as short-term training programs in highly specialized areas. Currently, 120 students are pursuing doctoral degree programs in Biotechnology, Bioinformatics, and Biostatistics in different RCB laboratories. So far, RCB has awarded 54 PhD degrees. RCB also has an integrated MS-PhD degree program where students with bachelor's degrees are admitted. A total of 49 students are currently registered for this programme. Besides, RCB has granted recognition to the MSc, MS-PhD (integrated), or PhD programs at 13 HEIs. More than 400 students from these recognized centers are registered for their degrees with RCB. More than 100 publications in high impact journals have been published during the reporting period and 04 patents have been filed.

Rajiv Gandhi Centre for Biotechnology (RGCB), Trivandrum: The mandate of RGCB is discovery and translation research in diverse areas of medical biotechnology and Plant Disease Biology where it has made significant contributions both in terms of publications and commercialization of research outcomes. In addition, the institute has done extremely well in response to SARS CoV 2: completed 14562 SARS CoV2 sequencing for the INSACOG; validated 110 diagnostic kits from different parts of the country in their Laboratory Medicine and Molecular Diagnostics facility for regulatory approval. A BSL3 Plus and Next Generation Sequencing facility has been established at the fully equipped new campus at Akkulam. RGCB is also a part of the IARC-India HPV multi-center vaccine study and played a pivotal role in the recommendation to implement single-dose HPV vaccination by WHO. RGCB has completed a science museum at Wyand to promote science culture among school students and the public.

Translational Health Science and Technology Institute THSTI, Faridabad: Translational Health

Science and Technology Institute (THSTI), a premier Institute of DBT, is engaged in cutting edge clinical, translational and basic research to improve human health. The thrust areas are Mother & Child Health, Vaccines, Tuberculosis, Virology and Diagnostics. THSTI has developed the largest cohort of over 12000 pregnant women and a birth cohort of nearly 5000 babies to decipher the causes of preterm birth with potential to change management protocols. THSTI has developed a SARS-CoV-2 vaccine which is likely to go into phase 1 clinical trial. THSTI is developing a panbetacoronavirus vaccine through \$12 million funding from CEPI. THSTI has developed novel anti-TB molecules. Clinical Development Service Agency is conducting 10 multicentre clinical trials and has started 'MSc in clinical research'. Its immediate Kangaroo care Mother (iKMC) study has led to modification of WHO treatment guidelines for pre-term babies. THSTI scientists received multiple awards, transferred four technologies, obtained four patents and published 70 research articles in the current year.

Biotechnology Industry Research Assistance Council (BIRAC): BIRAC is a Government of India Enterprise, not-for-profit, Section-8 company, set up in 2012 under Department of Biotechnology, Ministry of Science & Technology. BIRAC as an enabler aims to strengthen and empower the emerging Biotechnology ecosystem to undertake strategic translational research & development and create innovative, globally competitive products/technologies addressing unmet needs. To showcase the strengths of Biotech Startup Ecosystem, first of its kind, a mega national event called **Biotech Startup Expo 2022** was organized on 9-10 June 2022. BIRAC has established national and international strategic partnerships, networks and platforms involving Industry-Academia Innovation research and facilitate novel, high quality affordable product development through cutting edge technologies. BIRAC also integrates with National Missions (Make in India, Startup India, National Biopharma Mission, Ayushman Bharat), Policy

initiatives, G2G and Multilateral collaborations for International Ecosystem Connect to scale the Biotechnology Innovation Ecosystem across India. BIRAC also contributes to the Government's national programs such as "Make in India", "Startup India", "Swachh Bharat", "Ayushman Bharat", international alliances through program management units for National Biopharma Mission, Bill & Melinda Gates Foundation, Wellcome Trust and USAID.

Indian Vaccines Corporation Limited (IVCOL), New Delhi: The Company has no trading or commercial activity and is maintaining its establishment from DBT office at CGO Complex to look after its site and complying with the statutory obligations under the Company's Act, 2013.

Bharat Immunologicals and Biologicals Corporation Limited (Bibcol), Bulandshahr, Uttar Pradesh: Bibcol has manufacturing facility of dispersible Zinc Tablet in Pharmaceutical segment. BIBCOLD is also engaged in pilot scale formulation of Oral Cholera Vaccine and setting up the manufacturing facility.

Regulation, Intellectual Property and Legislation:

Biological Research Regulatory Approval Portal (BioRRAP)– "One Nation One Portal", launched by DBT as whole of Government approach in tune with our Hon'ble PM's vision to strengthen inter-departmental synergies in functioning of agencies regulating various aspects of biological research. The Portal serves as a gateway and helps researchers to see status of approval of their applications for regulatory clearances.

Standard Operating Procedures (SOPs) for regulatory review of Genome Edited Plants under Site Directed Nuclease-1 (SDN-1) and SDN-2 categories have been notified for enabling regulatory streamlining of genome edited plants and resilient crops for future.

Administration and Finance

The General Administration Section of the Department ensures that all the activities including housekeeping, cleanliness, stores, canteen, R&I, library, Staff Car arrangements, various procurements, issuance of Identity cards/CGHS cards, booking of domestic and international flight tickets and other administrative works for effective and smooth functioning of the Department.

In 2022-23, the Department has adopted version 7.0 of e-office. Almost all the work is now being performed through e-files. In addition, the e-bill regime has been completely active in Admin section and all the mandatory payments/releases eligible under this are being processed through e-bill system. A total number of 1371 new e-files have been opened from 1st April, 2022 till 15th December, 2022.

As per Government directives, during this Financial Year, a total procurement of Rs. 7212488/- has been done through Government e-Marketplace (GeM).

A Special Drive/Campaign was launched by the Government of India during 2nd October, 2022 to 31st October, 2022 for expeditiously disposing of various pending issues, namely, Parliament Assurances, Public Grievances, references from Members of Parliament, State Government references, Inter-Ministerial consultations, etc. A total of 331 grievances were received by the Department, from 01.01.2022 to 23.12.2022, through the CPGRAMS portal, out of which, 319 have been disposed. A total of 175 RTI applications were received by the Department, from 1.4.2022 to 23.12.2022, through the RTI portal, out of which 154 have been disposed, similarly a total of 27 RTI appeals were received by the Department, out of which 22 have been disposed respectively.

Department of Biotechnology (DBT) was allocated an amount of Rs. 2581.00 crores in the Budget Estimate (BE) for FY 2022-23. The allocation has, however, been reduced to Rs. 2192.92 crores at RE stage.

02

**BUILDING CAPACITIES:
HUMAN RESOURCE
DEVELOPMENT,
TRAINING &
WORKSHOPS AND
INFRASTRUCTURE
SUPPORT**

2

BUILDING CAPACITIES: HUMAN RESOURCE DEVELOPMENT, TRAINING & WORKSHOPS AND INFRASTRUCTURE SUPPORT

Capacity building, competence building and skill development in broad areas of biotechnology are the key verticals defining the mandate of Human Resource Development (HRD) Programmes of DBT. Recognizing the need for nurturing large pool of skilled and dynamic human capital which are critical for success in building of Indian innovation ecosystem as well as fostering the growth of the Indian Biotechnology industry, DBT has been supporting several human resource development programmes for promoting and supporting students, research scholars, faculty, scientists, entrepreneurs, etc., DBT's National Biotechnology Development Strategy 2021-2025 also places strong emphasis on creating high quality scientific and technical human resource in the country.

DBT-HRD programmes include postgraduate teaching/ training; fellowships for doctoral and postdoctoral research; schemes for women scientists and young investigators; biotech industrial training program; biotechnology finishing school program; scholarships and awards; re entry grants; innovative schemes like 'STAR college' and Research Resources, Service Facilities and Platform (Infrastructure). These schemes and programmes are now aligned with the efforts of Government of India's flagship initiatives such as Skill India, Start up India, Digital India, amongst others.

A detailed account of these HRD and Infrastructure activities is provided in the following sections of this report.

(A) Teaching Programme:

(i) DBT Postgraduate Programme (DBT PG) in Biotechnology (M.Sc./M.Tech./M.VSc.)

The Post Graduate Programmes in Biotechnology (DBT PG) are being implemented by DBT since the year 1985. The aim is to ensure a high quality standard of teaching and providing state of the art infrastructure facilities to universities and institutes across India and promote an ecosystem of trained manpower in the country required for industrial and academic activities. Financial support was provided for procurement of laboratory equipment and facilities essential for class room teaching, recurring grant for consumables, studentship, books and journals, travel, visiting faculty, contingency, thesis grant for in-house dissertation and equipment maintenance. Selection of students to these courses is made through the Graduate Aptitude Test-Biotechnology (GAT-B). GAT-B 2022 was held on 23 April, 2022 at 59 cities across India, where 8677 candidates appeared. Based on the results of GAT-B 2022; 675 candidates have been admitted in DBT supported postgraduate programmes in Biotechnology in 63 programmes running in 56 participating host universities/institutes. In all, there are ~1400 DBT supported Post Graduate students studying in first and second year of DBT supported PG Programmes in the year 2022-23.



Fig. 2.1 DBT supported Post Graduate (DBT PG) Programmes in Biotechnology in the year 2022-23.

(ii) **DBT Star College Programme:** The Star College Programme was initiated by DBT in 2008 to support colleges and universities offering undergraduate education to improve Science teaching across the Country. On a larger perspective, the scheme was initiated with a vision to encourage more students to take up higher education in Science. Through this scheme, the Department identifies colleges with potential for excellence and provides support for developing infrastructure for academics and laboratory activities.

Starting with a meagre 30 colleges in 2008, this pan India scheme has so far supported science departments in more than 300 colleges all over the country. The scheme acts as a catalyst in igniting young minds (faculty and students) to engage in networking, exposure visits to research institutes and industries and apply for research grants in order

to prepare them for future challenges after the successful completion of their undergraduate courses.

Major Initiatives during the year:

Science Setu Programme: The Science Setu Programme is for “Discovering Possibilities” and aims to build awareness about the importance of Science in our lives and through engagements with practitioners, showcases the excitement, the challenges as well as the opportunities arising from a career in science. Under this Programme, DBT Autonomous Institutes have been linked with Star Colleges for providing exposure to contemporary research to Undergraduate Students and College Faculty. Virtual lab visits, webinars and lectures are planned as well as discussions on career opportunities for participating UG and PG students. The programme is organised under the aegis of the Atmanirbhar Bharat, India@75 campaign. Under this programme, in the current year ~50 webinars were organized.

Star College Mentorship Programme: The special programme was launched by Hon'ble Minister of State (Independent Charge) of the Ministry of Science and Technology & Earth Sciences in November 2021. Under this programme, the colleges that have been conferred with the prestigious "Star Status" will adopt a higher role of mentoring the colleges that have currently initiated their journey under the "Strengthening Component" implementing the scheme's mandate, and also to make the colleges aware of other programs of the Department/Ministry and expand their efforts into networking, hand holding and outreach with a special focus on colleges from Aspirational districts of the country. This year 04 mentorship workshops were conducted at Prayagraj and Meerut (Uttar Pradesh); Rajkot (Gujarat); and Kolkata (West Bengal). Faculty from around 150 colleges participated in these workshops and DBT Officers made them aware about the Star College scheme and other HRD programmes of the Department, and resolved their

queries. As a result of these mentorship programmes, number of applications for Star College scheme has



Fig. 2.2 Significant outcomes of Star College programme

Significant notable outcome and achievements of the Programme: This year 23 new colleges have been supported under Strengthening Component and 02 Colleges have been supported under Star Status. Proposals of 05 colleges under Strengthening Phase and 10 Colleges under Star Status are at various stages of administrative and financial approvals. The categorization of the scheme into urban and rural categories during 2018-19 has ensured a level playing field for applicants hailing from rural and urban areas of the country. So far, 85 colleges from rural areas and 8 colleges from Aspirational district have been supported under the scheme. This year, the Department has received 125 proposals from Urban areas and 56 from rural areas. In addition, to enhance the outreach of Star College scheme in North-East region, a special Call was issued only for Colleges from NER and 35 proposals have been received under this category.

(B) National Fellowship Programme:

(i) DBT Junior Research Fellowship Programme: Department is providing fellowships to biotechnology students with Indian domicile for pursuing doctoral research at universities and research institutions across the country. Students are selected through a national computer based Biotechnology Eligibility Test (BET). Students are selected under two categories. Under Category-I, there is provision to select up to 500 fellows for award of DBT-JRF fellowship, candidates in the merit list beyond this number fall under category II and are eligible for fellowship equivalent to NET qualified candidates from extramural R&D projects being supported at universities/institutes. During BET 2022, 13,699 applications were received, out of which 11,771 students appeared for examination organized at 101 centers located across the country in 56 cities. Under Category-I, 434 candidates and 193 candidates under Category-II were shortlisted. This year, a total of 998 ongoing students have been supported and 209 new fellows have joined so far under the DBT JRF Programme. A total of 142 research articles and reviews have been published by DBT JRF fellows. A total of 29 fellows were awarded doctoral degree by respective institutions.

(ii) DBT Research Associateship (DBT-RA) Programme: DBT Research Associateship programme was initiated in the year 2001 with the objective to train post-doctoral students in frontier areas of research in Life Sciences and Biotechnology at premier institutions in country and enhance the post-doctoral culture in the country. There is a provision for 100 fellowships per year. The fellowship is initially awarded for a period of two years and can be extended based on review of progress. This programme is being coordinated by Regional Centre for Biotechnology, Faridabad since April, 2022. In year 2022-23, 107 ongoing fellows have been supported under the programme; 87 research articles published by DBT-RAs; and 8 fellows have reported employment/placement in universities/ research institutions. During 2022-23, 1033

applications were received in response to advertisement and 47 candidates were selected for the award of DBT-RA fellowship.

(iii) Distinguished Biotechnology Research Professorship: 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. A maximum of 5 fellowships can be conferred at any point of time.

(iv) Janaki Ammal National Women Bioscientist Fellowship: In order to recognize the contributions of senior and young Women scientists in the country who are working in the areas of Biology and Biotechnology, this fellowship was initiated in the year 1999. The fellowship is conferred under two categories-Senior category and Young category. The senior category fellowship recognizes life time contributions of scientists, who have done excellent research in the country and has applied the results for benefit of students and society. The young category fellowship is given to women scientists below 45 years of age in basic and applied research in the areas of Biosciences and Biotechnology including Agricultural, Biomedical and Environmental Sciences with potential for application/product and technology development. A total of 72 fellowships have been given so far.

(v) S. Ramachandran-National Bioscience Fellowship for Career Development: National Bioscience Fellowship for Career Development is conferred in recognition of outstanding contributions of young scientists below 45 years of age in basic and applied research in the areas of Biosciences and Biotechnology including Basic, Agricultural, Biomedical and Environmental Sciences with potential for application/product and technology development and to provide grant for research for their career development. A total of 182 fellowships

have been given so far.

(vi) Tata Innovation Fellowship: The Department initiated the Tata Innovation Fellowship scheme in 2006 to recognize and reward scientists up to 55 years of age, with outstanding track record in Biological Sciences, commitment to find innovative solutions to major problems in Healthcare, Agriculture and other areas related to Life Sciences and Biotechnology. Each year up to 10 fellowships are awarded. Each awardee receives, in addition to regular salary, a fellowship @ Rs. 25,000/- per month and a contingency grant of Rs. 10.00 lakh per annum. The duration of the fellowship is initially for three years which can be extended further by two years. During the year, 10 candidates are selected for award of fellowship.

(vii) Har Gobind Khorana - Innovative Young Biotechnologist Fellowship (IYBF): The Innovative Young Biotechnologist Fellowship (IYBF), initiated in 2005, is to nurture outstanding young scientists, below 35 years of age, with innovative ideas and desirous of pursuing research in cutting edge areas of Biotechnology. Selection of candidates for the year 2022-23 is under process.

(C) Building Critical Mass of Science Leaders

(i) DBT Ramalingaswami Re-entry Fellowship (DBT-RRF) Programme: The idea behind starting Ramalingaswami Re-entry Fellowship in 2006-07 was to attract highly talented Indian brains working abroad to pursue their research interests in Life Sciences, Biotechnology and other related areas in India. So far, 553 fellows have been supported under this programme, out of which 339 fellows have already secured permanent faculty positions in Indian institutions. As evident from the increasing number of applications for the fellowship, more and more number of people are showing interest to come back to India and serve the nation. In last few decades, Indian laboratories have also gained capacities,

quantitatively as well as qualitatively, to provide excellent facilities for the fellows to pursue their scientific endeavours. Currently, 299 ongoing fellows are supported under this programme.

(ii) M K Bhan-Young Researchers Fellowship Program:

The Department launched the M K Bhan-Young Researcher Fellowship Programme (MKB-YRFP) in 2020-21 with an aim to encourage young bright researchers to continue their research in the country after PhD. The scheme is to offer an independent research grant of Rs. 20.00 lakh/year and a fellowship amount of Rs. 75000/month to young Post-Doctoral Fellows for 3 years, so as to enable them to emerge as future leaders and take up cutting edge research focused on issues of national relevance. This fellowship is awarded for research work to be carried out at DBT-Autonomous Institutes only. The proposed number of fellowship under the program is 50/year. As of now 32 fellows have joined the fellowship. For the FY 2022-23, 23 fellows have been selected for this fellowship.

(iii) Biotechnology Career Advancement and Re-orientation Programme (BioCARE):

Biotechnology Career Advancement and Re-orientation Programme (BioCARE) is a special programme of the Department with a vision to promote women in Science. The programme aims at providing support for Research project grants to unemployed women scientists for whom it is the first extramural research grant and helps towards their career development. It offers a good opportunity for women scientists on career break to get into the mainstream research. Around 365 women scientists have been supported and have published 450 research articles. In current year, 15 articles have been published and 01 application filed for patent.

Some studies under the programme have been highlighted here:

A study carried out at CSIR- Indian Institute of Integrative Medicine, entails development of salts/

co-crystals of natural product derived anti-cancer leads with favorable biopharmaceutical properties. It has led to the formulation and scale up synthesis of IIM-288, IIM-985, IIM-290 and VKB-SD75 (pre-clinical candidates).

A study carried out at Interactive Research School for Health Affairs (IRSHA), Bharati Vidyapeeth (Deemed to be) University, is looking at local maternal cohorts for detailed characterization of Peroxisome Proliferator-Activated Receptors (PPAR) levels, miRNAs and finally an attempt to link these changes to maternal fatty acid levels perhaps through potential changes in epigenetic regulation. Project lays the foundation for an excellent platform to mine for changes and perhaps link up with fat-thin Indian phenotypes reported in this area with these genetically similar populations.

In another study at CSIR-Central Drug Research Institute, tissue specific transcript and cardiac glycoside profiling of Calotropis plant after different biotic and abiotic elicitor was identified. The accumulation pattern of four glycosides i.e. Calactin, Asclepin, Uscharin and Frugoside was identified. A putative Cardiac glycoside biosynthetic pathway involved in its biosynthesis and regulation in Calotropis procera was identified using customized microarray. It was observed that Kyoto Encyclopaedia of Genes and Genomes (KEGG) pathways mapped in stem tissue followed a different pattern as compared to leaf and root tissue, where “Biosynthesis of other secondary metabolites” and “Metabolism of terpenoids and polyketides” and “Glycan biosynthesis” were among the prominent pathways.

A study at National Centre for Cell Sciences, Pune is focusing on isolation of halophytic archaea from different saline ecosystem; exploration of those strains for production of Extracellular Polymeric Substance (EPS); optimization, purification and toxicity testing; biotechnological applications, sample collection of mangrove sediments, rock samples and sea water samples for isolation of haloarchaea in

area of Maharashtra. Of the 180 haloarchaea cultures isolated, 46 cultures were high EPS producers. EPS production was quantified in 26 cultures. Haloarchaeon HDS-1 is employed for production, optimization and characterization of exopolysaccharide. PI has submitted 18 haloarchaea to National Centre for Microbial Resource (NCMR) culture collection deposit and assigning the accession numbers to the cultures.

A study conducted at Centre for Cellular and Molecular Biology, Hyderabad is centred on the IPM through biocontrol, by employing the chitinolytic activity of an insecticidal strain of *Brevibacillus laterosporus*. The strain namely, Lak 1210, was isolated from mangrove soil. The PI successfully cloned the gene responsible for chitinase production in industrial strain of *E. coli*. The toxicidal activity and synergistic effect of chitinase for controlling *Spodoptera litura*, Tobacco Cutworm/Cotton Leaf-worm, is apparent from its application at its larval stages. One of the major outcomes of this project has been the draft genome sequence of the strain, which makes further studies possible on several biological aspects.

A study at NIPGR, New Delhi has identified the role of Cyclic Nucleotide Gated Channels (CNGC) specially the specific role of CNGC 4/CNGC19 in the perception of herbivory by regulating the Ca^{2+} fluxes in *Spodoptera litura*. Also, in *Arabidopsis thaliana* it activates cytosolic Ca^{2+} elevation, which triggers downstream defense with Jasmonic acid production. Loss of CNGC19 and CNGC13 function results in decreased herbivory defence. PI identified CNGC13 as a key gene activated in plants within 30 minutes of *S. litura* perception and involved in plant defence and characterized the role of plant calcium channel, CNGC19 in plant-insect interactions.

Another BioCARE supported scientist at NIAB, Hyderabad has designed peptides that can bind to uPAR; conjugated these sequences to iron oxide nanoparticles, and tested the efficacy of particle uptake by cancer cell lines expressing uPAR. The results show that the uptake efficiency is high and there is considerable killing of cancer cells.

A study on multimodal glioblastoma therapy by blood brain barrier traversing and glioma targeting anticancer peptide theragnostic nanoparticles is

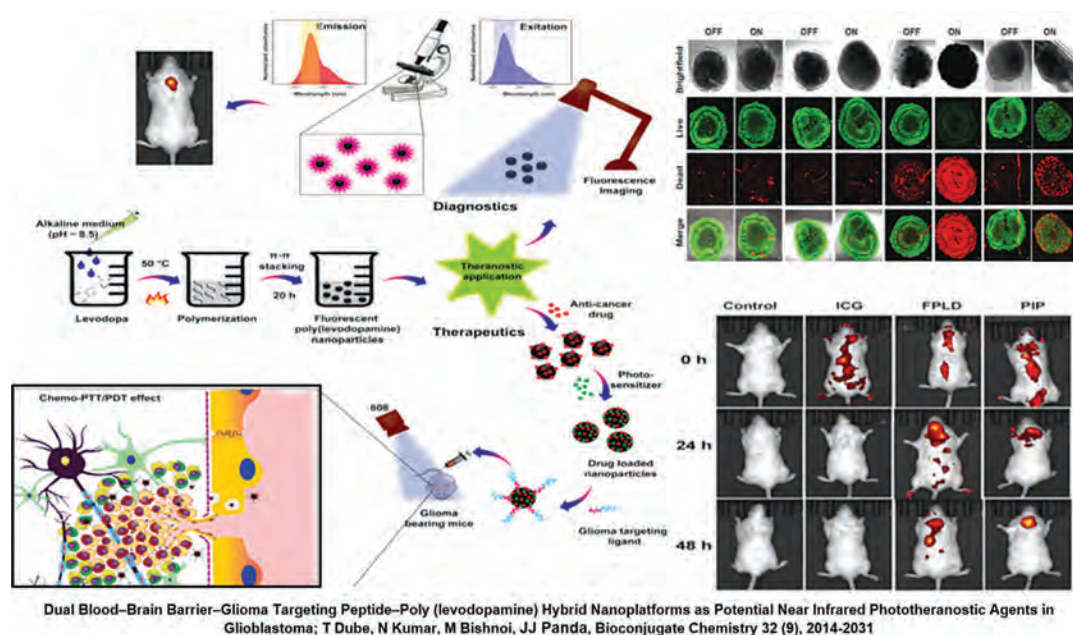


Fig. 2.3 Brain tumour targeting Levodopamine based photoresponsive nano structures.

being conducted at Institute of Nano Science and Technology (INST), Mohali.

A study at Gujarat University, Ahmedabad on “Biotransformation of castor oil into desired fatty acids for their uses and applications” has demonstrated hydrolytic enzyme (lipase)-catalyzed hydrolysis of Castor oil to produce Ricinoic acid. This process is performed at atmospheric pressure and at ambient or slightly higher temperature resulting in high-purity products.

(D) International Fellowship/Internship/Partnership Programme:

(i) **Khorana Program for Scholars:** The program is mainly designed to provide opportunities to Indian UG and PG students to gain exposure and access to world class research facilities at different laboratories of the USA for internship. The program is implemented through India- US S&T Forum (IUSSTF). The selection for the F.Y. 2022-23 is underway.

(ii) **PhD Fellowship Programme under Indo-Australia Collaboration (Indian Institute of Technology, Bombay-Monash University):** The broad scope of the Programme is to enable joint PhD degree from IIT Bombay and Monash University. This will also have one year research at Monash University. This program is for a period of 10 years and a total of 65 students will be supported. Under this programme, total 62 students have joined the PhD at various departments of IIT Bombay.

(iii) **DBT TWAS Programme:** ‘The World Academy of Sciences’ for advancement of science in developing countries or more commonly known as ‘TWAS’ was founded in 1983. With the aim to address societal challenges through application of S&T in emerging areas, DBT-TWAS Biotechnology fellowships have been jointly promoted since 2004 by Department of Biotechnology (DBT), New Delhi and TWAS, Trieste, Italy for scientists/ researchers

from developing countries other than India. DBT provides fellowship and contingency grant to the selected candidates tenable at Institutes in India under three categories: (a) Full Time Postgraduate Fellowship to pursue doctoral programme; (b) Sandwich Postgraduate Fellowship to the Students (registered for doctorate in their own countries) for training in India to help in their PhD; and (c) DBT-TWAS Postdoctoral Fellowship to pursue a postdoctoral research programme in India. A total 25 fellows have been selected against the call for the year 2021-22, out of that 10 fellows have joined their respective host institutions in India.

(iv) **DBT-Wellcome Trust Partnership/India Alliance (IA):**

Biomedical Research Career Programme (BRCP): The Department of Biotechnology (DBT, India) partnered with Wellcome Trust (UK) to support Biomedical Research Career Programme (BRCP), with a focus to build world-class biomedical research and innovation environment in India. Since its inception in 2008, BRCP is administered by the DBT/Wellcome Trust India Alliance (IA), a public charity jointly funded by the DBT and the Wellcome Trust.

To support high-quality basic, clinical, public health and veterinary research, India Alliance offers its three-tier fellowship programmes - Early career, Intermediate and Senior Fellowships - in both Basic Biomedical Research as well as Clinical and Public Health Research domains. In the current year, 12 Early Career; 07 Intermediate; and 06 Senior Fellowships have been awarded for cutting edge research in Biomedical Sciences.

These Science and Clinical/Public Health Research Centre Grants provide the much needed thrust to collaborative research and training and provide the opportunity to support and enable policy implementations and interventions to bring about systemic change. In the current year 05 grants have

been awarded for high-risk high-reward research in Biomedical Sciences.

India Alliance has also invested in building capacity for research management, an essential but often neglected ingredient in strengthening a nation's research ecosystem through its India Research Management Initiative (IRMI). In the current year 03 IRMI fellowships, 03 IRMI grants and 03 IRMI Travel grants have been awarded for building research management ecosystem at biomedical research institutes.

Significant achievements/outcomes:

Major Quantitative achievements during the year 2022-23:

Process/Product/ Technology Developed	02
Research Publications	445
Patents Applied	13
Patents obtained	02
Outreach programs	11
Science Communication workshops	14

Three BRCP fellows including Dr. Arun Shukla, Dr. Jeemon Panniyammakal and Dr. Amit Singh have received Shanti Swarup Bhatnagar Award (2021). Dr. Bushra Ateeq received Sun Pharma Science Foundation Research Award (2021) in Medical Sciences. Dr. Subba Reddy Maddika received CDRI Award for Excellence in Drug Research 2022. Dr. Shobhna Kapoor received SERB Women in Excellence Award for Chemistry. Dr. Sarit Agasti received Merck Young Scientist Award (2021). Dr. George M Varghese is appointed Trustee of the Royal Society of Tropical Medicine & Hygiene, UK. Dr. Shashank Tripathi received Global Scholar Award 2022 by American Society for Virology. Dr Tamal Das received Human Frontier Science Program research award. Dr. Sridharan Devarajan and Dr. Siddhesh Kamat received Swarna Jayanti Fellowship. Additionally, multiple BRCP fellows were elected to

the Indian Academy of Sciences, Indian National Science Academy and the National Academy of Sciences.

(v) Partnership Programmes with EMBO, HFSP

The European Molecular Biology Organization (EMBO), EMBC and India: In January 2016, the Government of the Republic of India became an associate member of EMBO by signing a Cooperation Agreement with EMBC. This was a stepping stone to strengthen scientific interaction and collaborative research between India and Europe by making Indian scientific community eligible to participate in all EMBO Programmes and activities.

HFSP: The International Human Frontier Science Program Organization (HFSP) funds an international program of research support for frontier research on the complex mechanisms of living organisms through the Human Frontier Science Program (HFSP). In 2021, five Indians received HFSP grants support in Research Grant (1) and Long-Term Fellowship (3).

EMBO and HFSP Fellowships/ Grants	Number
The Global Investigator	4
EMBO Postdoctoral Fellowships	5
EMBO Scientific Exchange Grants	3
Workshops funded by EMBO	2
India EMBO Lecture Courses funded by EMBO	4
EMBO Laboratory Leadership Courses	4
HFSP grants support in Research	1
HFSP Long-Term Fellowship	3

(E) Training Programmes

(i) Skill Vigyan State Science and Technology Partnership Programme in Life Science and Biotechnology (Skill Development Programme): This programme has been

implemented with an objective to provide hands-on-training in tools and techniques in Biotechnology and allied areas to generate skilled manpower. This programme has been designed for providing skill training under five categories (a) Students (b) Technician training (c) Faculty training (d) Entrepreneurship Training (e) Biotechnology Finishing School Programme. This year Department implemented the program in Kerala, Chandigarh (Union Territory) and Gujarat through their State Science and Technology councils and also supported the Skill Vigyan activities in ongoing projects implemented in nine states viz., Arunachal Pradesh, Himachal Pradesh, Meghalaya, Odisha, Punjab, Uttarakhand, Karnataka, Telangana, and Andhra Pradesh.

(ii) Biotech Industrial Training Programme (BITP): Department of Biotechnology is supporting Biotech Industrial Training Programme (BITP) for providing six months of hands-on training to fresh B.E./B.Tech./M.Sc./M.Tech Biotechnology students. The objective of this program is to impart skill based training to students for their holistic development so that their employability increases in relevant industries. The Department has adopted apprenticeship model for implementation of DBT-BITP Programme, and linkages have been developed with Life Science Sector Skill Development Council (LSSSDC), New Delhi for selection of partnering industries for providing apprenticeship in Biotechnology sectors. Provision has been made for the selection of 800 students/year (including 100 for NER candidates) under the DBT BITP Apprenticeship Programme. A stipend of Rs. 10,000/- per month is paid to all selected candidates for six months' period and companies are also providing apprenticeship to all trainees. During 2022-23,

linkages have also been established with Food Industry Capacity & Skill Initiative (FICSI) Council. For 2022-23, call for training requisition from companies has been published and so far 357 requisition from 30 companies have been received. The process is underway for advertisement of call for applications from students for selection under the program.

(iii) Foldscope Programme: The Department, as part of its science outreach and societal development activities to popularize science among the teachers and young students has implemented the Foldscope (a low-cost paper microscope) as a tool for education and research. Foldscope which is an ultra-affordable paper microscope invented by an Indian researcher Dr. Manu Prakash at Prakash Lab, Stanford University, USA was brought to India after the signing of a Statement of Intent between the Department of Biotechnology (DBT) and Prakash Lab (Stanford University), USA. During the year 2022-2023, the Department organized two hands-on training workshops on the use of Foldscope at Visakhapatnam, Andhra Pradesh and Washim, Maharashtra wherein 112 school teachers from 17 Aspirational Districts of South India, Gujarat and Maharashtra (viz. Vizianagaram, Kadapa and Visakhapatnam- Andhra Pradesh; Wayanad, Kerala; Ramanathapuram and Virudhunagar, Tamil Nadu; Bhoopalpalli, Khammam and Asifabad- Telangana; Yadgir and Raichur- Karnataka; Narmada and Dahod- Gujarat; Nandurbar, Washim, Gadchiroli and Osmanabad- Maharashtra) were trained in use of Foldscope. Besides this, 604 students were also trained on use of Foldscope for their science related projects. This training has provided a platform to the students & teachers to use Foldscopes as microscopy tool for their practicals, detection of samples, etc at their schools. (Fig. 2.4)



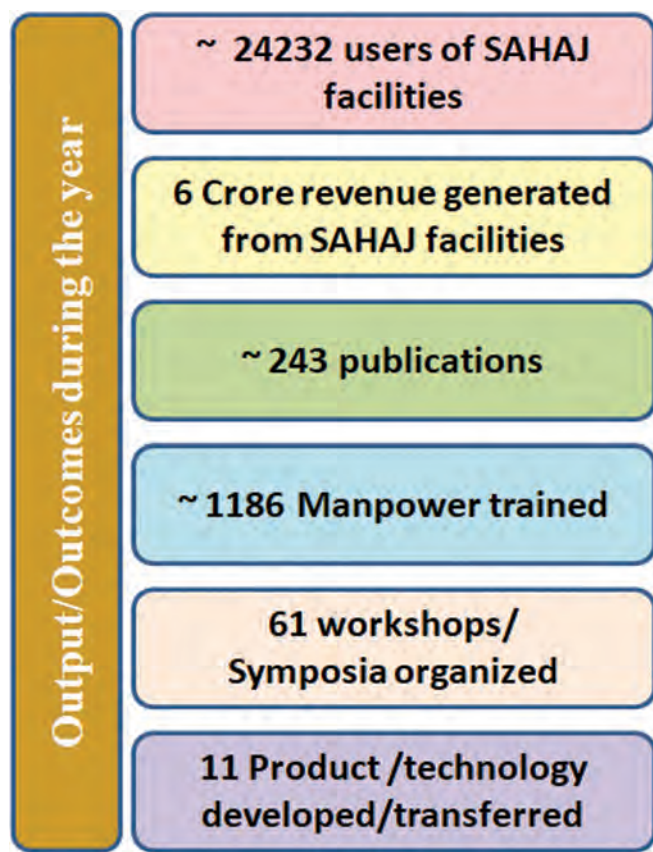
Fig. 2.4 Hands on Workshop for Teachers and Students under Foldscope Programme

(F) Award:

National Biotechnology Innovation Award: Department of Biotechnology has instituted National Biotechnology Innovation Award (NBIA) by merging Biotech Product Process Development & Commercialisation Award and Biotechnology Social Development Award. The NBIA is conferred in two categories (i) Product Process Development and Commercialization, and (ii) Societal Development. One award in each category is annually given by the Department to the Indian citizen engaged in research and development or societal development in areas of Biotechnology in the country. The award carries Rs. 5.00 lakh cash award for each category along with a medal and certificate. The first batch of the awardees under this program will be announced in 2023.

(G) Research Resource Service Facility and Platform (RRSFP): One of the primary mandate of the Department is 'Establishment of Infrastructure Facilities to support R&D and production'. DBT since its inception is supporting the development of research infrastructure at universities and research institutes across the country with the primary objective to augment Life Science and Biotechnology research activities. The Research Resource, Service Facility and Platform (RRSFP) Programme operates through 2 major arms:

DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research Programme (DBT-BUILDER): This arm of the programme specifically focuses to upgrade the post-graduate teaching and training laboratories by enabling interdisciplinary advanced research and teaching capacity.



DBT - Scientific Infrastructure Access for Harnessing Academia University Research Joint Collaboration (DBT-SAHAJ): The primary goal of DBT-SAHAJ is to create “national” service facility/research resource/platform to provide access to resources that could not be provided by any single researcher’s laboratory or scientific department. The DBT-SAHAJ portal which is now a valuable resource of the DBT website was introduced during 2018-19 and has led to the consolidation of all facilities supported and established by DBT. Through the SAHAJ portal, potential users/individuals can obtain information and access to these facilities through a single window.

Some notable achievements of DBT-RRSFP are mentioned below:

‘Comprehensive Mass Spectrometry-based Clinical Lipidomics Platforms for Promoting Biomedical

Research And Advanced Training For Indian Researchers’ at Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram, is planned around two mass spectrometric technologies: (a) Absolute quantitation and assay development using triple quadrupole (QqQ) that combines sensitivity and selective ion monitoring in sample analysis; and (b) Improving qualitative and quantitative analysis of large numbers of samples with the High Resolution Mass Spectrometer that utilizes the resolving power and accuracy of multiple analysers (Fig. 2.5).

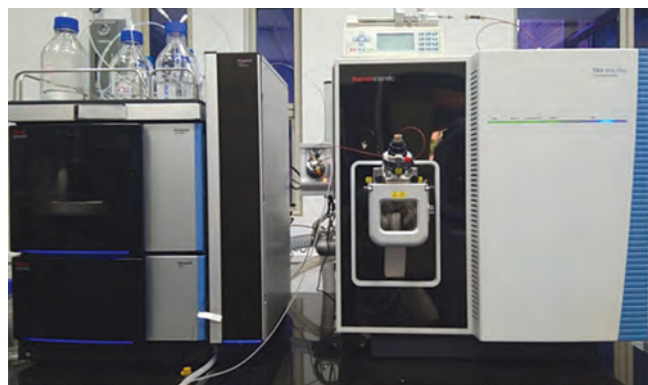


Fig a. Altis Plus QqQ from Thermo Fisher for targeted studies

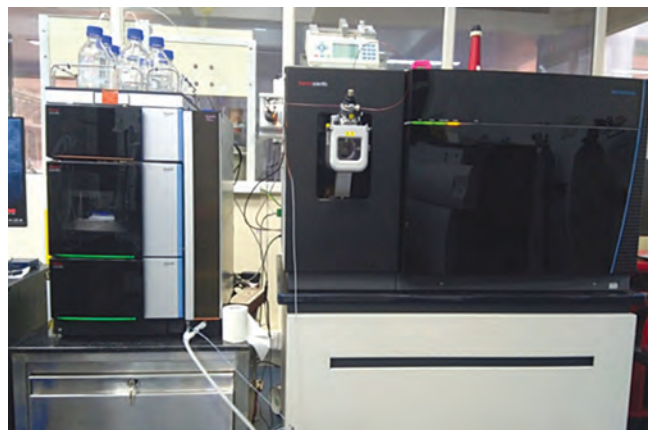


Fig b. Orbitrap Fusion Tribrid High Resolution Mass Spectrometer (HRMS) for global untargeted studies

Fig. 2.5: a) Altis Plus will enable the development of in-house and novel sample specific. b) HRMS is the most advanced mass spectrometer for untargeted analysis that can accurately and rapidly scan and distinguish metabolites in a few microlitres of sample.

The European Synchrotron Radiation Facility (ESRF) at Grenoble, France, is the world’s first fourth generation high energy synchrotron. The Extremely

Brilliant Source (EBS) of ESRF provides x-rays of the highest intensity and quality. Also, ESRF has recently developed Cryo-Electron Microscopy facilities for Structural Biology. The Department has supported a project at RCB, Faridabad for access to structural biology facilities at ESRF. The X-Ray diffraction facility within RCB is utilized to screen samples and identify the best ones for data collection at the ESRF. Access to Structural Biology resources at the ESRF has increased the scientific productivity in the area of Structural Biology and Life Sciences, both in terms of quantity and quality.

Under DBT Builder project supported at the University of Siksha O Anusandhan Interdisciplinary Life

Science Programme for Advance Research and Education, researchers are working on Artemisinin resistant malaria and have found that Artemisinin derivatives (artesunate, artemether) compete with kelch 13 protein (Pfkkelch 13) that helps Plasmodium falciparum survive in human blood. However, these derivatives fail to work in artemisinin-resistant malaria. In-silico findings under the project suggest that Withanolides have structural similarities with artemisinin. Withaferin A is more specific to the Pfkkelch 13 protein and thermodynamically more stable than artesunate and artemether. Therefore, its antimalarial effect should be checked, in animals and humans, to confirm its wide utility (Fig. 2.6).

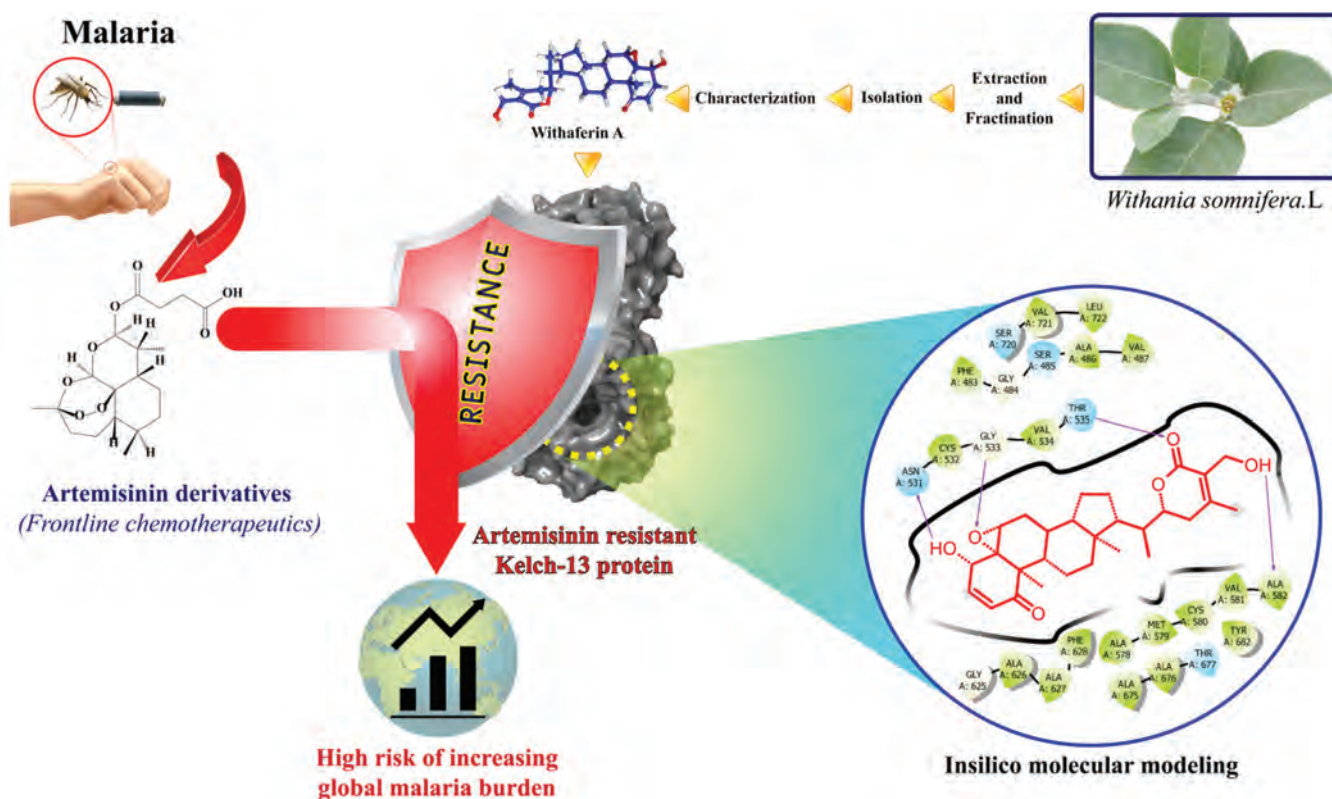


Fig. 2.6: Mutation in (Pfkkelch 13) results in resistance against artemisinin derivatives. Experimental findings suggest withaferin A could be a suitable therapeutic adjunct for clinical evaluation in artemisinin-resistant malaria.

The Advanced Center for Cryo-Electron Microscopy Facility (ACCEM-IISc) at Molecular Biophysics Unit, IISc, Bengaluru, is one of India's earliest macromolecular cryo-EM facilities. DBT has partially supported the setup of this facility under SAHAJ Programme. This facility is equipped with a 200 kV Talos Arctica with K2 DED and Vitrobot. Structures of several biological macromolecules, which are associated with infectious disease biology and host-pathogen interactions, including SARS-CoV2, gp120 HIV trimer and many other virulence factors & enzymes have been solved using the facility. Also, scientists developed a method to understand the mechanism of lipid membrane destabilization by bacterial toxin using cryo-EM.

As part of DBT BUILDER programme at Shivaji

University, Kolhapur, researchers have isolated metal tolerant bacteria for their use in green, biogenic synthesis of metal and metal oxide nanoparticles from soil of metal dumping sites near Kolhapur. In total, 50 bacterial isolates of 73 obtained initially, were screened for their potential to synthesize nanoparticles of gold, silver, platinum, palladium, copper oxide, cobalt oxide, nickel oxide, iron oxide, cadmium oxide, magnesium oxide, and manganese oxide. From these, four isolates identified as *Lysinibacillus xylanilyticus*, *Lysinibacillus* sp, *Lysinibacillus pakistanensis* and *Lysinibacillus macroides* with potential to synthesize nanoparticles of gold, silver, platinum, and palladium were further investigated and used for developing the simplified method of biogenic synthesis (Fig. 2.7).

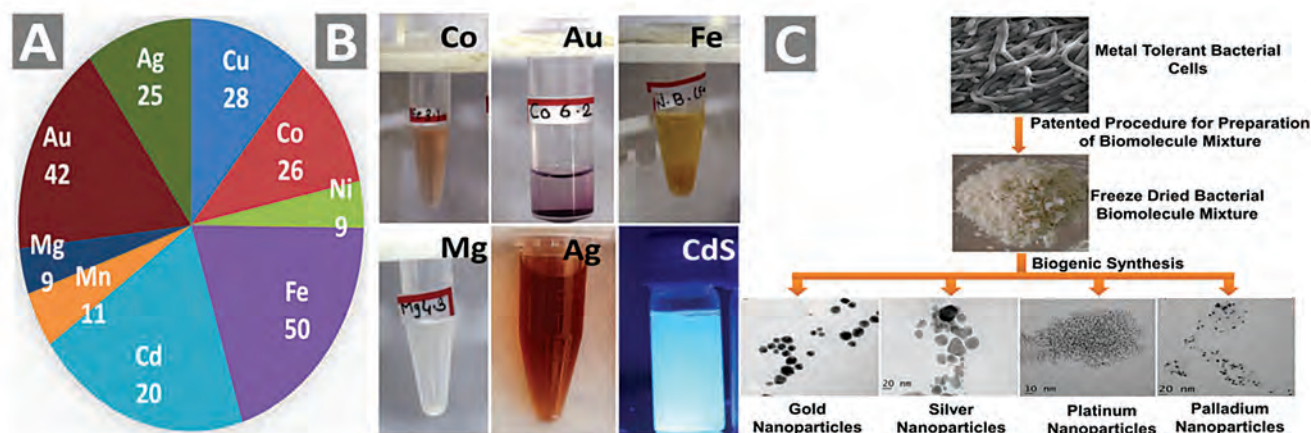


Fig. 2.7 A) Pie chart showing numbers of metal tolerant bacteria with potential to synthesize various nanoparticles B) images of colloidal nanoparticles of Co, Au, Fe, Mg, Ag, and CdS quantum dot synthesized using metal tolerant bacteria; C) Patented procedure involving use of metal tolerant bacteria for preparation of Biomolecule mixture for biogenic synthesis of multiple metal nanoparticles.

(H) DBT Outreach Programme

To popularize Biotechnology activities in India, the Department provides financial assistance towards organizing National and international Conferences in India. The department also provides Travel support to the researchers for presenting their research papers in the international conferences being organized in various countries abroad including GORDEN, PLOS, AMS and many more all over the world. It also extends support for organizing DBT

stalls in international and national exhibitions. Financial support is also provided for organizing Popular Lectures by various colleges, universities and Institutes. The collective term for these four activities is CTEP (Conference, Travel, Exhibition and Popular Lectures).

Major achievements during 2022-23:

- 25000 researchers participants benefitted under national and international conferences supported at the

national level.

- 387 scientists, researchers, students presented their research work in the prominent events including EMBO, Gordon, ASH annual meets etc across the globe in the international Conferences.
- More than 50000 participants visited the exhibitions being supported by the Department in various states of India.
- For promotion of Biotechnology in aspirational districts, 8 districts have been covered during the current financial year. One Conference, 2 travel supports, 1 exhibition and 4 popular lectures supported in aspirational districts.

Initiatives have been taken to popularise Biotechnology making use of social media platforms. A youtube channel (<https://www.youtube.com/@indiabiotechnologychannel>) has been specifically created for popularization of Biotechnology making use of the various programs organized under the umbrella of CTEP and various other activities being organized by the Department and other Ministries in the area of Biotechnology.

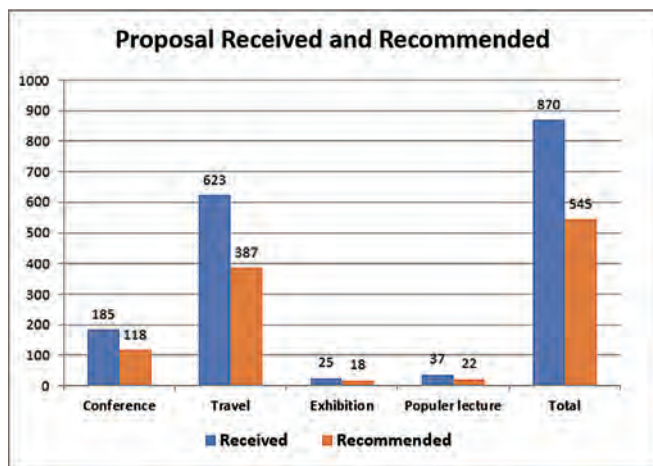


Fig. 2.8: Summary of proposals received and recommended under CTEP

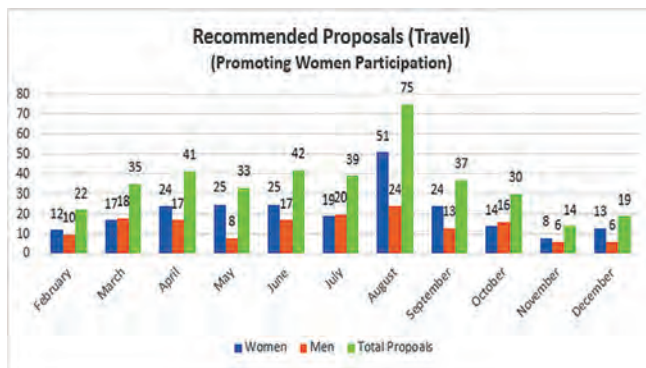


Fig. 2.9: Promoting women participation

BIO International Convention 2022: DBT has showcased the development in Biotechnology in India at the India Pavilion at BIO International Convention in San Diego, USA in June 13-16, 2022. In this conference cum exhibition the Department has participated along with BIRAC and 8 startups and biotech companies. The Department organized 25 bio-partnering meetings with the international delegates from various countries on various issues.

Akash for Life First Conference cum Exhibition on Panchmahabhoot

To shape the solutions to the challenge of climate change and associated environmental concerns based on the synergy of Indian philosophical tradition and modern science and in a blend of the modern and the traditional knowledge, the Government of India is organising five national conventions across the country on the Panchmahabhoot- the five elements for solving environmental issues for the betterment of society. The first conference cum Exhibition based on Panchmahabhoot - Akash or Space was organized by ISRO along with Science Ministries/Departments of Government of India and Uttarakhand State with Vijnana Bharti as knowledge partner, during November 5-6, 2022, at Uttarakhand University, Dehradun, Uttarakhand. Department of Biotechnology participated in the event with a team of senior officers.



Fig. 2.10 National Conference and Exhibition on Akash Tattva

India International Science Festival- 2022, January 21-24, 2023 - Bhopal

India International Science Festival (IISF) initiated in the year 2015, is an initiative of Ministry of Science and Technology and Ministry of Earth Science of

Government of India in association with Vijnana Bharati which is a science movement with Swadeshi spirit lead by eminent scientists of the country. This year IISF 2022 will be held at Maulana Azad National Institute of Technology, Bhopal from 21-24 January 2023.

03

Research and Development

3.A

AGRICULTURE BIOTECHNOLOGY AND ALLIED AREAS

Department is deploying new technologies to strengthen research infrastructure and train manpower in cutting-edge areas of agricultural research (crops, livestock, and fisheries). Department extends support to basic research to address the complex problems, blue sky research, and applied research that will provide improved crop varieties, livestock, fish brood stock, and other products to farmers and other stakeholders. The Department has created an ecosystem of Agriculture R&D across the country involving Universities/State Agriculture Universities and National Institutions.

3.A.1. Agriculture Biotechnology

The Agriculture Biotechnology program of the department supports research projects, translational research projects through Mission Programs, national networks, centers of excellence, international collaborations, and public-private partnerships. The support through programme is instrumental in developing varieties, technologies, and products to cater to the needs of farmers, consumers, and exporters.

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	37
Number of Process/Product/Technology Developed	Varieties 8 (6 Rice, 1 Pea & 1 mung bean) & 2 Technologies
No. of Research Publications	55
No. of Human Resources Trained	385

Major initiatives taken during the year:

A Centre of Excellence (COE) was established at G S Khush Institute of Genetics, Plant Breeding and Biotechnology (Punjab Agricultural University), Ludhiana, to honor the sterling contributions of Prof. G. S. Khush in the field of Agriculture. The CoE has nine sub-projects which will be targeted at addressing major constraints in productivity of field crops (pigeonpea, maize, cotton, brassica, wheat, basmati rice); vegetable crops (Pea); fruit crops (Citrus, Guava) and establishment of a Speed Breeding platform. The COE will deliver new varieties with new traits; value added traits like chapati quality and nutrition in wheat and new knowledge generation by understanding the genetic mechanisms of complex traits.

Some of the major achievements of the projects supported are as follows:

(i) Cereals:

Rice: In the network project a total of 13,517 rice accessions were evaluated. Rice accessions were screened for resistance to biotic stresses (Blight & Blast, sheath blight, false smut, Brown plant hopper, and root knot nematode), abiotic stresses (drought, and submergence) and photosynthetic efficiency. During evaluation, for biotic stresses resistance/tolerant accession to different disease's bacterial blight (108), leaf blast (2066), neck blast (73), bakanae (632), sheath blight (199), false smut (34), Brown plant hopper (130), resistant to root knot nematode (17) were identified. Evaluation for abiotic stresses led to identification of accessions tolerant to drought at reproductive stage (93), drought at

vegetative state (101), submergence (40), anaerobic germination (111), nitrogen use efficient (13), phosphorous use efficient (325) and photosynthetic efficient (143). A set of 500 landraces were also evaluated for quality parameters.

A blast disease resistant Shalimar rice 6 variety

developed through MABB has been released by the State Varietal Sub Committee in February 2022. Two lines (CR 4402-(1,2,3,4)-89-1-3-1; CR 4402-(1,2,3,4) 17-1-1) for multiple biotic stress tolerance (anaerobic germination tolerance, early uniform emergence, grain yield under DSR conditions, lodging resistance) have been nominated for the AICRP trials.



Fig. 3.A.1 Biotic stresses and abiotic stresses

Under a COE project, root-knot nematode (*M. graminicola*) resistant rice varieties (Seven genotypes Vandana, Suraksha, Khalibag, PhuleRadha EK70, NKSWR113, NKSWR43) have been identified. These varieties can be highly successful in reduced water use rice cultivation system. The project was successful in draft assembly of genome sequence of nematode parasite *M. graminicola*.

Under a speed breeding program, a core set of 300 rice varieties for seven different panels (yield, grain

quality, submergence, drought, sheath blight, brown plant hopper) have been created. Whole genome re-sequencing of 350 genotypes completed and assembled with 5 different reference genomes. Association studies of these 350 genotypes led to identification of MTAs for yield (80), BPH (50), sheath blight (20), drought (7), grain quality (11), and submergence (20).

Under a network project, three varieties (ADT 46-Sub-1; KR16024 (IET-28791) & IR 64-Sub1-DTY2.2)

for Submergence tolerance (Tamilnadu, Puducherry, & Jharkhand); one (HUR 105-Sub-1) for Submergence/flooding tolerance (Uttar Pradesh) and (MTU-1293) for Salinity tolerant (Andhra Pradesh) have been developed.

Wheat: Three high amylose bread wheat lines (TAC 35, TAC 75 and TAC 38) have been developed by EMS mutagenesis of the good chapatti wheat variety, 'C 306' and have been registered under NBPGR and PPV& FR. Under the mission programme on “Characterisation of Genetic Resources” One of the largest yield trials in the history of South

Asia was conducted, where a set of 3200 wheat accessions were evaluated in replicated trials. The project has successfully completed *de novo* genome assembly of a dwarf wheat sub-species *Triticum sphaerococcum*, which originated in ancient India. Re-sequencing of 56 accessions of wheat and its progenitor species were analysed to discover high-quality SNPs. A high density SNP chip based on Indian germplasm is being developed. A web server for identification and removal of duplicate germplasms (G-DIRT) (<http://webtools.nbpgr.ernet.in/gdirt/>) has been developed.



Fig. 3.A.2 Field view of wheat germplasm against abiotic stresses and biotic stress.

ii. Oilseeds:

Linseed: A core set accession's (259) and trait specific reference sets have been developed for agronomic traits (285); drought tolerance (200); salinity tolerance (396); alkalinity tolerance (299); *Alternaria* blight resistance (244) and bud fly resistance (155) and are being validated in current season at respective hotspots/controlled conditions. Genome assembly of popular linseed cultivar T-397 has been completed and is being improved with super-scaffolding.

Safflower: Genotyping of 3500 accessions of safflower has been completed. Whole genome assembly sequence of safflower cultivar is under

process. A major QTL, *QUc-Ct3.1* associated with tolerance to aphid was fine-mapped. Two putative QTLs (LG-8, CtDES-81-CtDES-72; LG-6, Ct40-SafM-880) associated with oil content are under validation.

Sesame: Chloroplast genome sequencing of cultivar Swetha and *S. malabaricum* has been completed. Draft *de novo* assembly for Swetha and *S. malabaricum* is completed with a genome size of 273.8 and 279.7 Mbp respectively. Accession were identified for biotic stress resistance/ tolerance, phyllody resistant (51), dry root rot (157), In screening of germplasm for water logging and drought stress, 159 and 232 accessions were respectively found tolerant.

Niger: Protocol for haploid generation in Niger has been standardized. Two transcriptomes of Indian and Ethiopian genotypes were generated and analysis revealed substantial differences in expression of

genes between the Indian and Ethiopian genotypes. Development and multi-location evaluation of genetic stocks of Soybean SL 958 which is photo insensitive is being carried out (YMV resistant variety).

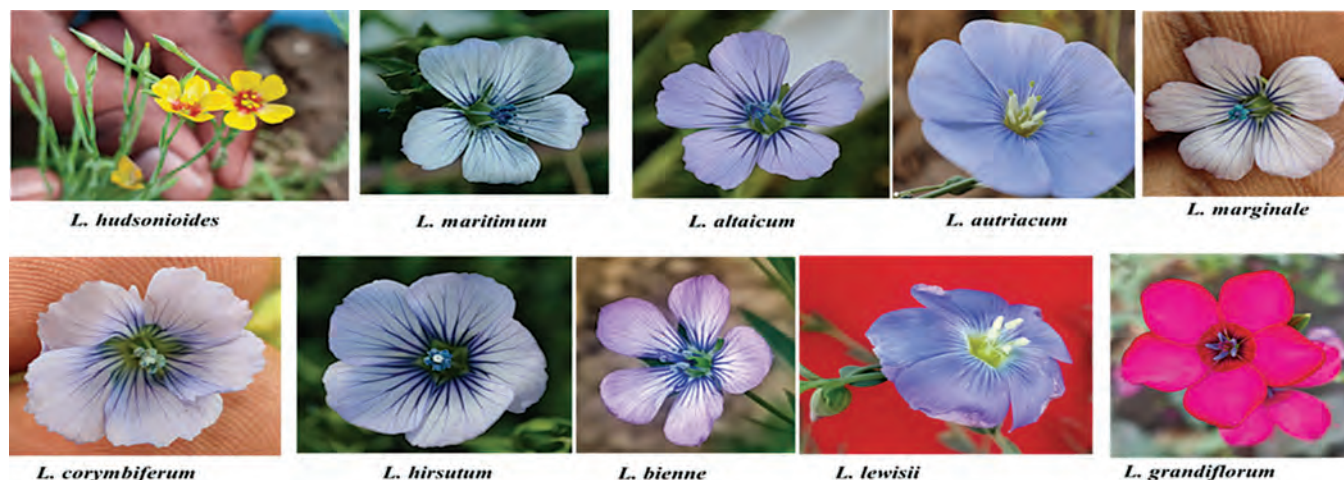


Fig. 3.A.3 Augmentation of wild *Linum* and multiplication at NBPGR

iii. Pulses:

Chickpea: A Pan Genebank Core of 5000 germplasm accessions (3500 ICRISAT and 1500 NBPGR) of chickpea has been constituted. Descriptor traits with the SOPs developed has been completed, which identified multiple accessions with superior yield component and plant architectural traits. To constitute an iterative core, genotypic characterization of 5000 chickpea accessions using whole genome resequencing (10X coverage) has been done. A first-ever 90K pan-genome SNP genotyping array “*Indian Chickpea panArray (IndiCA)*” has been developed for large-scale genotyping of *desi* and *kabuli* germplasm accessions to accelerate genomics-assisted crop improvement of chickpea and gene discovery.

Mung Bean: Genetic transformation for CLS (HIGS construct) and PMD (*Mlogene* construct) of mung bean have been standardized. *Mlogene* has been transferred to mung bean genotype (IPM-02-14). The genome edited plants are grown in transgenic greenhouse and evaluated under the project. A mung

bean variety HUM 27, which is early maturing, medium dwarf, green seed, resistant to MYMV and CLS has been released. Two new *Cercospora* isolates collected from coastal districts of Odisha and submitted in NCBI (Accession No. MZ475049 and MZ475050). The pure cultures of two isolates have also been deposited in National Agriculturally Important Microbial culture collection (NAIMCC), ICAR- National Bureau of Agriculturally Important Microorganism, Uttar Pradesh.

Pea: A MAS derived powdery mildew resistance variety “Him Palam Matar-2” has been developed and released in Himachal Pradesh. Variety has nineteen genes pyramided for powdery mildew resistance and has taken 13 years for development.

Minor Pulses: High quality reference grade genome assemblies for *Vigna mungo*, *Vigna unguiculata*, and *Vigna radiata* were created and gene expression patterns in various tissues of *V. aconitifolia*, *V. mungo* and *V. unguiculata* were profiled and candidate genes for functional characterization were identified. Root Knot Nematode resistant accession were found in

cowpea (3), green gram (2) and black gram (5) and YMD resistant in black gram (16). Mapping populations developed in mung bean for yellow mosaic disease (6 populations) urdbean (3 populations) and cowpea heat tolerance, photo-thermo insensitivity and YMD Resistance (4 population). Two accessions *V. umbellata* and *V.*

vexillata registered as unique germplasm for resistance against bruchid (*C. Maculates*). A core set has been developed in rice bean (231) accessions (selected seven promising rice bean accessions with superior desirable traits for registration/variety release). Green gram (400), black gram (218), cowpea (425), horse gram (300) and amoth bean (461).



IC351508: semi-determinate, early maturing, higher yield



Fig. 3.A.4 Seven promising rice bean accessions with superior desirable traits for registration/variety release.

iv. Vegetable and horticultural crops:

Tomato: Recombinase polymerase amplification and polymerase spiral reaction assays have been developed for rapid, on-site, field-based identification of *T. palmi*. Improved ArkaVikas line (AV-7-10-16-9-16) with Sw-5 and improved Pusa Ruby line (PR-5-9-4-8-67) with Sw-5 is nominated for release in Telangana State through State Varietal Release Committee (SVRC).

Guava: Reference genome of Allahabad Safeda has been assembled and deposited in the NCBI. Re-sequencing for Purple Local at 25 X followed by mapping on reference guava genome led to identification of numerous *in silico* polymorphic markers. The Guava INGDB is set for release.

Onion: A new defense responsive miRNA from onion and immune suppressive Fx-sRNAs from *Fusarium oxysporum* f. sp. *cepa* has been identified & characterized as potential diagnostic tools for resistance breeding programme.

Technologies developed:

A sensor based technology was developed to detect food contamination by mycotoxin. MIP-based mycotoxin sensor is a better alternative, convenient and cost-effective technique for mycotoxin detection in food products.

Under the National Quarantine facility two technologies were developed: a) GMO matrix of 22 GM food crops with >130 GM events approved globally developed as Decision Support System and

Multiplex PCR based GE diagnostics developed and validated for GM detection in seeds/ food derivatives. b) Visual Loop-mediated Isothermal Amplification (LAMP) based GM/GE detection technology targeting pinII terminator sequence with limit of detection (LOD) up to 0.01%.

3.A.2. Genome editing/engineering and nanotechnology applications in Agriculture

The overall aim of the programme is to harness the immense potential of the new and emerging tools of biotechnology for in-depth understanding of natural and cultivated plant systems, engineering novel biological pathways and unique plant architectures to transform crop improvement. Program area is focusing on utilizing New Breeding Technologies (NBTs) primarily Genetic Engineering/Genome Editing, speed breeding & next-generation genotyping/phenotyping platforms to understand basic plant biology as well as to develop improved plant varieties. Further, Nanotechnology having shown immense potential in therapeutics and biomedical engineering is also at a ripe stage where it is being now explored for developing nano-formulations to increase plant input use efficiency and nanosensors/nano-diagnostics for abiotic and biotic stresses. Program area will contribute to the growing bioeconomy, food & bio-security and sustainable technologies to reduce environmental footprint.

Quantitative and Qualitative indicators for Major achievements	
Number of Process/Product/Technology Developed	9
No. of Research Publications	23
No. of Patents Applied/Granted	03
No. of Human Resources Trained	51

Major initiatives taken and R&D efforts:

R&D activities are being supported to develop gene

edited lines for a wide range of traits including plant architecture (wheat, sugarcane), nutritional improvement (tomato, soybean, mustard), yield (rice), biotic stress tolerance (tomato, chilli, rice, papaya), abiotic stress tolerance (rice, pigeon pea) along with functional genomics studies in rice, tomato and chickpea. Genome edited lines have already been developed for nutritional improvement of mustard, aroma in rice, better tolerance to biotic stressors including *in-planta* edited chilli lines resistant to white fly mediated infection, sheath blight resistance in rice, rice tungro disease resistance and these developed lines are at various stages of segregating generations.

Some of the major achievements of the projects supported are as follows:

A viable protoplast transformation system has been standardized, successfully yielding protoplasts at the rate of $\sim 41.52 \times 10^5$ cells/ml/g tissue in indica rice, Pusa Basmati. Molecular analysis of putative T_0 transgenic lines showed integration of T-DNA cassette and the integration was confirmed by Hygromycin-B antibiotic specific primers along with gRNA scaffold specific primers.

A total of 328 putative transgenic plants of ASD16 engineered with *SpCas9* have been generated and CRISPR/Cas9 platform for creating precise mutations (knock out mutations) in rice has been established. Several genes have been successfully mutated where fragrance gene (*OsBADH2*) was precisely mutated and novel alleles of *OsBADH2* have been generated. Besides, Protein Farnesyl Transferase A (FTA) was also edited in rice cv. MTU1010 by using CRISPR-Cas9 SDN1 approach and in T_1 lines five different alleles were identified. Homozygous mutants of two alleles of FTA were also identified in T_2 (9 base deletion and 1 base insertion) and ABA sensitivity analysis showed that both the alleles are sensitive to ABA where it was found that FTA function is conserved across species as negative regulator of ABA signalling. Further, it suggests that

FTA611+A insertion allele is stronger than FTA 606-614 deletion allele in conferring ABA sensitivity. Both

alleles resulted in early flowering. Phenotyping is in progress for drought tolerance.

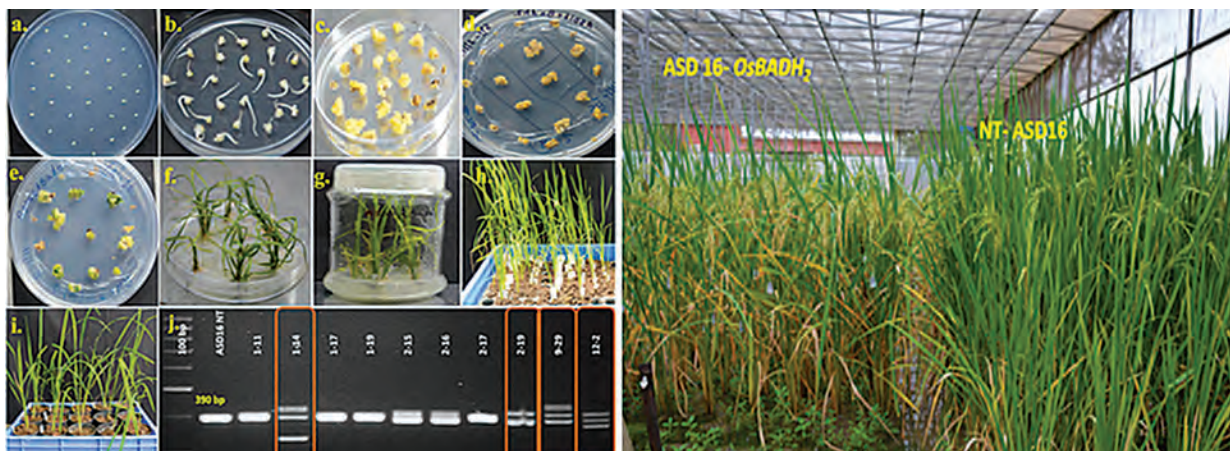


Fig. 3.A.5 ASD16 rice variety gene edited with SpCas9 and CRISPR/Cas9 platform for creating precise mutations in *OsBADH2* gene (knock out mutations) for enhanced aroma.

For understanding the role of calcium signaling components during abiotic and nutrient deficiency stresses, two genes *CIPK9* and *CIPK23* were targeted to develop CRISPR/Cas9 lines of rice. Phenotypic analysis revealed CRISPR transgenic lines

of *OsCIPK9* and *OsCIPK23* are susceptible in potassium deficit media and can work as positive regulator for providing potassium deficiency stress tolerance in rice. Further, based on its active kinase activity *OsCIPK9* and *OsCIPK23* T₁ plants were successfully generated.

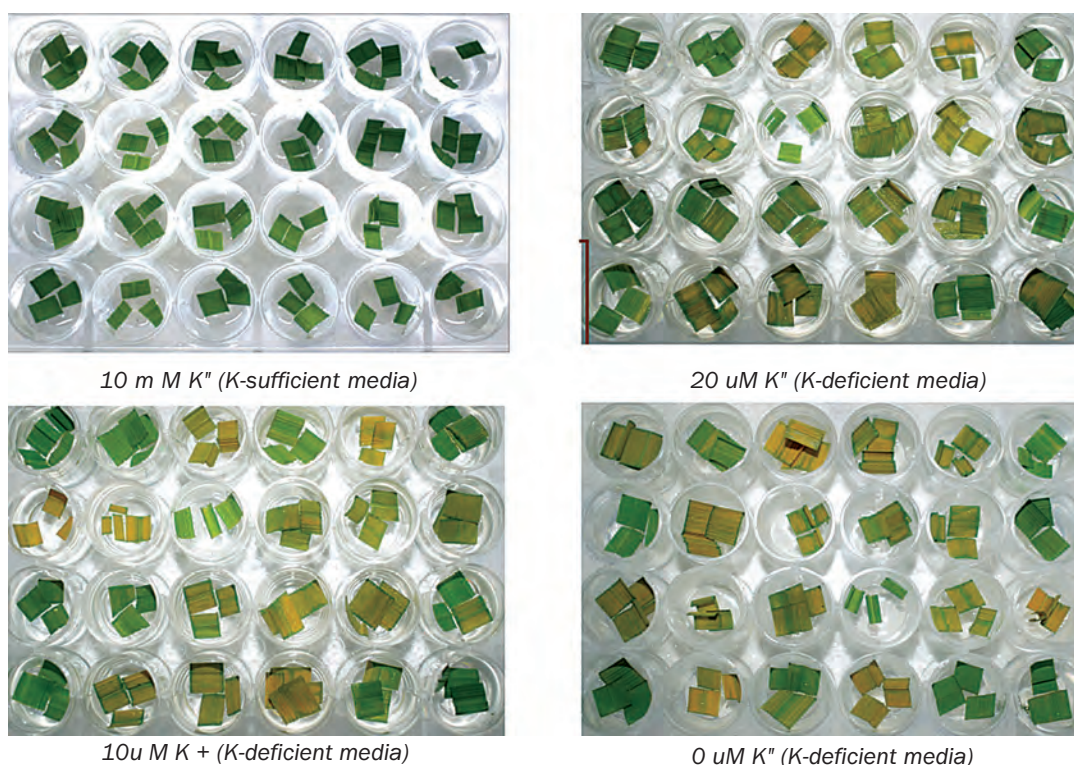


Fig. 3.A.6 Leaf disc assay depicting susceptibility conferred by *OsCIPK9* and *OsCIPK23* genes to rice leaves in potassium deficit media. These genes act as positive regulator for providing potassium deficiency stress tolerance in rice.

25 knock out lines of *MPK3* gene using CRISPR-Cas9 were grown up to T₃ generation stage and are reported to be transgene free. Two key cell cycle regulator KRP3 and CDKD have been identified as interacting partner of MPK3 and were confirmed to be phosphorylation target of MPK3 gene. A double CRISPR knockout of MPK3 and KRP3 was also developed to understand the role of phosphorylation upon KRP3 by MPK3 via analyzing all the mutant lines for both growth and yield parameters. The phenotypic data illustrated a parabolic fall for all the parameters like plant height, seed size, seed weight in mutant lines compared with the wild plants confirming KRP3 as a negative regulator.

An efficient regeneration and transformation protocol was standardized for foxtail millet.

19 PCR positive Chickpea AHAS1 edited lines have been generated providing herbicide tolerance. A total of 7851 explants were infected and were regenerated on various MS regeneration media (R1, R2, R3, R4 and R5) supplemented with Kanamycin (100mg/L) and Cefotaxime (250mg/L) and 28 putative transformed plants were successfully established in the soil.

CRISPR activation and inhibition toolkit has been optimized for Solanaceous plants. Multiple complex CRISPRa and CRISPRi gene constructs were generated with tomato codon optimized dCas9. Temperature inducible gene regulation was achieved by harnessing the transmembrane domain of SINACMTF3 with tcodCas9-VPR/KRAB where simple heat/cold stress efficiently activated synthetic gene regulation system and altered the expression pattern of the targeted endogenous genes. Inducible editing system will prove useful in transcriptional programming at multiple genes simultaneously in tomato, utilizing the technique of CRISPR RNA scaffolds.

NanoBioClay formulations have been developed for phytoprotection against aphid infestation. Synthesis and physicochemical characterization of nanoclays of Mg-Al-NO₃ (MA) LDHs and Zn-Al-NO₃ (NZA) LDHs was done and stable aqueous dispersions of Mg-Al-NO₃ (MA) LDHs and Mg-Al-NO₃ (NZA) LDHs were developed and validated using topical sprays in the field. Degradation of Mg-Al-NO₃ (MA) LDHs nanoclays was also confirmed under environmental condition before releasing loaded dsRNA into it. Vital gene fragments of mustard aphid (*Lipaphis erysimi*) such as AchE, vATPase, SHP, C002, Cathepsin-L were successfully isolated and cloned followed by bacterial expression and purification of low-cost dsRNA. dsC002 and dsVATP were successfully loaded into MA and NZA nanoclays. Topical application of different “NanoBioClay” formulations of dsC002-MA, dsVATP-MA, dsC002-NZA and dsVATP-NZA were found to protect Mustard plants from aphid infestation when tested in field.

Bio-degradable nanofiber encapsulated biofertilizer was developed to enhance phosphorus and other micro nutrient uptake in rice. The mycorrhiza spore and the helper bacteria were pumped in different channels in controlled velocity and viscosity to facilitate encapsulation in the desired ratio. The formulation consists of polysaccharide coating that assures stickiness to bind the seed and water holding capacity to improve the survival and shelf life. Beside the polysaccharide, readily available carbon source was added in optimum concentration for the immediate biosynthesis of metabolites that can enhance survival. This formulation recorded >25 % enhanced availability of the biofertilizer as evident through the colony count and spore viability examination at monthly intervals for 3 months. The field study of the formulation is in the progress; up to now the crop biometrics show enhanced growth and development compared to the control.

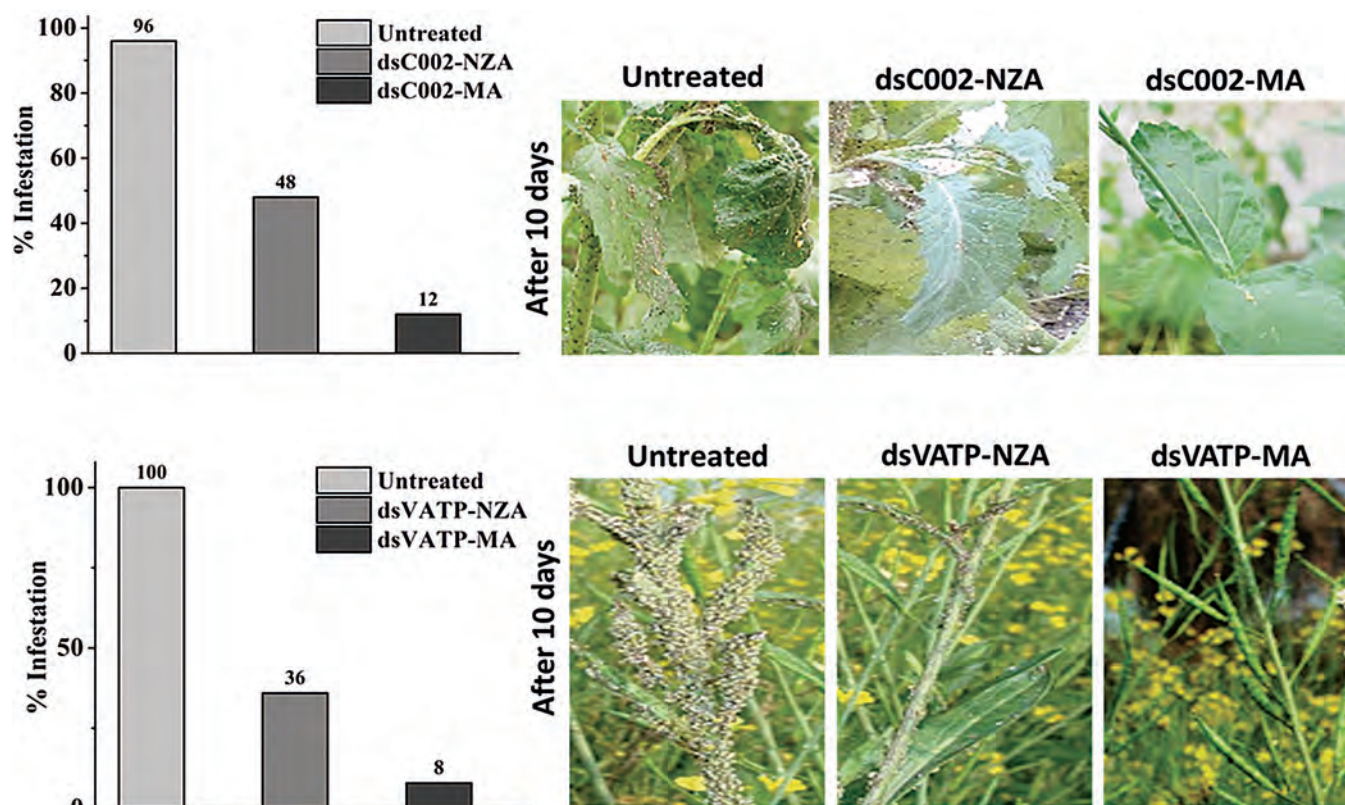


Fig. 3.A.7 Topical application of dsC002-LDH (NanoBioClays) protected Mustard plants from aphid infestation. (a) % Aphid transmission in mustard plants with and without treatment of NanoBioClays after 10 days. (b) Representative images of NanoBioClay treated and untreated plant leaves after 10 days.

3.A.3. Animal Biotechnology

Animal Biotechnology programme is focused towards developing newer techniques/ technologies to enhance livestock production and productivity. R&D projects are being supported in the applied areas of animal reproduction, development of transgenic animal, genome and genetic characterization of indigenous breeds, animal nutrition, development of novel livestock by-products, development of animal vaccines and diagnostics, development of therapeutics, technology for bovine sperm sexing, production of bio-pharmaceuticals through transgenesis etc. The program is also focuses on establishment of collaborative research for development of new generation vaccines and diagnostics along with translation of existing candidate vaccines and diagnostics for field use around major animal diseases of national importance

to make product affordable to small and marginal farmers.

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	12
Number of Process/Product/Technology Developed	28
Process/Product/Technology Transferred to User Agency/Industry/ Stakeholders:	02
No. of Research Publications	39
No. of Patents Applied	03
No. of Patents Granted	01
No. of Human Resources Trained	404

Major initiatives taken during the year 2022-23:

The department has supported a project on 'Transitional Applications for Therapeutics from Veterinary and Allied Microbials (TATVAM)' to establish a platform for translation of the omics data of animal microbiome into potent probiotics, animal feed, microbial isolates/consortia like products with nutraceutical properties.

An inter-Ministerial program "Scientific Utilization through Research Augmentation Prime Products from Indigenous Cows" (SUTRA-PIC India) has been initiated by DST in the collaboration with DBT, CSIR, MNRE, AYUSH ICAR and ICMR. SUTRA-PIC programme is developed to establish and carryout Scientific research on prime products from indigenous cows. Under the project, DBT has been assigned the thematic area "Scientific research on Prime-products from indigenous cows for agricultural applications". Five proposals have been supported by the department.

Bovine sexed semen sorting technology: The department has constituted a 'Interdisciplinary Group of Experts on Bovine Sexed Semen Sorting Technology' for mapping of existing technologies of semen sorting and formulating the road map for future. Therefore, a call for proposals on 'Bovine

Sexed Semen Sorting Technology' has been initiated to develop a program.

Some of the major achievements of the projects supported are as follows:

Translational Research Platform for Veterinary Biologicals (TRPVB): TRPVB is a partnership programme between DBT and TANUVAS. During this reporting period, 8 products/ processes/ techniques have been developed – (i) Diagnostics - CRISPR/ Cas12-based next-generation diagnostic platform with detection in a fluorimeter setup for *E. Canis* & *B. gibsoni* and Indirect ELISA for *B. gibsoni* & Oxytocin detection; (ii) Vaccine candidates - local isolate of Lumpy skin Disease virus (LSD) and *Theileria annulata*. The LSD strain had been isolated during 2020 was completely characterized and transferred for the development of an inactivated vaccine to M/s Biovet Pvt Ltd, Bangalore and a collaborative programme is under progress to develop a live attenuated vaccine. The Live attenuated *Theileria annulata* vaccine technology which is at TRL-6 level has been transferred to M/s Hester Biosciences Pvt Ltd, Ahmedabad. (iii) Product development - a thermo-reversible polymer had been developed and characterized that will be used for intra-mammary delivery. A total of 3995 units of the different products were supplied for use in the Field Level Demonstration (FLD)/ On-Farm Demonstration (OFD) programs.



Fig. 3.A.8 LSD vaccine technology transfer to M/s BioVet, Bengaluru

TRPVB has NABL accreditation for testing two animal diseases under ISO/IEC 17025:2017, cGMP licensing for manufacturing of four drugs, and recently obtained the manufacturing license for test purposes for the TANUCHEK SCC kit. The techniques and processes optimized have been used to provide Biotech diagnostic testing services for A1/A2 detection, haemoprotozoan infection, antibody detection to IBR and Brucella, Lymphoma, IMHA and IMTP detection in canines and detection of IBR in semen samples to the semen bank attached to the Govt. of Tamil Nadu.

The Mycobacterial Diseases in Animals network (MyDAN) programme is initiated by DBT with seven Centres to understand the incidence of TB in different spectra, evaluate synthetic peptides as a suitable simple and confirmatory diagnostic tool (Defined Skin Test/DST), evaluation of BCG for its efficacy in preventing disease and onward transmission and to develop national TB control programme for livestock in India. During the course of time, the sensitivity and specificity of DST antigens was determined in 46 adult buffaloes (35 non reactors and 11 reactors) and 20µg concentration was found optimum for use in buffaloes for testing in field. Further, in two districts of Haryana, 543 buffaloes in three age groups (calves, <1 year; heifers, 1-3 years and adults, >3 years) were tested to compare the DST with tuberculin i.e., PPD-A and PPD-B. In 9 buffaloes, tuberculous lesions were observed either in lungs and/or lymph nodes, liver. The PCR results also revealed the presence of MTBC by IS1081. Cultural examination of organs and lymph-nodes revealed the presence of *Mycobacterium orygis* and was further confirmed by PCR. To perform preliminary BCG vaccine immunogenicity studies in buffalo calves, 188 dams were tested by skin test. 28 calves (dams skin SIT negative and calves IGRA negative) were selected and included in this trial. BCG vaccine was administered in 16 buffalo calves and remaining

calves were taken as control. Blood was collected on 1st, 28th, 42nd and 120th day for IGRA and serum separation. Skin testing was performed by injecting PPDs (PPD A, PPD B) and DST on 42nd and 120th day. In addition, three PCRs (two conventional and one SYBR-green based real-time) were developed for differentiation of *Mycobacterium tuberculosis* complex (MTBC) from non-tuberculous Mycobacteria (NTM); confirmation of MTBC in milk samples; and differentiation of major MTBC of animal origin. Further, to obtain preliminary accurate prevalence estimates and begin to identify risk factors associated with bTB, the dataset of more than 1500 animals screened for bTB in West Bengal with either SICCT, IGRA, or both were analyzed. Results reveal a high animal level bTB prevalence in the organized cattle farms of West Bengal and a greater risk of infection within organized production systems, mostly among cross-bred animals.

A reduced graphene oxide (rGO) based immunosensor has been developed using Fluorine-doped Tin Oxide (FTO) electrodes conjugated with anti-Penicillin antibody (FTO/rGO/Pen-Ab) for sensitive detection of **Penicillin G in food samples**. The limit of detection for Penicillin G against Pen-Ab and Com-Pen-Ab was determined as 0.724 pM and 0.668 pM respectively and both displayed negligible cross reactivity with against other β-lactam antibiotics (Cefalexin and Ampicillin). Furthermore, antibiotics were also detected in spiked milk, egg and meat samples and the electrode was evaluated for repeatability and storage stability. The in-house developed Pen-Ab showed better sensitivity as compared to with Com-Pen-Ab. The fabricated FTO/rGO/Pen-Ab biosensor showed future potential for rapid detection of penicillin and other β-lactam antibiotics for safe consumption of animal products and its by-products in humans.

A network programme on **Anthrax Diagnosis and Control** in India has been supported by the department to provide a multi-disciplinary research

consortium with involvement of 10 partnering Institutes/Universities. The program will strengthen the competences for surveillance, outbreak investigation, laboratory capacity, vaccination, specific predictors of outbreak risk and risk mapping. During this year, A Latex agglutination test (LAT) for the detection of *Bacillus anthracis* spores in animal feed supplements and soil samples has been developed. Further, the study for development of plant based edible vaccine has been initiated. The *ctxB* gene encoding for the cholera toxin B subunit has been fused with domain IV of the protective antigen sequence encoding for SEKDEL peptide and used for targeting the antigen proteins to the Endoplasmic reticulum.

A culture of the Goat Mammary Epithelial cells (GMEC) has been established and the cultured GMEC cells were transfected with a transgene construct bearing buffalo beta-casein promoter upstream of EGFP gene. The expression of EGFP was obtained in the GMEC cells which proved the functionality of the buffalo beta-casein promoter in the GMEC cells. Further, a construct has been developed by cloning IFNg cDNA under the control of buffalo beta-casein promoter (for in vivo work) as well as under CMV promoter for all subsequent in-vitro work.

A project has been supported by DBT to develop **single dipstick for instant detection of multiple adulterants in milk**. A total of eight individual dipsticks have been developed for the instant detection of starch, urea, hydrogen peroxide, detergent, neutralizer, maltodextrin and ammonium sulphate. Further, in the 2nd version of technology, a nanotechnology based single dipstick has been developed for instant detection of multiple adulterants in milk. The product has been patented and technology transfer is underway.

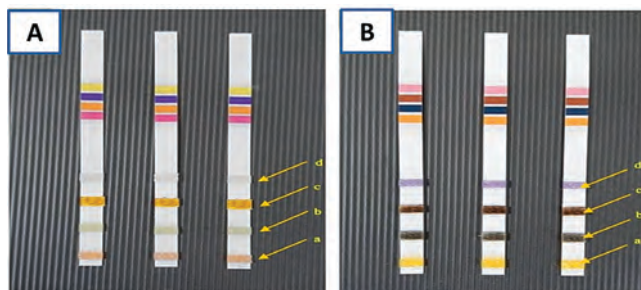


Fig. 3.A.9 Nanotechnology based single dipstick for instant detection of multiple adulterants in milk. (A) Dipstick for detection of a) Neutralizer, b) Hydrogen peroxide, c) Starch and d) Urea. (B) Dipstick for detection of a) Boric acid, b) Detergent, c) Malto-dextrin and d) Ammonium sulphate.

Department has supported a project to develop an Aptamer based lateral flow device for the **detection of heat or estrous in buffalo**. The aptamer showed high structural and functional stability and integrity in biological fluids like milk and serum. The selected aptamer was used to develop an affordable, portable, easy to use electrochemical impedimetric apta-sensor to detect progesterone detection in undiluted milk and serum. The apta-sensor was evaluated for its sensitivity and specificity in biological sample (milk and serum) as correlated with standard ELISA (kappa value > 0.9). Further, the validation of the apta-sensor for field-level detection of estrus were also performed and confirmed the pregnancy in the farm animals.

The Department has supported a project to develop an injectable nanofibrous implant for oestrus synchronization in cattle. The microneedles have been prepared using PVA and a combination of PVA and sucrose led to sustained and burst release of the hormone in both in vitro and in vivo experiments. With the assistance of in vivo live imaging in mouse model, burst release of sulforhodamine B molecule (PVA Sucrose patch) was observed within 1 hour while sustained release (PVA patch) up to 5 days. This system will have wide applications for transdermal delivery of various molecules like peptides, DNA, hormones, micronutrients, vitamins and drugs having therapeutic applications. After

establishing the prototype in mouse model, GnRH analogue loaded microneedle for burst release has been prepared.

One Health Initiative: The Department has supported a mission mode network project to carry out research on priority area of “One Health” which is being coordinated by National Institute of Animal Biotechnology, Hyderabad. This network project comprises of 27 research/ academic institutions and state government laboratories. The main target is to assess simultaneous country-wide prevalence of two each of bacterial, rickettsial, viral, parasitic and food-borne diseases, namely brucellosis, tuberculosis, scrub typhus, Q fever, Japanese

encephalitis, Crimean-Congo haemorrhagic fever, cryptosporidiosis, cysticercosis, salmonellosis, and listeriosis. Besides, prevalence of five transboundary diseases viz. African swine fever, porcine reproductive and respiratory syndrome, swine influenza, lumpy skin disease, and Nipah encephalitis in pigs is being carried out exclusively for north-eastern states. The study could contribute to long-term programs on dissecting factors contributing to human-animal interface and spill-over of diseases from animals to humans, leading to strategies in controlling or preventing such diseases, resulting in improving animal of human health, ultimately improving welfare of humans, animals, and by extension of plants and the environment.

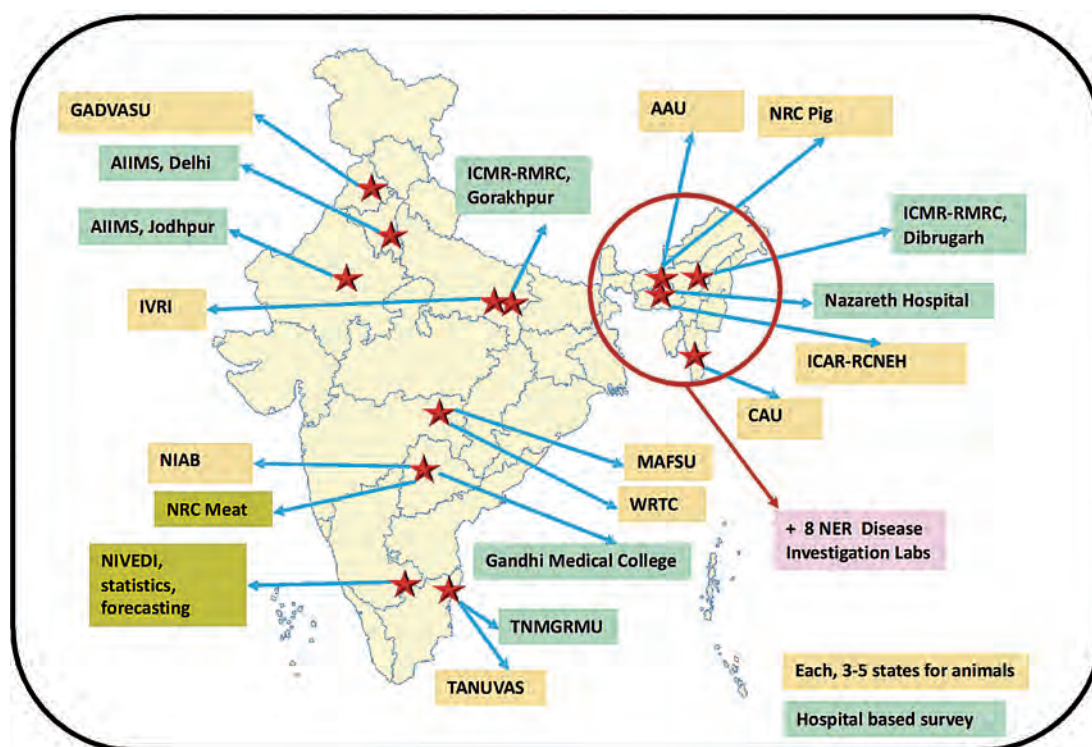


Fig. 3.A.10. The One-Health consortium institutes

3.A.4 Aquaculture and Marine Biotechnology

Aquaculture & Marine Biotechnology programme was initiated during 1988-89 to support R&D projects towards development of useful products and process from the marine resources. It is an important

sector of food production providing nutritional security, besides livelihood support, gainful employment and its emergence as largest group in agricultural exports from India. The major goals of this programme are to enhance fish production through sustainable utilization & development of

natural resources, to facilitate the conservation of the natural aquatic and marine resources for improving the ecosystem and the deter the climate change, to develop the aquatic and marine available resources as nutraceuticals, to develop the technology for aquatic and marine animals disease diagnosis and their treatment, to develop the feed for sustaining the fisheries sector, to augment the development of constituents of aquatic or marine reserves /resources for mankind healthcare and waste management, to conserve the aquatic/marine ecosystem.

Quantitative and Qualitative indicators for Major achievements	
Number of Process/Product/Technology Developed	09
No. of Research Publications	35
No. of Patents Applied/Granted	01
No. of Human Resources Trained	54

Key achievements during the year 2022:

A dedicated laboratory for marine fish larval microbiome and nutrigenomics research has been established at Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi by the department. A full length *R. canadum* (Cobia) transcriptome is reported for the first time. Metagenomics of commercial marine larviculture probiotics was initiated. Identified critical microbial dysbiosis in Cobia larvae post-transportation and provided the prospective metagenomic signature of health.

A vaccine against Nodavirus infection is developed at C. Abdul Hakeem College, Melvishram, TN and tested for efficacy at Central Marine Fisheries Research Institute (CMFRI), Mandapam. Further, the development of vaccines against Tilapia lake virus (TiLV) and Cyprinid herpesvirus -2 of fish in Indian aquaculture system is underway.

Based on de-novo Whole Genome Sequencing of

Asian Green Mussel *Perna viridis* using PacBio and Illumina platforms, the Genome Size of *Perna viridis* has been estimated as 731 Mb. Genomic and transcriptomic investigations on this species are vital to understand genes, gene combinations and pathways important in economically important traits like growth, reproduction and disease resistance.

A study identified that the micromolar concentration curcumin excited with blue light (λ_{ex} : 460 nm) from an LED source can inactivate pathogenic species of *Vibrio* (*V. cholerae*, *V. campbellii*, *V. harveyi*, *V. campbellii*) and *Aeromonas Hydrophila*. Photodynamic Antimicrobial Chemotherapy (PACT) can bring about killing of more than 95% of total bacterial population in combination with micromolar concentration of curcumin (up to 5 μ M) with exception to *V. campbellii*. The photo degradative products of curcumin are non-toxic and kill pathogen through the production of singlet oxygen.

The Diatom Culture collection, a first of its kind in India, has been established. In addition, a cost-effective methodology for indoor mass cultivation of two benthic marine diatoms *Chaetoceros* sp. and *Thalassiosira* sp. in the laboratory has been developed. It was found that Inductively Coupled Plasma (ICP) synthesized nanosilica is responsible for enhanced biomass production in marine diatom isolates. ICP nanosilica is the main catalyst behind enhancing biodiesel characteristics.

Based on the *in-vitro* tests, two efficient combinations of antibacterial compounds were developed against *Aeromonad* infection in fishes. Preparation of supplementary feed with indigenous plants extract with confirmed antimicrobial biomolecules as feed additives to boost immunity levels and bacterial disease resistant in healthy fishes and subsequently challenge test was also performed to know for infection caused by the bacterium in both test & control groups with satisfactory results.

Four peptides (KK12YW, KK12FW, KY12WY and

RH12) designed and synthesized in the laboratory showed antimicrobial activities against selected fish bacterial pathogens *A. sobria*, *A. hydrophila*, *E. tarda*, *S. aureus*, *S. epidermidis*, *V. parahaemolyticus*, *P. aeruginosa*, *E. coli* and *A. salmonicida*.

Two bacteriophage formulations namely Coliphage Cocktail and Vibriophage (xLV6) formulation have been developed. The Coliphage cocktail formulation is for controlling antimicrobial resistant (AMR)

Escherichia coli, while Vibriophage (xLV6) formulation is for controlling luminescent vibrios in shrimp culture. Safety of coliphage cocktail was assessed by toxicity analysis in BALB/c mice. The Vibriophage-xLV6 formulation has a phage titre of $\sim 10^{11}$ pfu/ml. Phage treatment using vibriophage-xLV6 in shrimp post-larvae tanks that were spiked with luminescent bacteria showed higher post-larvae survivability, lower luminescent bacterial counts and lower sucrose non-fermenting vibrio loads.

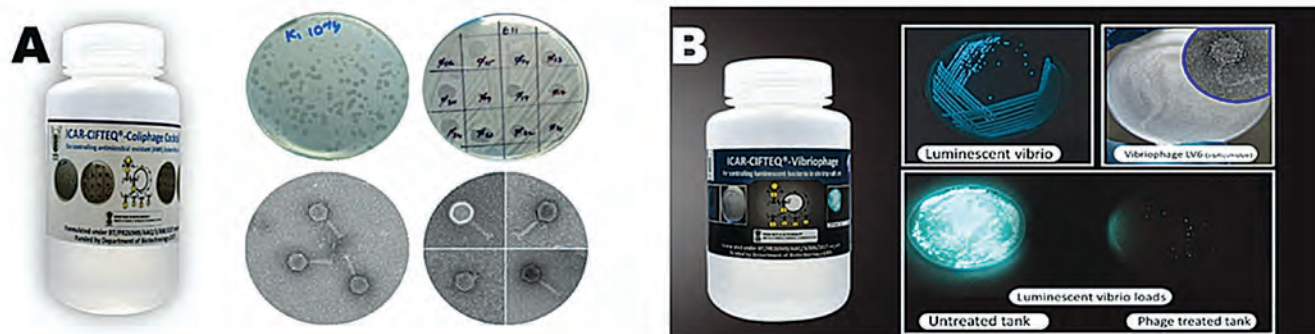


Fig. 3.A.11 (A) Coliphage Cocktail Formulation (B) Vibriophage Formulation

The novel designs of photobioreactors for Spirulina biomass production are developed and trials were completed successfully. These photobioreactors can reduce the cost of production. Further work on upscaling technologies (using seawater as basal medium) and customization of the designs of

photobioreactors in collaboration with industries is required as a follow-up. Further, two compositions of low-cost media (using industry grade chemicals and aquaculture wastewater) were developed and yield of biomass and phycocyanin was estimated. The yield was appreciable in comparison to the control.

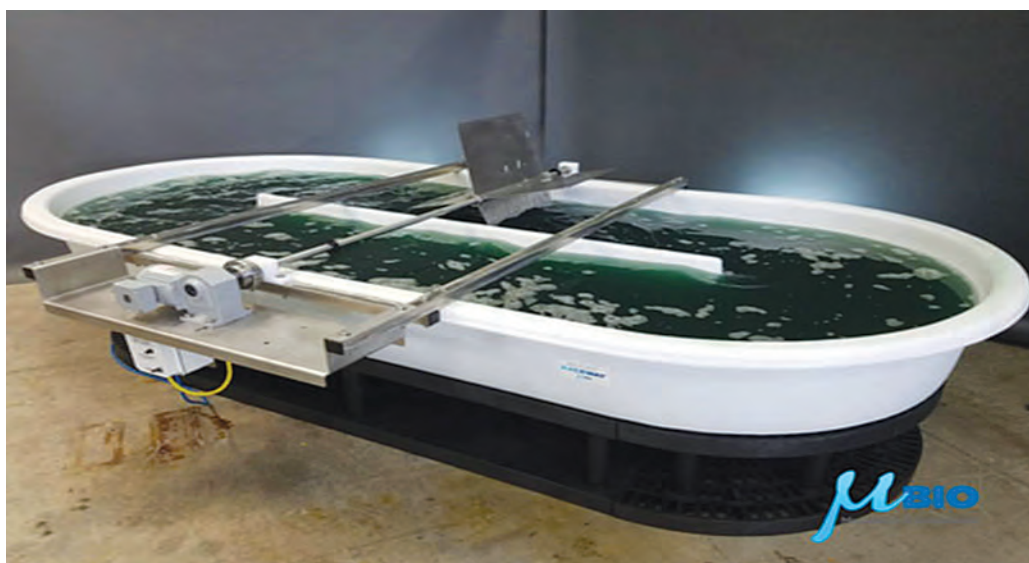


Fig. 3.A.12 Paddle wheel less open tank with panels of submersible pumps and aeration devices.

3.B

BIOENERGY, BIORESOURCES, ENVIRONMENT AND FOREST

3.B.1 Bioenergy

The Bioenergy program promotes technology innovation by creating an enabling environment through Centres of Excellence, Extramural and Demonstration projects and International Cooperation through Mission Innovation. The vision is to make available cost-effective and sustainable biofuel technology by improving or developing feedstock and improvement of biofuel production technologies. Department has established five Bioenergy Centres, specifically to strengthen the research base in biofuel area and to promote translation of processes and technologies from research to scale up and commercialization. Under Mission Innovation Programme, development and demonstration of Integrated Biorefinery is encouraged for cost effective production of fuels with co-production of chemicals and materials. DBT has been supporting Waste to Value technologies to address the issues of Municipal Solid Waste (MSW) management. DBT has also supported three demonstration projects to produce energy in the form of Biogas from Organic Waste in the range of 1Tn-10Tn waste/day. These clean technologies have potential to utilize waste for creation of value in the form of Energy.

Major initiatives taken during the year 2022-23:

Department has received 53 proposals under call for proposals for Sustainable Aviation Fuel announced to support & conduct research, development, and demonstration (RD&D) to foster technological innovations to produce advanced biofuels for aviation applications.

A Centre of Excellence (CoE) established at ICT, Mumbai for Bioprocessing for Bioenergy and Biochemicals aims to develop a platform by which the technologies developed can be translated to pilot/demonstration/commercial units. The current research programme focuses on developing technologies in the biofuel and biochemical space and ensure commercial viability of processes by efficient management of resources.

During the current year, DBT has supported 12 new projects to promote research and translational activities related to commercially viable Sustainable biofuel produced from agricultural residue, production of fuels and aromatics from lignocellulosic biomass, efficient deconstruction of agriculture waste residue, biohydrogen etc.

Significant outcomes and achievements during the year 2022-23:

Major Quantitative achievements during the year 2022-23:	
Projects completed	11
Process/Product/ Technology Developed	49
Process/Product/Technology Transferred	05
Process/Product/Technology Commercialized	02
Research Publications	92
Patents Applied	10
Patents obtained	03
Human Resources Trained	204

Bioenergy Centres:

DBT Pan IIT Center for Bioenergy is focused on addressing some of the bottlenecks associated in the current realm of bioenergy research including- Cyanobacterial and Algal biofuels, Biomass to biofuel conversion, and Techno-economic and life cycle analysis of biomass-derived biofuels. The center has shown several remarkable results and deployable leads in projects including development of efficient and cost-effective catalysts, photo-autotrophic production of platform chemicals from cyanobacteria, bio-butanol production, bio-ethanol production using co-fermentation techniques and biomass processing.

The Centre has engineered a novel, robust and fast growing *S. elongatus* strain PCC 11801 for producing succinate, by inserting only two major genes of succinate producing pathway namely α -ketoglutarate decarboxylase (kgd) and Succinyl semi aldehyde Dehydrogenase (gabD).

DBT –ICGEB Bioenergy Centre is focused on development of low cost indigenous cellulase enzyme for 2G Ethanol Production. Currently, the enzyme activity is being validated and compared with commercial enzyme. In addition, the center is exploring industry partnership for scale up activity.

DBT-Indian Oil Cooperation Limited Bio-energy Centre, Faridabad had developed an indigenous 2G enzyme formulation with good enzyme activity tested at pilot plant of 12 TPD. During this year, the enzyme activity was further improved using process intensification involving fed batch and semi-continuous mode of fermentation. Further, a continuous process developed for conversion of xylose stream from biomass into xylitol using free and immobilized wild type *Saccharomyces cerevisiae*. The Centre has developed indigenous technology for 2G ethanol demonstrated at 250 kg/day pilot plant scale. The demonstration plant of 10 TPD scale is being commissioned at Panipat for indigenous 2G

ethanol Technology with onsite enzyme production.



Fig. 3.B.1: 2G Ethanol Demonstration Plant - Panipat, Haryana Capacity: (100 KL/day)

At DBT-ICT Centre for Energy Biosciences, Mumbai, a pilot plant based on algal photobioreactor is under commissioning stage for treatment of sewage water. A process has been developed to extract 85% of the protein from the grass before it is sent further for biogas generation. Two strains of axenic *Haematococcus pluvialis* were developed from industrial samples. Process for heterotrophic cultivation of axenic strains was developed for Astaxanthin production. Omega 3 fatty acid enriched oil was produced from *Aurantiochytrium limacinum*. This process was scaled up to 20 L stirred tank reactor for an industry partner. Metabolic engineering of *Saccharomyces cerevisiae* has been carried out to efficiently ferment glucose and xylose into ethanol. Respiratory-deficiency along with transcriptional activation of pentose phosphate pathway genes allowed *S. cerevisiae* expressing a heterologous xylose metabolic pathway to produce ethanol at a yield of 0.47 g/g sugars (conversion efficiency >92%).

DBT-TERI Center of Excellence is actively exploring

development of clean technologies for production of advanced biofuels; biodiesel, biohydrogen, pyrolytic bio-oil, using algae biomass as next generation feed. A sunlight distribution-based improved outdoor algal growth and harvesting system has been demonstrated at Mumbai coast to grow marine algae using sea water and CO₂. Pilot scale (100 L scale) process developed for recovery of 90% lipids from wet algae, without requiring land and energy for drying. Ionic liquid catalyzed transesterification processes developed for biodiesel production from marine algae lipid (100 gram per batch) and mixed oil of varying fatty acid such as

FFA including UCO (100 L/day). Pilot scale 3rd generation batch of bio hydrogen process demonstrated at a 100-liter scale per day (18 hr) using deoiled marine algae based mixed feed. An indigenous catalytic process has been developed for production of diesel, jet fuel, aromatics through downstream upgradation of bio oil via dry and wet pyrolysis of whole and deoiled marine algae biomass. A greener process has also been developed for lutein production and its downstream recovery through supercritical fluid extraction approach. Further process developed for cultivation of red algae; *Porphyidium cruentum* for high value pigment production.



Fig. 3.B.2: Marine algal production and processing project site in Navi Mumbai Coast
(Capacity:100,000 L spanning across 220 sq. m scale)

Scientists at CSIR-Indian Institute of Chemical Technology (IICT) has developed and patented a high rate biomethanation technology based on “Anaerobic Gas lift Reactor (AGR)(Patent Number: 307102)”, for the generation of methane rich biogas and nutrient rich biomanure. The Department has sanctioned project to CSIR-IICT for the installation of biogas plants of various capacities (500 kg/day and 5 ton/day) in the vegetable market yards of Telangana. Three plants of 500 kg/day capacity at Erragadda,

Baatasingaaram and Kukatpally vegetable market yards have already been installed and operated for generation of biogas and biomanure from market vegetable waste. These biogas plants are operational and about 80 tons, 43.6 tons and 27 tons of vegetable waste is treated for the generation of 3199, 2402 and 1253 m³ of biogas from these plants respectively. The fourth biogas plant of capacity 5 ton/day is under installation at Gudimalkapur vegetable market yard in Hyderabad.

A pilot scale demonstration biogas plant of 500 kg/day capacity set up at CSIR-CLRI, Chennai for 'Co-digestion of Leftover Food Waste, Vegetable Peels and Fruit Peels generated from cafeterias, hotels and hostels' with circular economy concept.

DBT has supported Sardar Patel Renewable Energy Research Institute (SPRERI), Vallabh Vidyanagar, Gujarat for the development of an integrated zero waste process for micro-algae cultivation using dairy effluent which recovers clean water suitable for irrigation and cleaning purposes. In continuation with this, SPRERI is also associated with process development for biofuel and value added products from microalgae. SPRERI's cultivation system has a maximum capacity of 6000 L in the form of raceway ponds, which can generate microalgae biomass with high lipid content.

Scientists from Vellore Institute of Technology, Vellore, aimed to develop bioconversion of CO₂ to biofuel through Microbial Catalysed Systems such as microbial electrochemical systems and gas fermentation. Efforts were made to enrich the microbial cultures collected from anaerobic sludge for the production of value-added products (ethanol and butanol). An effective CO₂ reduction was observed by the enriched culture.

"National facility for marine and fresh water Cyanobacteria", which has a collection of more than 2000 wild strains, was created at Bharathidasan University. The project explores the possibility of co-culture, photo heterotrophic adaptation process in a sustainable and economical way. During the current year, 35 cultures have been deposited to the existing culture collection in NFMCF. In addition, 101 mesophilic and 09 psychrophilic strains of microalgae and cyanobacteria have been added to the NRMCF – marine repository and optimized the growth conditions for maintenance of new cultures.

DBT-BIRAC Initiative to scale up clean technologies with Stakeholders

Program was launched in 2020 as a part of the 100 days agenda of the Department of Biotechnology under the Swachh Bharat Mission. Few promising technologies previously supported by DBT and BIRAC in the area of waste management/waste to energy were taken forward for Scale up/implementation at 10 sites in association with Municipal Corporations/Urban local bodies (ULBs).

Under this programme eight projects have completed. The biogas generated is being used as cooking fuel or being converted to electricity for use at electric charging stations. A 2 ton per day plant, set up at Haji Ali in Mumbai uses organic fraction of municipal solid waste for conversion to biogas. A yield of approximately 100 cu.m gas is being obtained. Another project focuses on conversion of food waste to biogas. Digestors of different capacities treating 25 Kg to 250 kg per day of food waste have been installed at several canteens in Goa for generation of biogas.

DBT has leased a land from DDA at the Barapullah drain site. A "Clean Technology Demonstration Park" has been proposed to be developed at this land, which will be showcasing four technologies for treatment of sewage at Barapullah drain. The DBT-BIRAC clean tech Demo Park will show case the clean technologies which can be used for cleaning the drain. Clean Energy Incubation Centre, New Delhi act as the local implementation partner.

Aspartika Biotech Private Limited has worked on project "Production & Commercialization of Omega 3 Fatty Acids based products and nutraceuticals using Supercritical fluid extraction technology". The project resulted in source of omega 3 fatty acid, which is 50% cheaper and 10% richer in omega 3 fatty acid content compared to the common marine sources. The products are manufactured through a

novel process of supercritical fluid extraction to produce a completely sterile, chemical/solvent free and odourless pupa oil for both human and animal applications, pet-food, and aquaculture industries for value-addition. The raw material used was silkworm pupae from silk reeling industry. The process used for extraction is a complete clean and green technology focused on waste reclamation where, even the left-over cake after extraction is used further to develop products. The total capacity of the super critical extraction vessel is 20 kg.

Synthetic Biology (Biological Engineering) and Systems Biology

Synthetic biology is at a very nascent stage in India. In order to promote research, development and commercialization activities, BIRAC had announced two call for proposals for Synthetic Biology in the year 2018 and 2019. The calls focused on pathway engineering/genome engineering for fine and specialty chemicals, polymers, bio-lubricants, hydrocarbons, enzymes, etc. 11 projects were funded and few of them resulted in proof of concept development for the production of fragrances, high value metabolites, steroids, drug intermediates, pigments and other specialty chemicals for application in cosmetics, pharmaceuticals and food industry.

To promote the synthetic biology field, webinars were conducted in the month of April/May 2022 in association with ICGEB on the role of synthetic biology in bioenergy research and value added biomolecule production. In addition, a discussion meeting was conducted in July 2022 on 'Synthetic biology in India - Way Forward' under the Chairmanship of Secretary DBT, Dr. Rajesh S Gokhale and was attended by representatives from DBT, BIRAC and researchers from academic institutions. The meeting aimed at understanding the synthetic

biology status in India and ways by which synthetic biology can help India in achieving the goal of affordable product development in five niche areas: Agro products/Plant based products; Food industry; Cell culture related products/Cell mediated therapies; Enzymes and Proteins; and Metabolic pathways.

The Bioenergy program is promoting Biological Engineering and Systems Biology tools to develop clean energy technologies. Efforts are directed towards 2nd and 3rd generation biofuels by working on developing engineered cellulase enzyme concoction, engineered strain to ferment C5/C6 fermentation to produce ethanol and other energy-dense molecules, and engineered algal biofuels.

Mission Innovation- Multilateral Program to Accelerate Clean Energy Innovation

Mission Innovation (MI) is a global initiative of 23 countries and the European Commission (on behalf of the European Union) working to reinvigorate and accelerate global clean energy innovation to make clean energy widely accessible and affordable.

India through the Department of Biotechnology, being the nodal agency coordinated the Mission Innovation (MI) clean energy initiatives. DBT has hosted the MI Gathering meeting on 4th-6th April 2022, at New Delhi, bringing together representatives from across Mission Innovation (MI) members to discuss and set MI's strategy and work-plan for the year ahead, as well as to share insights on national priorities and strengthen their network of senior clean energy innovation leaders. During the event, the Hon'ble Minister for Science and Technology and Earth Sciences, Dr Jitendra Singh announced the launch of Mission Integrated Biorefineries along with Dutch Minister (Climate) Frederik Wesselink. Dr. Singh emphasized on the role of MI in advancing clean energy technologies critical for the energy industry.

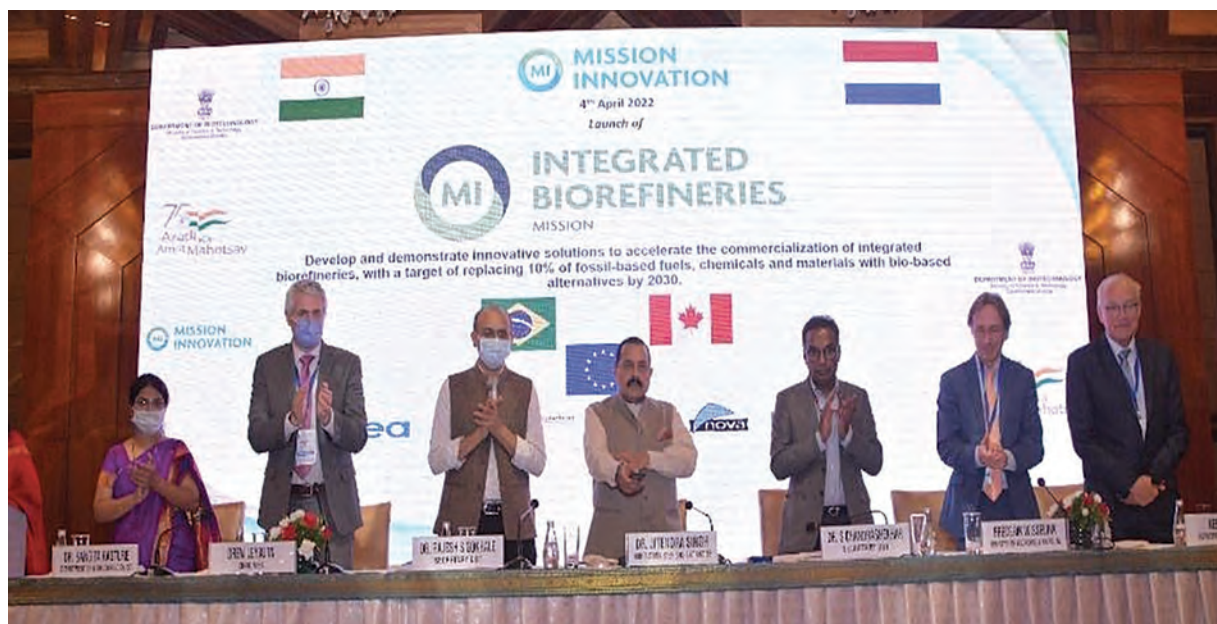


Fig. 3.B.3 Launch of Mission Integrated Biorefineries by Hon'ble Minister S&T and ES Dr Jitendra Singh at the Mission Innovation Annual Gathering -April, 2022

The first Global Clean Energy Action Forum (GCEAF) meeting was hosted by the Department of Energy, United States of America at Pittsburgh, Pennsylvania, USA on September 21-23, 2022. It was the first Joint convening of Clean Energy Ministerial (CEM13) and Mission Innovation (MI-7). The meeting was attended by 23 countries and the European Union. The Hon'ble Minister Science & Technology and Earth Sciences, Dr. Jitendra Singh led the Indian delegation. India participated in the Topical Roundtables on "Sustainable Bioenergy and Biorefineries" and "Net Zero Built Environment with

Connected Communities"; Main stage event "International Collaboration to Accelerate the Clean Energy Transition"; and "India Clean Energy Showcase" a side event. Hon'ble Dr. Jitendra Singh, announced the Innovation roadmap of mission Integrated Bio-refineries Roadmap (on behalf of Co-lead Netherlands and core Members Brazil, Canada, EC and the UK) for further implementation with collaborating international partners, highlighting the need for increased funding for energy research, development, and demonstration (RDD) over the next five years.



Fig. 3.B.4 7th Mission Innovation Ministerial (MI-7) and 13th Clean Energy Ministerial (CEM13) meeting, Pittsburgh, USA, September 2022

Considering the mandate and active engagement of DST in clean energy R & D activities, the nodal agency for India changed from DBT to DST in November, 2022. However, DBT will continue its engagement in MI 2.0 through Biorefinery Mission & Innovation for Sustainable Aviation Fuel (ISAF) and other Biotechnonology relevant activities.

The Clean Energy International Incubation Centre (CEIIC) is the joint initiative of DBT, Govt. of India, BIRAC and Tata Trusts under Mission Innovation India. CEIIC was set up in 2018 for promoting innovations in the energy space and as the first International Incubator by India under Mission Innovation. The Incubator is designed to offer complete “lab to market” incubation support to clean energy enterprises, both Indian and International, which can bring about deep and irreversible social and environmental impact. CEIIC supports the incubatees by providing last-mile connectivity and end-use deployment of successful research outputs. In the year 2022 CEIIC has provided incubation support to around 39 startups with excellent recognition at international platforms.

3.B.2 Environmental Biotechnology

Programs under Environmental Biotechnology have been envisioned to provide biotechnology-based innovative clean and green solutions for the management of environmental issues of National and global concern in the area of climate and environment. Department supports Research, Development, and demonstration activities to promote innovations for the addressing environmental issues and technological intervention for major challenges such as anthropogenic pollution and climate change, and for efficient monitoring of environmental health, treatment of solid & liquid wastes, bioremediation of polluted sites. Major thrust areas include decontamination of natural resources; Restoration of degraded lands; Bioremediation technologies; Biodegradation of pesticide residues; conservation of biodiversity and to develop the technologies for monitoring and

mitigation of environmental pollutants. The development of novel bio-based technologies using research-based insights from bioprocesses is the key to achieving the vision.

Department has proactively taken R&D initiatives for the development of Biodegradable Alternatives for Single Use Plastics and for mitigating and management of microplastics. Also, Department has invited short-term R&D proposals for development of Rapid Biodegradability Test for biodegradable plastics.

Salient Achievements-Environmental Biotechnology:

Major Quantitative achievements during the year 2022-23:	
Projects completed	23
Process/Product/ Technology Developed	02
Research Publications	12
Patents Applied	02
Patents obtained	01
Human Resources Trained	100

A constructed wetland technology with potential applications for the scaled-up establishment of a Hybrid Constructed wetland system for septage treatment has been upgraded under a DBT project supported at Graphic Era Deemed to be University, Dehradun as potential tool for sustainable management of municipal septage wastewater.

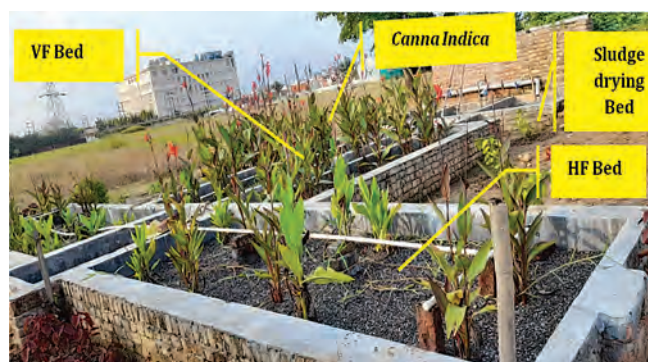


Fig. 3.B.5 Hybrid Constructed Wetland system

In-situ bioremediation of crude oil contaminated sites is being performed at Lakwa in Assam and Gandhar in Gujarat using bioaugmentation, biostimulation or phytoremediation approach, where an efficient 5 member consortium was designed for field application

including *Pseudomonas putida*, *Alcaligenes sp.*, *Gordonia sp.*, *Achromobacter xylosoxidans* and *Pseudomonas aeruginosa*. Simultaneously, results from the microcosm study showed that the consortium worked efficiently in the 1:10 oily sludge to soil ratio.



Fig.3.B.6 PAH and crude oil contaminated sites at Gujarat and Assam for sampling

As part of a study supported under DBT- ATGC program at Indian Institute of Space Science, Thiruvanthpuram, sensing nanomaterials have been optimized for fabricating the gas sensors (CO , CH_4 , NH_3 , and N_2O). HSFC-ISRO (Human Space Flight Centre-ISRO) and the IIST signed MOU (20-05-2022) to develop CH_4 , CO , NH_3 , and O_2 sensors for Human Space Mission Program.

A bio-restoration technology developed through DBT support is being demonstrated by West Bengal State University at about 163 acres (~65 hectares) comprising 31 degraded mangrove sites at Indian

Sundarbans outside the protected area through a site-specific approach across differential degradation gradients. The site has the potential to be an Important Coastal Biodiversity Area (ICBAs) that includes an interface or transition area between land and estuarine river that holds ecological values with socio-economically important significant unique mangrove ecosystem and cultural functions. Activities are aligned with the theme of “Building Ecological Resilience in Vulnerable Mangroves of the Indian Sundarbans: Sustainable and Equitable Management of Biodiversity and Ecosystem Services in the era of Climate Change”.



Fig. 3.B.7 Restoration of a 10-ha degraded mangrove site

Scientists at IISER Mohali under a DBT supported project have developed a microbial electro-synthesis technology-based platform to produce valuable organic products from unpurified industrial CO₂. The technology may have wider applications restricting the Industrial CO₂ emissions at point of source, and synthesis of value-added chemicals from CO₂.

A plant based surfactant has been discovered through microbial production identified as saponin at Indian Institute of Technology, Delhi. The biosurfactant has shown immense potential in polyaromatic hydrocarbon solubilization and in enhancing the recovery of residual oil. The biosurfactant produced in this study has the potential to be used in various other industries like the personal care industry, home care industry, pharmaceutical, and agricultural.

Researchers from Tamil Nadu Agricultural University, Coimbatore have generated leads on Tolerant and Nutrient efficient genotypes for calcareous soils for Maize and Groundnut; Effective microbes and amendments for calcite and nutrients solubilization in calcareous soils; and calcite solubilizing microbes for improving the crop yield and nutrient availability in calcareous soils.

A lead has been generated on the XC polymer using novel *Xanthomonas sp* in a study being supported at TERI New Delhi. The technology has achieved the Technology Readiness level 6 (TRL-6).

3.B.3 Forest Biotechnology

The Forest Biotechnology program of DBT facilitates application of biotechnology for forest conservation, resource utilization, and scientific management of invasion, studying ecosystem services, and climate change. DBT is closely working with ICFRE, CSIR, ICAR, State Forest Departments, and academia to take forward the efforts on modeling and control of invasive species in the forest, carbon sequestration, and technologies for measuring and maintaining ecosystem services. A new initiative on

“Biotechnological interventions for management of protected areas” project has been undertaken to provide a model for the sustainable management of protected areas (PAs) in the country using ecological principles.

Salient Achievements-Environmental Biotechnology

Major Quantitative achievements during the year 2022-23:	
Projects completed	02
Process/Product/ Technology Developed	02
Research Publications	14
Human Resources Trained	273

Microsatellite markers have been developed to study genetic diversity of *Primula* and *Rhododendron* species in a study supported at University of Delhi, Baba Ghulam Shah Badshah University, J&K, Sikkim University, and IIT, Kharagpur. The developed markers will help in analyzing the diversity pattern of species at three different elevations and hence the adaptation strategies toward changing environments, which in turn will assist in their conservation strategies.

Scientists from Regional Plant Resource Centre, Bhubneshwar have applied the Vegetative propagation technology with potential applications of micro-cuttings as well as Black taping method for the regeneration of saplings for re-introduction of IUCN-listed RET species *Heritiera fomes* and *H. littoralis*, at Bhitarkanika National Park.

Scientists from the Indian Institute of Science, Bangalore under DBT funded project aimed to investigate the resilience of north-east Indian forests has established that the vegetation or forests of northeastern India are characterized by a single stable state, unlike their counterparts in Africa and South America.

Genotyping of four populations of *C. acanthospathus* (15 SSR loci) and *C. nambariensis* (15 SSR loci) along

with three populations of *C. brandisii* (25 SSR loci), six populations of *C. andamanicus* (10 SSR loci) has been successfully completed in a project jointly implemented by Kerala Forest Research Institute (KFRI), Thrissur, Kerala, Institute of Forest Genetics & Tree Breeding (IFGTB), Coimbatore, and Advanced Research Centre for Bamboo and Rattans (ARCBR), Aizwal. Ecological niche modeling and Genotyping of twelve populations of *Korthalsia laciniosa* is underway using neutral SSRs and EST-SSRs.

In other efforts, a single-step, stringent PCR-based assay has been developed for the detection of the pathogen for sandal spike disease. This assay will facilitate early detection of the pathogen and enable plantation managers to take adequate measures to control the spread of the disease.

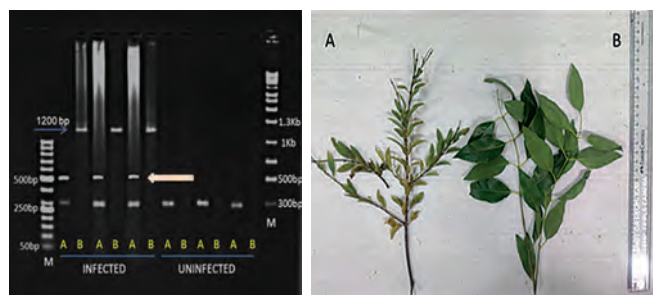


Fig. 3.B.8 A single-step diagnostic test for sandal spike disease. (A) *Phytoplasma* infected leaves (B) uninfected leaves.

Scientists from Sher-e-Kashmir University of Agricultural Sciences and Technology- Jammu have reported extraction of Lantadene (Phyto-constituents from *Lantana camara*) to fight against *Vorroe* mite; Fruitful development in extending *Plectranthus rugosus*'s range- a sole source to obtain sulai (wild) honey; Selection of climate-smart bees and promising lac race and Novel method to reduce insect pests of Lac.

Investigators from the Department of Botany, Savitribai Phule Pune University, Pune have identified the locality having maximum Gamma-Amino Butyric Acid (GABA) content and developed a method to extract higher yield of herbal GABA per unit weight of plant material from *Pandanus odorifer* leaves.



Fig. 3.B.9 Climate Smart Bee Keeping Training.

3.B.4 Bioresources- Microbial and Natural Resource

The programme explores, discovers, and assesses economic importance of microbial and natural resources. It develops models of sustainable use of bioresources, discovery based product, and capacity building to strength the R&D in biotechnology. Bioresources from extreme environments, hotspots, and coastal region are being explored, cultivated and preserved at national repository. Several initiatives have been taken up to discover the potentials of available resources.

Major initiatives taken during 2022-23:

During this year, efforts continued to support the research for bioprospecting, inventorization and characterization, value addition and sustainable utilization of bioresources along with relevant training, capacity building and awareness generation. The major initiative taken is given below:

With an aim to screen anti-viral activity of molecules against SARS-CoV2 and the emerging variants of concern, DBT and BIRAC jointly invited Proposals on "Anti- SARS-CoV-2/nCoV-2 Virus Studies using Botanical Ingredients and Traditional Formulations". As an outcome two high throughput screening platforms (HTSPs) established at Institute of Life Sciences (ILS), Bhubaneswar and Institute for Stem

Cell Science and Regenerative Medicine (InSTEM), Bangalore.

Marine Bioresource & Biotechnology Network Programme aims to strengthen marine biotechnology and biology research (Prospecting, conservation and exploration of sea bio-diversity) in the country. Seven network projects under this initiative have been implemented. It has a strong linkage with the Deep Ocean Mission of Ministry of Earth Sciences.

To have a biotechnological intervention in AYUSH sector and to have a platform for exchange of information, a Call for R&D Proposals on 'Biotech interventions in medicinal plants' was jointly announced by DBT and NMPB. Under the call 300 proposals had been received, out of which 17 proposals were recommended.

A National Conference on Underutilized Horticultural Genetic Resources: Conservation and Utilization, was organized during June 3-4, 2022 on the occasion of World Environment Day, which was attended by 291 delegates representing 89 organizations of 30 states/ UTs.

Major Quantitative achievements during the year 2022-23:	
Projects completed	21
Process/Product/ Technology Developed	07
Research Publications	49
Patents Applied	03
Human Resources Trained	650

Major achievements for 2022-23:

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. Subsequently, it was recognized as an International Depository Authority (IDA) for the purposes of patent procedures; Designated National Repository under

the Biodiversity Act of 2002; and also affiliate member of the World Federation for Culture Collections (WFCC) and registered with the World Data Centre for Microorganisms. Total 4169 bacterial and fungal cultures were deposited by various researchers across India for their long-term preservation. NCMR has started the repository of AMR isolates and received 611 isolates in total. In the reporting period, NCMR has published 53 research papers including 14 novel bacterial taxa.

Indian Bioresource Information Network (IBIN) has been launched as a single window gateway to access distributed bioresource database available in the country to offer information of plants on taxonomic classification, synonyms, habitat, chromosomes, chemicals, general and morphological description, phenology, and conservation status. At present, the new IBIN portal is in making, and holding data on following diverse categories of species – plants (22,740), animals (14,318), bacteria (577), chromista (406), fungi (5,790), protozoa (286) and archaea (24).

A Microbial repository of 72586 microbial cultures including bacteria, fungi, yeast and actinobacteria has been established at IBSD, Imphal. These microbial isolates were isolated from different unique ecological niches of NE India such as caves, hot spring, cold spring, high altitudes, sacred forest, fermented foods and beverages, lakes, forest, endophytes, epiphytes, mushrooms, and untouched ecosystems.

Conservation, Propagation and Mass Multiplication of Selected Orchid species from North-East has been initiated and a pilot project has been sanctioned for developing bio-based entrepreneurship in North-East India at IBSD. The project is implemented through 75 beneficiaries in 15 clusters of 5 members each.

While exploration of native microorganisms and biocatalysts from traditional fermented products of Sikkim Himalayas, scientists have identified Angiotensin Converting Enzyme (ACE) inhibitor and antioxidant peptides in yak and cow milk hard chhurpi

cheese of the Sikkim Himalayan region. A total of 1473 peptides originating from different milk proteins were identified. Out of these, 101 peptides were found to have antihypertensive property. The development of bioprocesses for the controlled milk fermentation using defined proteolytic starter strains are necessary to produce bioactive peptide enriched functional yak and cow hard chhurpi cheese. Furthermore, a novel α -galactosidase variant, catalytically active in a wide pH range from extreme acidic to alkaline, has been identified from an aquatic habitat metagenome of the Sikkim Himalayas.

The emerging resistance of malaria parasite against Artemisinin-based Combination Therapies (ACTs), and of mosquitoes against insecticides together with global warming are of great concern. The parasite heme pathway is essential for the mosquito and liver stage development of the malaria parasite, and dispensable for the blood stages. Targeting the parasite heme pathway with griseofulvin – a FDA approved antifungal drug, prevents cerebral and severe malaria in mice. The findings assume significance in the context that the only treatment option available for severe and cerebral malaria patients is intravenous administration of artemisinin or quinine with supportive therapies (Nat Commun 13, 4028 (2022); and Indian and international patents have been filed. This study provides a new adjunct therapeutic option for cerebral and severe malaria that are responsible for the malaria mortality and therefore, warrants clinical trial in humans.

Silk protein sericin is a natural protein secreted by various silkworms, tasar silkworm is one of them. Sericin has various biological properties *i.e.* antioxidant, anti-diabetic and anticancer. It has been observed that the extraction method significantly affects the biochemical activities of silk proteins. Scientists from Central Tasar Research and Training Institute, Rachi have developed technology for separation of tasar sericin.



Fig. 3.B.10 Prototype Purification technology unit for separation of tasar sericin

3.B.5 National Certification System for Tissue Culture Raised Plants (NCS- TCP)

The tremendous potential of Plant Tissue Culture to revolutionize the growth of agriculture in India led Government of India to establish National Certification Systems for Tissue Culture Raised Plants (NCS-TCP) in 2006. The Department of Biotechnology was notified as Certification Agency and charged with the responsibility for implementing NCS-TCP programme. NCS-TCP has been anchored to National Institute of Plant Genome Research (NIPGR), New Delhi as a NCS-TCP Management Cell of DBT w.e.f. October 1, 2021. NCS-TCP provides accreditation to Tissue Culture Production Facilities (TCPFs) and certifies the tissue culture raised propagules up to laboratory level and regulate its genetic fidelity and virus indexing as prescribed. There are around 200 commercial tissue culture companies with a plant tissue culture market of more than Rs 500 crore in India. Several important crops such as Apple, Bamboo, Banana, Date Palm, Potato, Sugarcane etc. are being grown at TCPFs and there is continued rise in their demand in domestic and foreign market. Currently, 71 companies are recognized under NCS-TCP and around 30 are lined up for renewal. A total of 14 TCPFs are freshly recognized in the year 2022 and a few more are in process of certification. NCS-TCP has provided 10,870 certification labels corresponding to more than 66.30 million tissue culture raised plants in the year 2022.

3.C

HEALTHCARE AND MEDICAL BIOTECHNOLOGY

Healthcare & Medical Biotechnology has been a strong focus area of the Department of Biotechnology since inception. DBT has been actively supporting biomedical research & innovation for understanding the causes of human diseases such as non-communicable diseases, emerging infections, anti-microbial resistance, genetic disorders, maternal and child health, nutrition issues at the genetic and molecular level, early detection, preventive measures, development of vaccines, innovative tools and therapies, healthcare delivery systems and development of products for medical applications. Over the years, Department of Biotechnology has funded projects in different thematic areas that include, Bioengineering, Cancer Research, Chronic Diseases, Drug Development, Human Genetics, Infectious Diseases, Public Health & Nutrition, Stem Cells & Regenerative Medicine, Vaccine R&D and Women & Child Health and also Genome Editing & Nanotechnology Applications in Healthcare. Each of these thematic areas has been detailed below:

Biomedical Engineering

Biomedical engineering is an interdisciplinary area of research involving engineering and other quantitative sciences for unravelling the complexities of biological systems and provides cost-effective solutions for improved quality of life. The division of biomedical engineering fosters and supports innovative ideas in the field of bio-medical devices, diagnostics, implants bioinstrumentation, tissue engineering for development of affordable healthcare technologies and enhancing their access.

A call for inviting LOI on “Research on key components or resources for Biomedical Technologies” was announced on 15th August 2022. A total of 477 applications were received which are being reviewed for further consideration.

Significant Outcomes-

No. of research publication during 2022-23	10
No. of patent filed	4
No. of human resource trained	9
Technologies developed	8

Salient Achievements-

A project being implemented at Dr. Reddy's Institute of Life Sciences- Hyderabad, has led to development of technology for manufacturing microneedles (MNs) on small scale. Comparative study of the drug release from two types of the formulation (drug was loaded either as amorphous powder, or in form of nanoparticles) demonstrated advantage of the NPs-containing formulation. This is being explored for Iron and Vitamin B-12 supplementation in women. In a project implemented at Sardar Vallabhbhai National Institute of Technology, Surat, a compact, lightweight, robust and stable wearable textile antenna sensor device has been designed for detection of knee effusion (Fig. 3.C.1). The textile antenna is fabricated using laser cutting process and embroidery technique employing silver coated conductive thread. The prototype design was successfully tested on knee aspiration anatomy model for knee effusion detection and has shown good agreement with the simulated results.

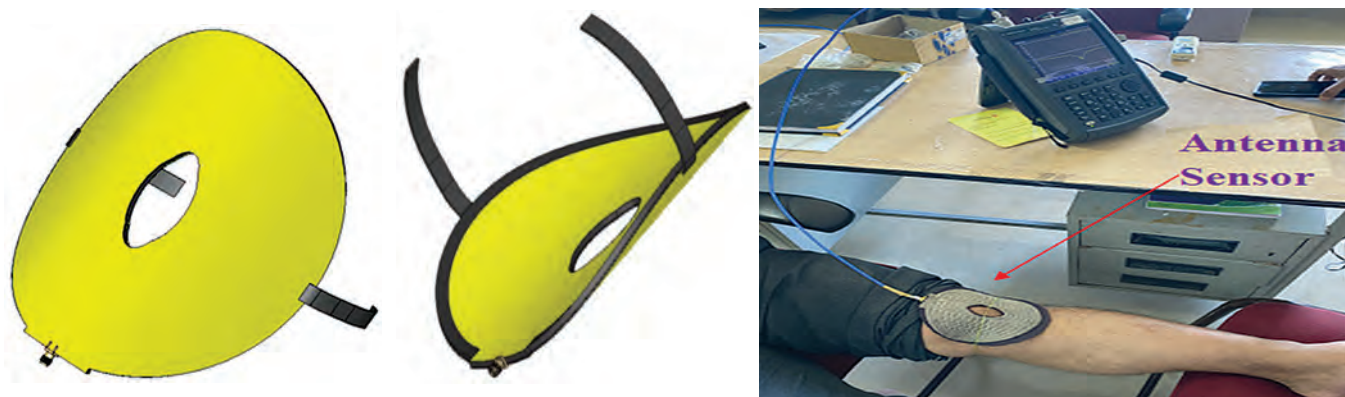


Fig. 3.C.1 - Textile Antenna based wearable bio sensor device for detection of knee effusion

In a project implemented by BITS Pilani and CEERI, fluorescence based probes selective for Human Serum Albumin (HSA) and creatinine detection have been standardized. The enhancement for building rapid detection platform for urine samples is being pursued. In a project implemented at Indian Institute of Technology, Guwahati, a novel suture mediated closure device having the option of making 3 different modes of operation with two sets of needles has been designed (Fig. 3.C.2). The prototype is manufactured using 3D printing technique and animal trials have been conducted on three different animals.

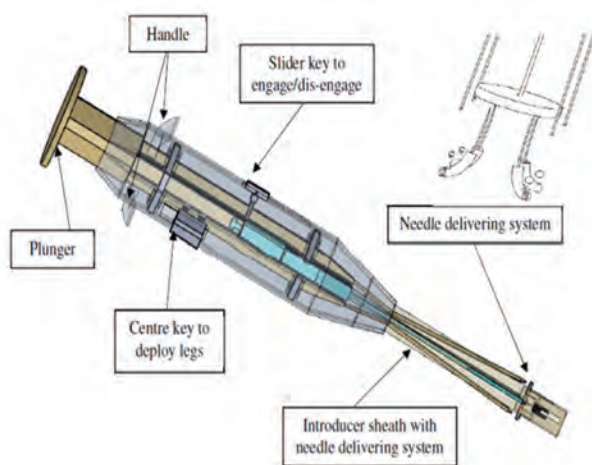


Fig. 3.C.2 - Design of suture mediated Vascular Closure Device

In a Center of Excellence (COE) project implemented at IISc, Bangalore, HDPE and UHMWPE-based biomaterial has been developed with clinically relevant performance-limiting properties, predominantly mechanical and wear properties. The acetabular cup liner prototypes are under pilot-scale production at a GMP-compliant facility at INDO-MIM Pvt. Ltd, Bangalore, India (Fig. 3.C.3). Also, the commercialization plans for these liner prototypes are conceived with OrthoTech India Pvt Ltd. 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 has been designed and were successfully pre-clinically validated in human cadaver bone, pig bone and rabbit model. The implant manufacturing will be scaled up at Arka Medical Devices Pvt. Ltd., an ISO 13485 certified and CDSCO approved medical device manufacturer.

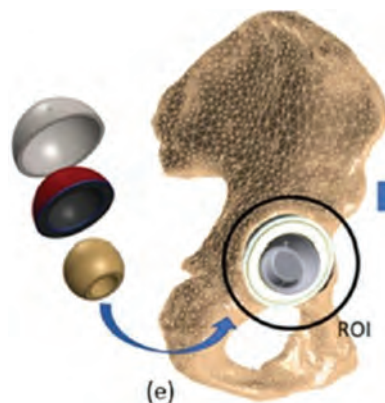




Fig. 3.C.3 a) CAD models of the acetabular components & b) Acetabular Cup liner

Cancer Disease Biology

Cancer is a major public health concern in India. India sees an incidence of more than 1 million new cases of cancer every year, a number that is likely to increase given the increasing age of Indian population and lifestyle changes. Cancer is enormously complex and highly adaptable; many subtypes of the disease have distinct clinical features and susceptibilities to therapy. Many cancers are still not diagnosed until they are at advanced stages and some resist most attempts at treatment. Through R&D programs, and multi-institutional networking projects, DBT has provided resources to individual investigators and to institutions to carry out basic, applied, translational and clinical research and to develop new methods to prevent and treat different types of cancer.

Significant Outcomes

No. of Research Publications	50
No. of Patents Applied	5
No of Human Resources Trained	55
Process/Product/Technology Developed	3

Salient achievements

Under the aegis of the Virtual National Cancer

Institute (VNCI) collaboration entitled “Multi-Omics analysis to decipher mechanism of hormone Resistance in Breast Cancer”, hormone therapy sensitive and resistant breast cancer using multiomics big data generation approaches are being investigated. The group has devised sensitive and specific non-invasive assays using cell free tumour DNA to identify these changes and develop a prediction method for onset of resistance. Tata Memorial Hospital (Mumbai) is the host clinical institute where patients are being recruited. TMH is also identifying the proteomic and phosphoproteomic profiles of patients resistant and sensitivity to therapy. Additionally, TMH is studying the clonal evolution of patient tumors in response to therapy over time using patient samples before administration of therapy, relapse or progression of disease post administration of therapy, and multigenerational patient derived xenograft mice pre-clinical models. Advanced Centre for Treatment, Research and Education in Cancer (ACTREC, Navi Mumbai) has generated and is analyzing Whole Exome Sequencing (WES) and Whole Transcriptome Sequencing (RNA-Seq) data from sensitive and resistant patients. National Institute of Biomedical Genomics (NIBMG, West Bengal) has generated and is analyzing whole genome sequencing (WGS) data from resistant and sensitive patient tumours. Kalinga Institute of Industrial Technology (KIIT, Bhubaneswar), will generate Patient Derived Xenografts (PDX), and will test various cancer drugs to understand tumour response to these compounds.

Unit of Excellence (UoE) in Cancer Research in Multiple Myeloma (MM) implemented at AIIMS New Delhi and IIT New Delhi has advanced knowledge regarding Multiple Myeloma (MM). The investigators have validated a nucleic acid-based algorithm for Revised - International Staging system (R-ISS). The proposed algorithm is resource-effective in terms of small quantities of sample requirement, feasibility of batch processing and reduced overall

cost for the total number of regions evaluated and can be used for staging and risk stratification in low to middle income countries and in patients in whom baseline molecular testing data is not available. For patients of MM, wherein the baseline analysis of molecular aberrations is not possible due to any reasons, an AI based modified risk staging (MRS) system comparable to R-ISS has been developed. Chromothripsis has been identified as an independent poor prognostic factor in MM. A 42-gene based NGS test useful for MM in clinical practice has been established at AIIMS, New Delhi. Immunophenotyping profiling in MM has helped in establishing Minimal Residual Disease (MRD) protocols for clinical management of stem cell transplant recipients in MM at AIIMS. A flow panel of CD19/CD56, CD56/CD27 has been found to be most informative. A server-based database for multiple myeloma patients has been created which contains the clinical and laboratory data for nearly 2000 patients of plasma cell proliferative disorders including nearly 1500 patients of MM.

A program supported under **Glue Grant Scheme** entitled 'Exploring Novel BCL2-specific Inhibitors against Leukemia and Lymphoma' has shown significant progress in taking forward the novel BCL2 inhibitor, Disarib. Disarib synthesized in laboratory conditions as well as in the GLP-certified laboratories inhibited tumor progression with comparable efficacies. Importantly, combinatorial studies in leukemic cell lines and in vivo xenograft models with use of Disarib and clinically approved drugs helped in identification of 3-4 different combinations that are synergistic in nature. The first phase of pre-clinical toxicological studies in mice and rats using Disarib has been completed. 28 days (mice and rats) and 90 days (mice) of repeated dose toxicological studies showed no significant toxicity induced by the Disarib at hematologic level, or at a functional level in the case of kidney, liver, or at morphology level in the case of kidney, liver, heart, intestine, lung, thymus, and spleen.

These results suggest that Disarib is safe to consider for a clinical trial, Phase I, after performing relevant toxicity studies in a non-rodent (dog).

Accelerated Translational Grant for Commercialization (ATGC) - Healthcare

Skin-On-A-Chip: A Platform Based on Microfluidic Technology to Support Pre-Clinical Research- In a joint project sanctioned to Institute of Chemical Technology, Mumbai and IIT Bombay the investigators have achieved development of a single compartment micro-physiological system, using in-house fabricated microfluidic device. Further, the investigators have also designed a static device, having similar dimensions, to generate the human skin model. Morphological characterization of developed skin equivalent, determined using confocal and high content scanning system, demonstrated the spatial orientation of two distinct skin layers i.e., epidermal and dermal after 11-days of culture. Enhanced cellular viability was achieved under continuous flow conditions as compared to the static culture. Hematoxylin and eosin staining followed by immunohistochemistry studies confirmed the human skin formation with the expression of cell specific markers. Further, biomechanical characterizations also demonstrated enhanced strength and rigidity of skin equivalent developed using microfluidic device. Thus, this proof-of-concept investigation augments research relating to human skin models and in-vitro 3D disease models supporting accelerated drug discovery and for evaluation of novel cosmetics, chemicals, pharmaceutical drugs and allergens.

Chronic/ Lifestyle Disease Biology

Chronic or Non-communicable diseases are on the rise across the globe accounting for 73% of all deaths. In India, non-communicable diseases accounts for 53% of all deaths and 44 % of disability-adjusted life-years lost. Also an increase in proportion

of deaths due to NCDs from 37% in 1990 to 61% in 2016 suggests a rapid epidemiological transition with a shift in disease burden to NCDs. The Department of Biotechnology under its 'Chronic Disease Program' supports and promotes basic, clinical, translational and interdisciplinary research in focused high disease burden areas such as Diabetes, Cardiovascular Diseases, Liver & Kidney Disorders, Respiratory & Autoimmune Diseases, Skin, Bone & Muscular Diseases, Eye disorders etc. The present thrust is to leverage cutting edge technologies and innovations in order to develop early screening tools, identify predictive and diagnostic biomarkers; develop risk stratification models and to accelerate the development of therapeutics.

During the year, a request for proposals was advertised on 'Chronic Pain & its Management' for gaining deeper insight into the pain mechanism and advancing research methodologies for developing targeted effective and non-addictive pain treatment options. The proposals received are under review.

Salient achievements -

Diabetes and metabolic syndrome- To gain a deeper understanding of the molecular mechanisms involved in adipogenesis and lipid metabolism, a project was supported to explore the role of the PRIP-interacting protein with methyl transferase domain (PIMT), a coactivator-binding protein, as a crucial regulator of obesity. It was observed that during adipogenesis lentiviral mediated knockdown of PIMT in 3T3L1 preadipocytes caused a reduction in the transcript and protein levels of Perilipin, Caveolin, FASN, along with a drop in glycerol and free fatty

acid accumulation. *HFD mice* treated with shPIMT lentiviral injections displayed neutral body weight and enhanced insulin sensitivity. Recurrent infections including sepsis in subjects with Type2 Diabetes (T2D) are one of the primary causes for increased morbidity and mortality. In one such study, it was shown that Neutrophils fail to respond to form extracellular traps in T2D mice upon induction of sepsis.

Skeletal muscle is the major tunable glucose utilizing organ and its resistance to insulin is the primary cause of type 2 diabetes. Sarcolipin (SLN) plays an important role in muscle physiology and the SLN-SERCA interaction is an important contributor to muscle-based thermogenesis. It is known that binding of SLN with sarco/endoplasmic reticulum calcium ATPase (SERCA) is enhanced by a small bio molecule named Capsaicin which is a major constituent of plants belonging to genus Capsicum. A study was supported to synthesize Capsaicin analogues and examine if it also helps in SLN-SERCA binding. So far the team has succeeded in synthesising 12 analogues of capsaicin in the lab and a comparative analysis of different capsaicin analogues was carried out for their antidiabetic activities. Among the tested capsaicin analogues C9 (N-(3-hydroxy-4-methoxybenzyl)nonanamide) and C11 (N-(3-hydroxy-4-methoxybenzyl)-2-methylnonanamide) has the maximum potentiality to alleviate these glucose-homeostatic disorders which were validated in vitro. In yet another study the role of bioactive lipid arachidonic acid was shown in reversal of skeletal muscle atrophy in the C2C12 myotube hyperglycemic model.

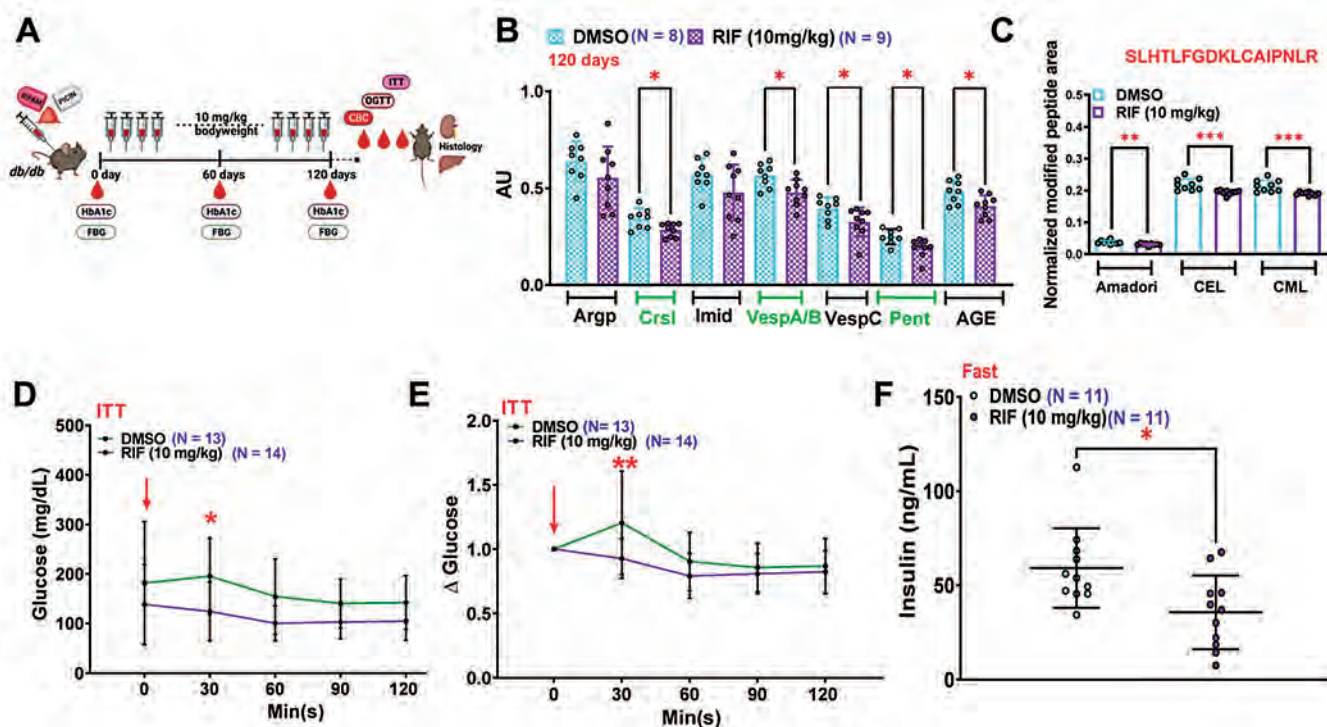


Fig. 3.C.4. (A) A schematic diagram depicting the key phases of the mice study. (B) Fluorescent plasma AGEs : quantified spectrophotometrically. Rifampicin-treated db/db mice showed reduction in AGEs levels. (C) Normalized Amadori, CML and CEL-modified peptide area shows a significant decrease in peptide SLHTLFGDKLCAIPNLR from albumin in plasma of rifampicin-treated mice as compared to DMSO-treated mice. (D) Changes in blood glucose levels during Insulin Tolerance Test (ITT) in db/db mice after 120 days of RIF or DMSO treatment. Mice were fasted for 5 hours before the insulin challenge. Arrow indicates when the insulin was injected. (E) The same results are presented after normalizing to the baseline levels of glucose. (F) Serum Insulin levels were determined under fasting condition. RIF treatment decreased the insulin levels in fasted db/db mice.

In one of the project, studying the potential of anti-tuberculosis drug Rifampicin in alleviating hyperglycemia-related complications during type 2 diabetes, it was found that rifampicin and RIF-Q (Rifampicin analog) have significant anti-glycating activities in db/db mice & helped in improving glucose homeostasis and reducing diabetic complications (Fig. 3.C.4). Toxic deposition of human Islet Amyloid Polypeptide (hIAPP) on pancreas is the major cause of type-2 diabetes mellitus (T2DM) that affects normal b-cell function. Employing an integrated approach in one study, the investigators compared the aggregation kinetics of hIAPP with its N-terminal 18 residue peptide fragment and the C-terminal 21 residue peptide VY21 (V17-Y37). The ability of VY21 oligomers to enhance hIAPP aggregation while reducing overall cytotoxicity makes it a potential target for inhibitor design.

Acute Lung Injury (ALI)/ Acute Respiratory Distress Syndrome (ARDS) - Cardiolipin (CL), a mitochondrial DAMP (Damage-associated molecular pattern) is known to be elevated in tracheal aspirates of pneumonia patients, blocks IL-10 from lung Myeloid-derived suppressor cells (MDSCs), thereby, preventing lung-inflammation resolution. This inhibition by CL is through SUMOylation of PPAR α at K107 residue which alters its transcriptional activity. Leads from the ongoing research showed that CL induces a concomitant PPAR α S112 phosphorylation and reversing this phosphorylation can rescue the IL-10 suppression. Based on these observations, further investigation of the role of post-translational modifications of PPAR α in impairing IL-10 production and therefore, lung inflammation resolution during bacterial pneumonia has been undertaken.

Indian Chronic Kidney Disease (ICKD) Study-

The ICKD project has created a countrywide CKD cohort, a first of its kind initiative in developing countries. The project has enrolled >4000 patients across 11 centers across India. The project has produced multiple original research articles in international peer reviewed journals, received international recognition and is now part of iNET-CKD, an international consortium of CKD cohort studies and Global Kidney Patients Trials Network (GKPTN). In terms of finding new biomarkers, the team has demonstrated that serum catalytic iron levels are strongly and independently associated with composite major adverse kidney events in patients with CKD. This finding is completely novel, calls for validation in other populations and a more comprehensive approach for stemming the tide of CKD burden. The ICKD study data and biobank have become a national resource, open to other investigators who want to define and identify risk factors for progression of CKD in our country. ICKD Study has helped in capacity building – through training of around 20 research staff at multiple levels including PhDs and Post-Doctoral fellows. The consortium has also started 3 clinical trials using the ICKD database that will provide answers to important clinical questions

- Allopurinol for CVD in CKD (AVOID-CKD): A double blind, randomized controlled trial
- Role of Levothyroxine on progression of chronic kidney disease in subclinical hypothyroid populations: A multi-centre randomized controlled trial
- A feasibility study of SGLT2 inhibitors in slowing down the progression of CKD of uncertain etiology.

Systemic Lupus Erythematosus- This is a 10 centre pan-India project with the main objective of developing a cohort of patients with Systemic Lupus

Erythematosus (SLE) to have better understanding of this disease. Over last 4 years 2500 patients with SLE who visited the 10 hospitals were enrolled in this cohort. The median disease duration is 9 months with 70% presenting within 1 year. 14% were children and 90% are females. Skin, joint and kidney were the most common involved organ. Detailed autoantibody analysis showed that there are 4 distinct clusters which had correlation with clinical phenotype (Fig. 3.C.5). A low- cost calculator to differentiate infection from disease activity in SLE has been developed. After studying 15 markers including MRP8/14, procalcitonin, the investigators could find that just 3 variables- Age, total leucocyte count and C reactive protein done routinely in a patient with SLE gives good accuracy to separate infection from flare. The biorepository has serum, plasma, urine, and RNA samples from 257 patients and their 6 monthly longitudinal samples. Till date 48 patients' longitudinal samples have been collected for 3 years. In addition, DNA samples of nearly 2500 well phenotyped SLE patients have been collected for future genetic and epigenetic studies that can be done from our country as there is no data available from South Asia.

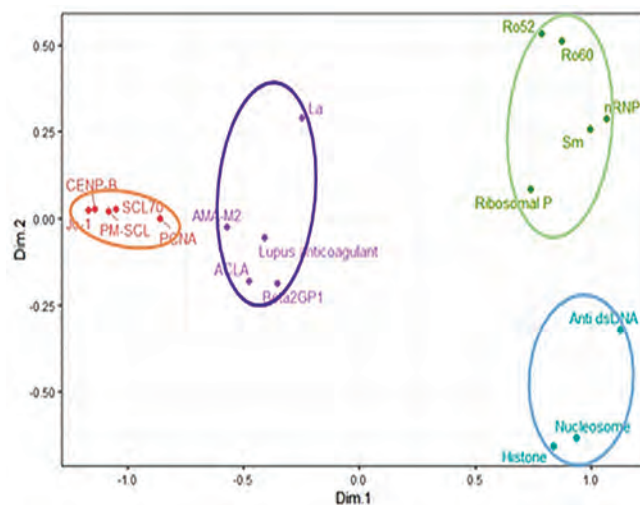


Fig. 3.C.5. Autoantibody analysis showing 4 distinct clusters having correlation with clinical phenotype

Genome Editing Applications in Healthcare

The development of genome editing technologies has opened the possibility of directly targeting and modifying genomic sequences in almost all eukaryotic cells including humans. With an aim to nurture new and innovative genome editing technologies and their applications in healthcare, the Department has been engaged in promoting research and innovation to make such technologies accessible and affordable for wider use. Efforts have been made to encourage R&D programs in emerging genome engineering technologies; development of new tools and technologies for efficient delivery of genome editing constructs for therapeutic purpose and building capacity in terms of trained manpower and establishment of platform facilities.

Significant outcomes and achievement of the programme in 2022-23

Process/Product/ Technology Developed	2
Research Publications	10
Patents Applied/ Obtained	1
Human Resources Trained	49

Research Outcomes

In a study supported at the Indian Institute of Science Education and Research (IISER), Bhopal, a robust reporter assay was developed which enables high-throughput screening of small molecules to discover those that can enhance the loss-of-function CRISPR/Cas9 gene-editing. These findings were validated in human primary T-cells by editing an important gene required for entry of HIV particles, providing proof-of-concept that a virus-resistant pool of cells can be generated with such an approach (Fig. 3.C.6)

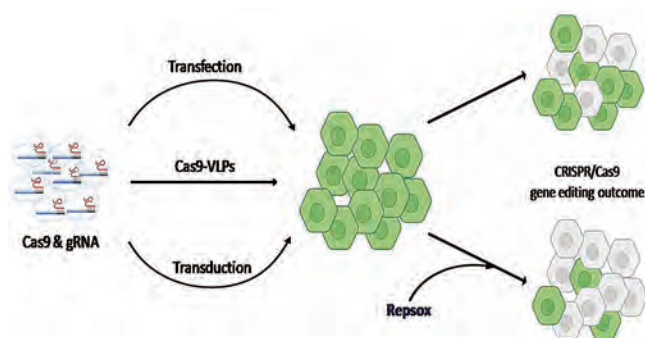


Fig. 3.C.6. Enhancing the knockout efficiency of CRISPR/ Cas9 via treatment with Repsox. Cells shown in grey are genome edited.

In another study, undertaken at the Christian Medical College (CMC), Vellore, a vitamin E-based ionizable lipid nanocarrier system was developed for delivery of genome editing tools and reagents which was more efficient, safer, and less expensive compared to that of commercially available LF 3000 transfection reagents (Fig. 3.C.7).

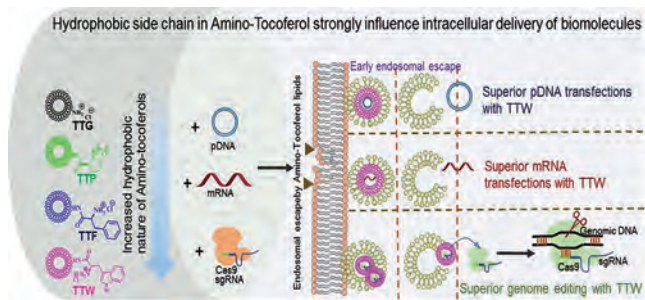


Fig. 3.C.7. Novel Vitamin-E-derived lipid nanoparticles as an efficient tool to deliver CRISPR/Cas9 reagents in cultured cell lines.

In a study undertaken at Translational Health Science and Technology Institute (THSTI), Faridabad and CSIR-Institute of Microbial Technology, Chandigarh, a strategy to harness the power of CRISPR/Cas9, for modulation of gene expression in the Tuberculosis (TB) pathogen *Mycobacterium tuberculosis* (Mtb) was developed. The CRISPRi system helped in studying as to how this pathogen regulates the level of proteins under external stimuli. Besides, the CRISPRi technology was implemented to address an

important question as to how *Mtb* adheres to host cells for invasion. In another collaborative study, it was shown using CRISPRi that *Mtb* utilizes its own amino acid biosynthesis machinery for survival in the host environment.

Genome India and Human Microbiome Initiative

Genome India-Cataloguing the genetic variations in Indian population

The pan India multi-institutional Genome India project is intended to build an exhaustive catalogue of genetic variations (common, low frequency, rare, SNPs and structural variations) and construct a reference genome and haplotype structure, by performing whole-genome sequencing (WGS) of 10,000 individuals representing the Indian

population diversity. The project is being implemented across 20 national institutions. Four institutions viz. CBR, Bengaluru, NIBMG, Kalyani, CCMB, Hyderabad & IGIB, New Delhi are involved in whole genome sequencing. So far, a total of 13803 participants have been enrolled for the study and their phenotyping, blood sampling, and biochemical investigations have been completed. The research centres across India involved in identifying the population and collecting biological samples for genetic analysis are shown in Fig. 3.C.8. Genome-wide genotyping using GSA chip is done for 8063 samples and Whole-genome sequencing (WGS) is completed for 6221 samples. Genetic variant calling has been done on 3918 samples using GATK pipeline and analysis after sequence variant calling is done for 986 samples (using DRAGEN).

The landscape of diversity among the populations

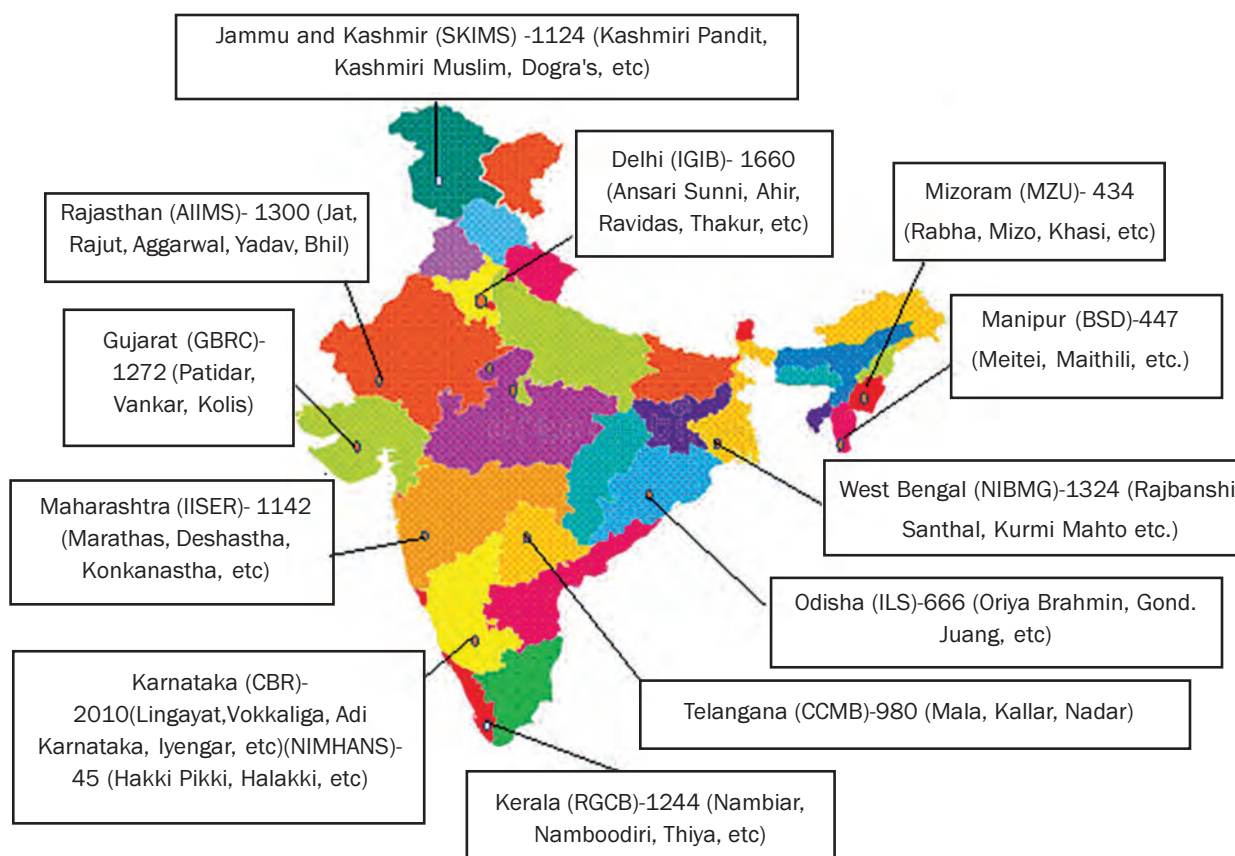
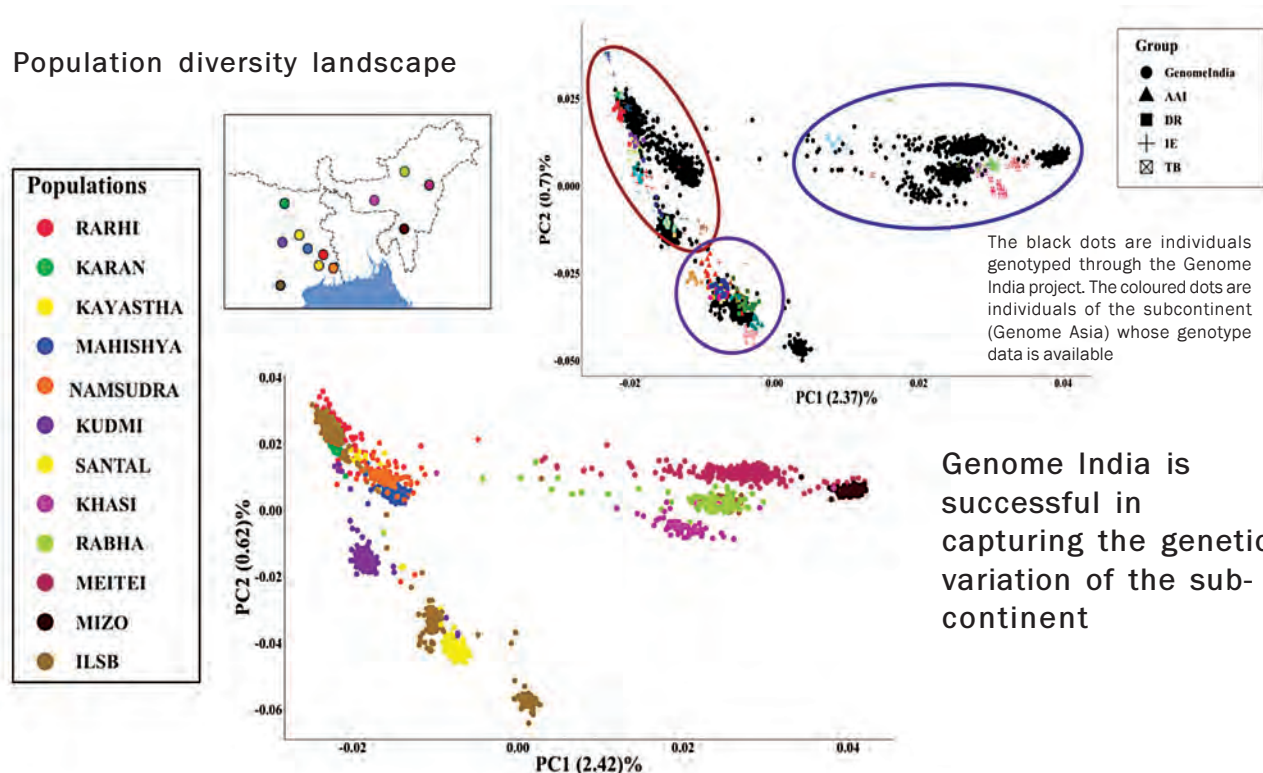


Fig. 3.C.8. Research centres across India involved in identifying the population and collecting biological samples for genetic analysis.

collected and genotyped in NIBMG is presented in Fig. 3.C.9. Populations are genetically clustered in accordance with all the known mainland ancestries. The Principal Component Analysis (PCA) reveals distinct clusters as previously reported in other scientific publications. Additionally, it spans on the entire space of genetic variation as captured by the first two principal components, revealing that the

Genome India populations have captured the diversity of the Indian populations. This is in spite of the fact that populations depicted here are only from East and North-Eastern part of India. Genetic variant calling analysis shows that about 40 million SNPs and 5 million insertions and deletions have been identified in 1011 Indian individuals by whole genome analysis at CBR, Bengaluru.

Population diversity landscape



Genome India is successful in capturing the genetic variation of the sub-continent

Principal Component Analysis (PCA) of populations genotyped in Genome India project.

Fig. 3.C.9. Principal Component Analysis of populations genotyped in Genome India project.

Human Microbiome Initiative of select endogamous populations of India

Human Microbiome Initiative is aimed to map the reference microbiome of 3400 healthy individuals across 11 non-tribal and 6 tribal communities spread across the country (Fig. 3.C.10). This multi-centric project focuses on elucidating the microbiome variation across the diverse biogeographic and dietary variations in India. The project also looks at the microbiome variations with respect to Ayurvedic Prakriti.

Significant outcomes:

- Completion of 2644 first time-point and 807 second time-point samples across the country.
- Complete microbiome profiling of 2181 subjects and partial microbiome profiling of 789 subjects has been completed.
- Diet shows highest influence on microbiome followed by ethnicity and geography.

- People with vegetarian and non-vegetarian diets have different microbiomes indicating the impact of specific diet groups on the microbiome.
- Consumption of spices, condiments and savouries play a significant role in shaping Indian human microbiome.
- Indian population shows 5

enterotypes whereas only 3 enterotypes have been noted across the world showing significant microbiome diversity in Indian population.

- Tribal communities have higher microbial diversity than non-tribal communities.
- Ayurvedic prakriti assessment of 993 subjects by Ayurvedic physicians shows high correlation with human microbiome.

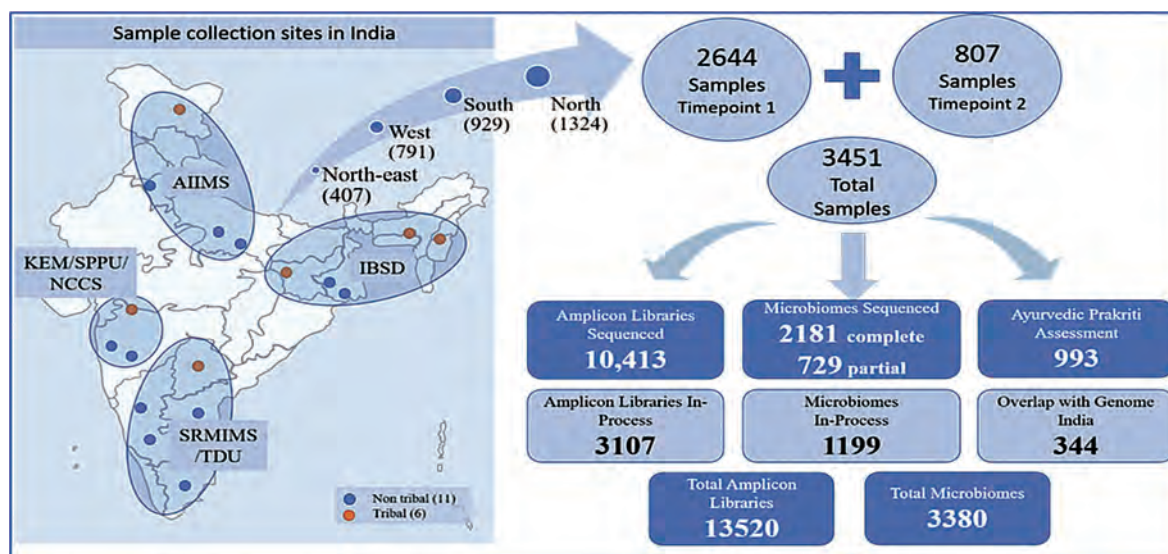


Fig. 3.C.10. Human microbiome sampling across 11 non tribal (endogamous) and 6 tribal communities was carried out by 7 participating institutes.

Human Genetics, Genome Analysis and Precision Medicine

Individual genetic makeup and variation inform the risk of disease, and can be used as a screening tool; more precisely characterize health outcomes; advise medicine selection, including treatment and therapies that may be designed to target specific disease condition. Human Genetics and Genomics program of the Department of Biotechnology (DBT) supports research and development activities across the spectrum: basic; translational and clinical research to establish how to use the genomic information to advance medical care. The diseases which have been studied under ongoing and new projects

include: pediatric rare genetic disorders, lysosomal storage disorders, Covid-19, beta thalassaemia, schizophrenia & Parkinson's disease, hemophilia, congenital nonsyndromic deafness, primary cardiomyopathies, monogenic diabetes, movement disorders etc. About 25 research publications emanated from the R&D activities supported under this program and more than 150 human resources were trained in this area. The Department has also established research platform and National Genomics Core to facilitate pursuit of biomedical genomics at the national level by opening up its core facilities of genome sequencing and analysis to universities and other national labs.

Salient scientific achievements-

Systems Biology of Complex Diseases: From Genetic Findings to Lead Molecule Development for Rheumatoid Arthritis: The main aim of the project was to provide a proof-of-concept of new identified druggable target(s), and attempt systematic drug discovery approaches. Three targets thus identified namely ARL15, BTK and MAP3K8 have been taken forward for lead molecule development. The novel class of molecules designed de novo computationally, five of which have shown excellent BTK inhibition is a notable outcome of this study.

Mission Program on Pediatric Rare Genetic

Disorders: DBT initiated this mission program spanning diagnostics, research and counselling for pediatric rare genetic disorders with the aim to analyse a total of 6000 individuals (2000 patient-parent trios) over 5 years and to identify the cause of undiagnosed genetic disease (Fig. 3.C.11). The objectives of this mission program will be achieved through a multi-faceted approach including high-throughput whole genome DNA sequencing, analysis of sequence data, functional validation of the novel genes/variants, and generation of a database of variants. Results obtained from these studies will be provided to the patients/families along with appropriate genetic counselling.

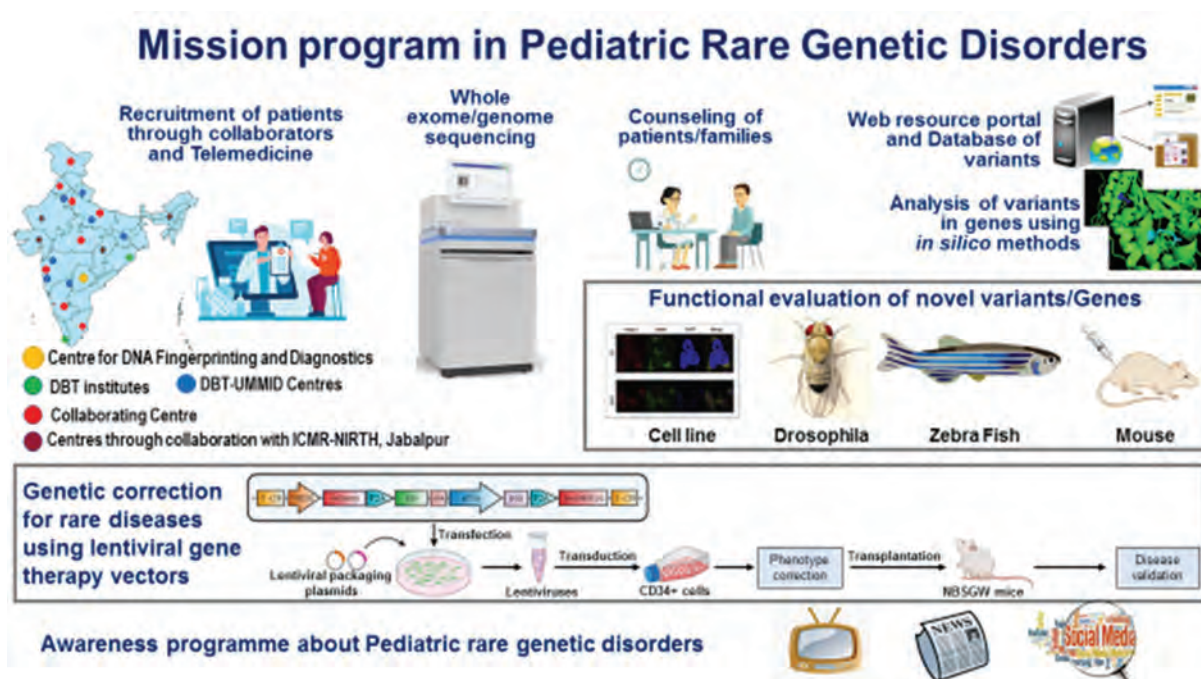


Fig. 3.C.11. Mission program in Pediatric rare genetic disorders.

Development of genomic technologies for predictive genetic health and forensic profiling: This project has led to development of next generation sequencing based assays to effectively test genetic disorders so that it can serve as a prototype for development of similar assays for other groups of genetic diseases. Investigators have validated the DNA-based markers and used the

cutting edge NGS technology in forensic casework analysis and criminal and missing persons' investigations and to effectively tackle crime against women and children in the country, especially those under the ambit of the Criminal Law (Amendment) Act, 2013 (Nirbhaya Act) and the Protection of Children from Sexual Offences Act (POCSO Act) 2012.

Comprehensive Molecular Studies in Monogenic forms of Diabetes in India: In this network study the investigators have established and utilized targeted panels for MODY & Monogenic diabetes (30 genes) and also established a comprehensive panel for Young Onset Diabetes (YODI) panel covering 62 genes in clinical settings. They have further screened 709 samples for MODY and monogenic forms of diabetes. In addition, based on the Positive Predictive Value (PPV) they screened 194 samples for the extended YODI Panel. This is one of first comprehensive collaborative efforts in India, providing the foundational data required for future studies in monogenic diabetes.

National Genomics Core: National Genomics Core is a platform to provide genomics services – genome-scale DNA and RNA sequencing, genome-wide microarrays, gene-panel assays, etc. to individuals, institutions, and the industry throughout the country. The Genomic Core facility is intended to be a facilitator of genomics-driven discovery and application, and to accelerate the ushering in of a vibrant bio-economy in our nation. The core is distributed into two centres: a central Core housed within the National Institute of Biomedical Genomics, Kalyani, with sub-cores at Centre for DNA Fingerprinting & Diagnostics (CDFD), Hyderabad. In addition, it will also function as a facility for skill development in genomics for utilization of high-throughput technologies and for storage, retrieval, computation and statistical analysis of big data. Both centres have started generating service orders. In addition, NGC-NIBMG and CDFD NGC facilities have also facilitated data generation and analysis of over

30000 SARS-Cov-2 genomes under the umbrella of INSACOG.

Consortium on Celiac Disease (CeD): In this network project, a cohort of total 628 subjects (363 CeD, 47 follow-ups, 83 controls and 135 FDRs) have been recruited and all the sample have been deposited to biorepository and stored/located via LIMS. Towards, discovery and validation of novel biomarker(s) for the detection and monitoring of enterocyte injury in patients with CeD and other small intestinal mucosal diseases, 12 signature plasma proteins were identified using Protein Atlas database as reference. Studies are also in progress with respect to genotype phenotype correlation of celiac disease in India.

Other R&D Projects: In the project on understanding the mechanistic basis of early striatal damage in Glutaric Aciduria Type-I, at Dr. Reddy's Institute of Life Sciences, Hyderabad, investigators have established true GA1 model in zebrafish using a *gcdha* knockout combined with lysine rich diet. Patterns of altered glutarylation with a potential link to the mechanism of striatal damage in GA1 have been identified (Fig. 3.C.12) In the project on designing a comprehensive diagnostic NGS panel for inherited bleeding disorders (IBD) to aid carrier screening and prenatal diagnosis at PGIMER Chandigarh, researchers identified a cohort of patients with inherited bleeding disorders through coagulation studies and platelet function studies. A panel was made for sequencing on a MiSeq sequencer. Causal variants were identified and Sanger validated. Genotype phenotype correlation was done.

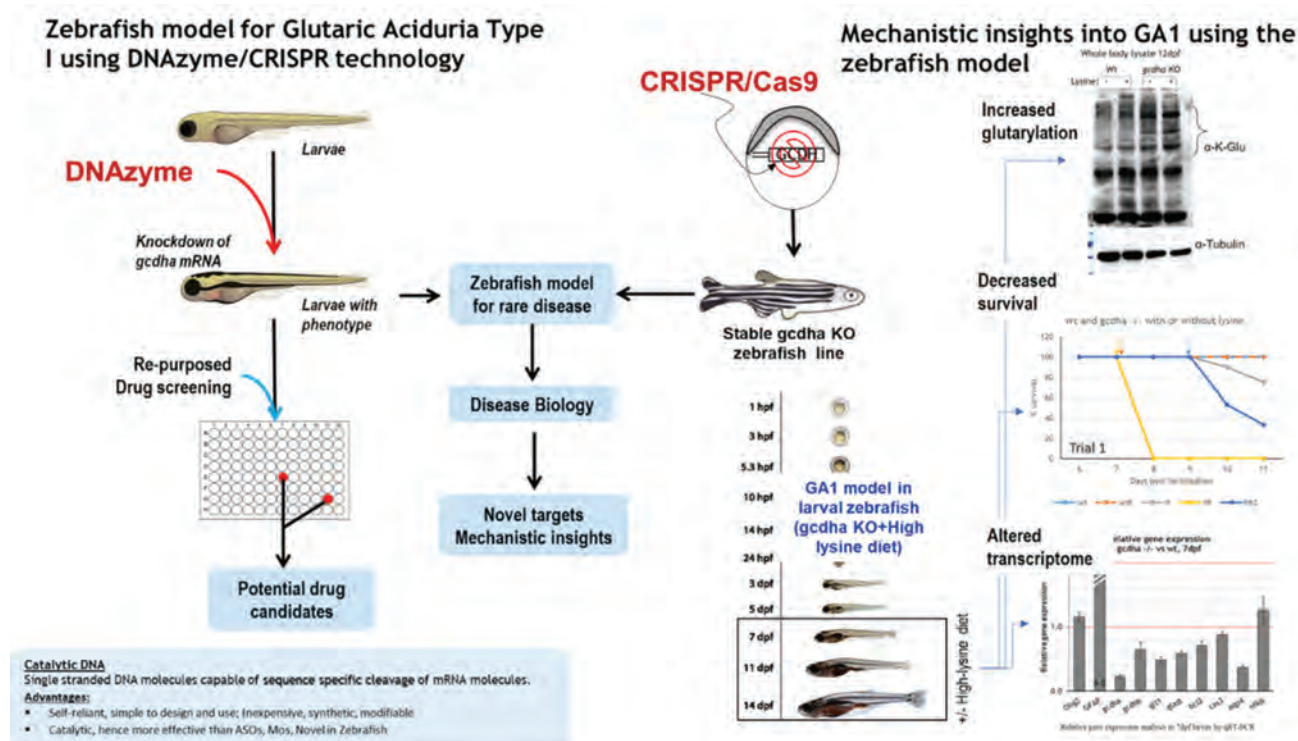


Fig. 3.C.12. This schematic illustrates the two approaches used to develop a Zebrafish GA1 model.

In a network project on Beta Thalassemia, determinants of excess alpha globin chain as a central modifier of phenotypes are being studied. Polymorphism study reveals higher percentage of dominant allele in the homozygous state for three polymorphisms but higher number of polymorphic allele for BCL11A1 rs11886868. HBG gene expression was found to be higher in patient group as compared to housekeeping gene ACTB. Thus gene fold expression for gamma globin gene was significantly higher in patient group as compared to healthy controls. In the network project on deciphering idiopathic intellectual disability (DIID) through next generation sequencing (DIID-NGS study) carried out at IIGB & AIIMS, New Delhi, investigators have identified etiology of families. Twenty-eight families harbored 32 variants pathogenic/likely pathogenic (n=18)/ variant of unknown significance (n=14) variants. Twenty-five variants were novel while 7 have been previously reported. AR ID appears to be the most common cause of ID followed by AD and X linked probably

due to higher prevalence of consanguinity (33% in this cohort). Overall, project outcomes give us meaning full insights into the various causes of ID.

Unique Methods of Management of Inherited Disorders (UMMID) Initiative

A rare disease is defined as having an incidence of less than 10 in 10000 individuals (WHO). However, more than 7000 rare diseases are currently known, and with many having no or prohibitively expensive treatments, the rare diseases group may possibly be the largest disease area of unmet need. Prevention of genetic disorders requires the establishment of a nationwide network of quality genetic testing and counselling services.

The Unique Methods of Management of Inherited Disorders (UMMID) initiative, launched in 2019, aims to provide a model framework to seed the establishment of such a network in the Government healthcare system. UMMID envisages working at three closely linked levels of medical care starting

with the establishment of diagnostic services, training of clinicians in diagnosis and management of genetic diseases, and outreach activities to propagate the services to vulnerable sections of society. The screening program primarily screens pregnant women for hemoglobinopathies such as thalassemia, sickle cell disease etc, and newborns for five major genetic disorders requiring early intervention, including congenital hypothyroidism, congenital adrenal hyperplasia, biotinidase deficiency, galactosemia, and G6PD deficiency. Under the pilot phase of the UMMID initiative, the Department has supported the establishment of 5 NIDAN Kendras

(genetic testing laboratories), 6 Training Centres, and 7 Outreach Centres for screening of pregnant women and neonates in 9 Aspirational Districts.

Outcomes and achievements

- The five NIDAN Kendras have provided screening services to more than 58,000 beneficiaries so far, and identified genetic abnormalities in over 13,000 cases, providing invaluable data for appropriate management of their conditions (Fig. 3.C.13).

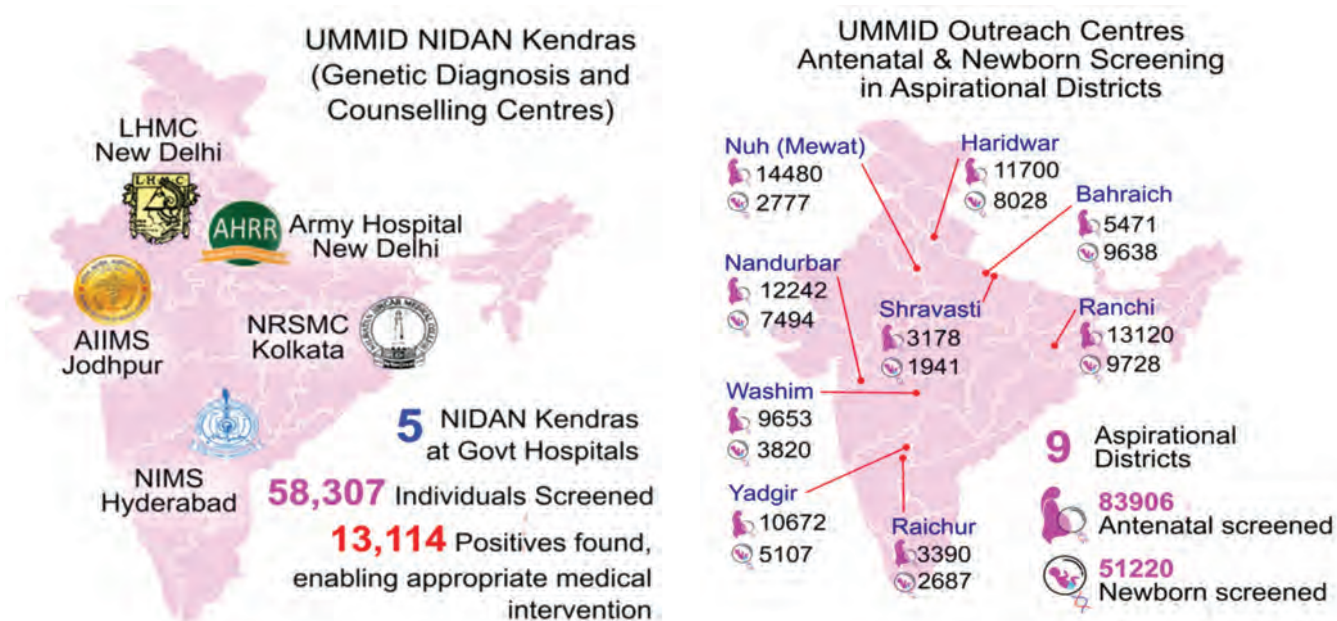


Fig. 3.C.13. UMMID NIDAN Kendras & Outreach Centres.

- The seven Outreach Centres have provided genetic screening to over 83,900 pregnant women and 51,200 newborns in nine Aspirational Districts. This helped to prevent around 34 hemoglobinopathy-affected births, and identified more than 150 carrier couples having a 1 in 4 chance of having an affected child in future. More than 350 newborns received timely diagnosis useful for enabling early treatment.
- The six Training Centres have imparted rigorous hands-on training (up to 6 months) on genetic diagnosis and counselling to 47 Government Doctors from 18 states/UTs, covering all 6 geographical zones.
- The number of screenings done and outcomes are periodically monitored and compiled at a central data repository. This data set is expected to provide valuable information, such as frequency and

distribution of particular rare diseases.

- The provision of free genetic screening services at NIDAN Kendras and aspirational districts mainly benefits the economically weaker sections of society, who are most vulnerable to the impact of inherited disorders due to lower awareness and high dependence on the public healthcare system. Mass awareness programmes regarding prevention, screening, and management of inherited disorders were routinely held at various levels including workshops, lectures, and distribution of pamphlets at high schools, nursing colleges, and primary health centres, as well as display of public hoardings.

Infectious diseases are among top 10 causes of total number of deaths in the country which is dominated by diarrheal diseases, neonatal disorders, lower respiratory infections and tuberculosis. For India as a whole, the disease burden or DALY rate for diarrhoeal diseases, iron-deficiency anaemia, and tuberculosis is 2.5 to 3.5 times higher than the average globally. Under the aegis of Infectious Disease Biology program, the Department is supporting basic and applied research to better understand and ultimately provide solutions in terms of therapeutics, diagnostics and preventive measures for infectious diseases of national and global concern such as HIV/AIDS, tuberculosis (including MDR & XDR TB), vector borne diseases; emerging or re-emerging threats such as influenza, Japanese Encephalitis; neglected tropical diseases such as Malaria, Leishmania, Dengue & AMR (Anti-Microbial Resistance).

Infectious Disease Biology

ACHIEVEMENTS- Quantitative & Qualitative indicators

No. of Research Publications during 2022-23	98	No. of Patents Applied/ Granted	Applied- 14; Granted- 3	No. of Human Resources trained	257
Process/Product/ Technology Developed	<ul style="list-style-type: none"> • 2 lead molecules (Ar5 and SMJ5) tackling AMR through efflux pump mediated combination therapy developed. • Novel antimicrobial peptides based on α-MSH designed against staphylococcal infections. • Five phage cocktails developed & tested for efficacy and safety in vitro and in- vivo. • Novel small molecule PPEF, to inhibit the growth of ESKAPE pathogens developed which shows good efficacy in in-vivo studies. • Methodology towards isolation of Indian camelid antibodies against antibacterial efflux transporters developed. • Avirulent strain of <i>Candida albicans</i> with whole-cell vaccine potential identified. 				

- Assays for biofilm formation and inhibition in *Pseudomonas aeruginosa* developed.
- 3 lead antibacterial agents and 2 combinations thereof identified.
- a single plasmid system for gene editing using CRISPR-Cas9 that incorporates all the elements required for genome editing developed
- process for synthesis of monocyclic and bicyclic iminosugars of biological relevance developed
- pediatric HIV-1 native -like trimer as a potential clade C immunogen was designed and characterized

MAJOR INITIATIVES

Dare2eraD TB

The Department has launched Data Driven Research to Eradicate TB – “Dare2eraD TB” on the occasion of World TB day (Fig. 3.C.14). This is an umbrella TB program comprising of following key initiatives- Setting up the Indian Tuberculosis Genomic Surveillance Consortium, organising Indian TB Knowledge Hub

Webinar Series, developing host directed therapies against TB and developing treatment regimens for extra-pulmonary Tuberculosis. Request for applications in the area of host directed therapies against TB was launched by the Department in 2022. Under the Indian TB Knowledge Hub Webinar Series, 8 webinars have been organised so far with participation of eminent speakers, experts from industry, academia and DBT officials.

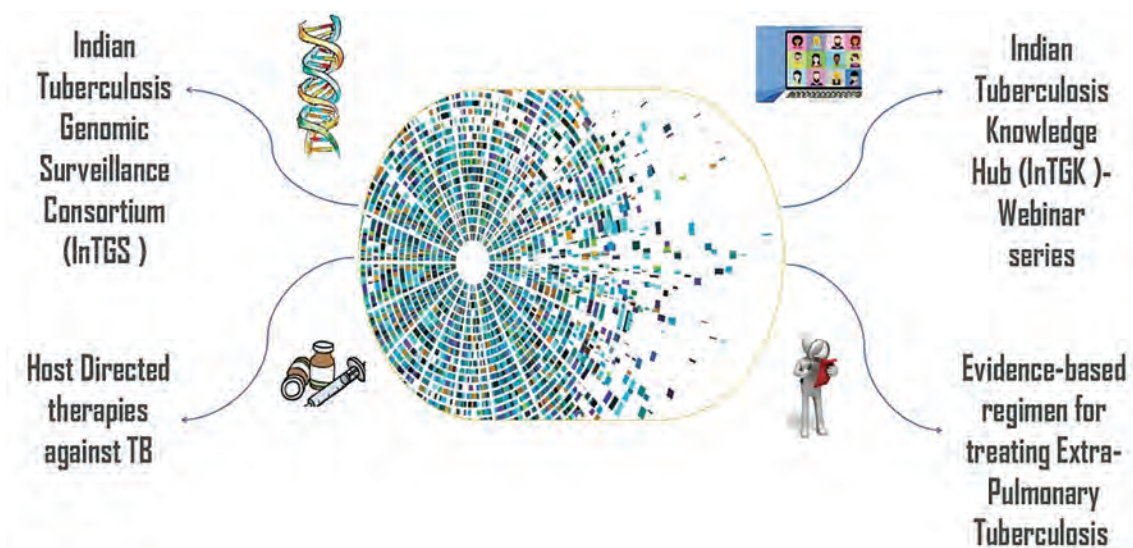


Fig. 3.C.14. Data- Driven Research to Eradicate TB- “Dare2eraD TB”.

Mission Antimicrobial Resistance (AMR)

The Department of Biotechnology in alignment with the National Action Plan on Antimicrobial Resistance (NAP-AMR) had launched an ambitious “Mission AMR”

wherein India has joined Global AMR R&D Hub; 10 projects have been supported for developing newer treatment regimens for AMR; National Centre for Microbial Resource (NCMR), National Centre of Cell

Sciences, Pune has been notified to function as a Bio-repository for resistant microbes /infective agents (Bacteria and Fungi) with deposition of nearly 1700 samples so far and Indian Priority Pathogen List has been developed working along with WHO India Office to guide research, discovery and development of new antibiotics in India.

National HIV Cohort Program

The National HIV Cohort Program is a multi-institutional collaborative program co-funded by the Department of Biotechnology (DBT), Indian Council of Medical Research (ICMR) and International AIDS Vaccine Initiative (IAVI). The aim of the project is to establish well-characterized cohorts of HIV, state-of-the-art biorepository of biological specimens and develop a national HIV/AIDS database. A network of 6 CoEs with 10 sites across India has been established. A total enrolment target of 30% has been achieved. A total of 14,423 samples vials

(serum, plasma and PBMCs) have been collected and stored in the biorepositories. Moreover, the stable version of the database at National Institute of Epidemiology (NIE), Chennai has been developed and deployed at the sites.

National Liver Disease Biobank (NLDB), ILBS, New Delhi

NLDB is a first of its kind national biobank, executed as a joint initiative of Department of Biotechnology (DBT) and Institute of Liver & Biliary Sciences (ILBS) for translational research in liver and allied diseases. NLDB is first biobank in India certified by CTR.Net, CANADA and accredited by ISO 20387:2018. It is contributing to three forthcoming biobanks at (i) ICMR (ii) AIIMS and (iii) NBRC. Biobank at ILBS provided 8198 NGS, 6510 Mass Spectrometry and 3526 cell sorting and 8200 animal pathology services. NLDB collected 25000 samples and shared 8772 biosamples in 2022 (Fig. 3.C.15).

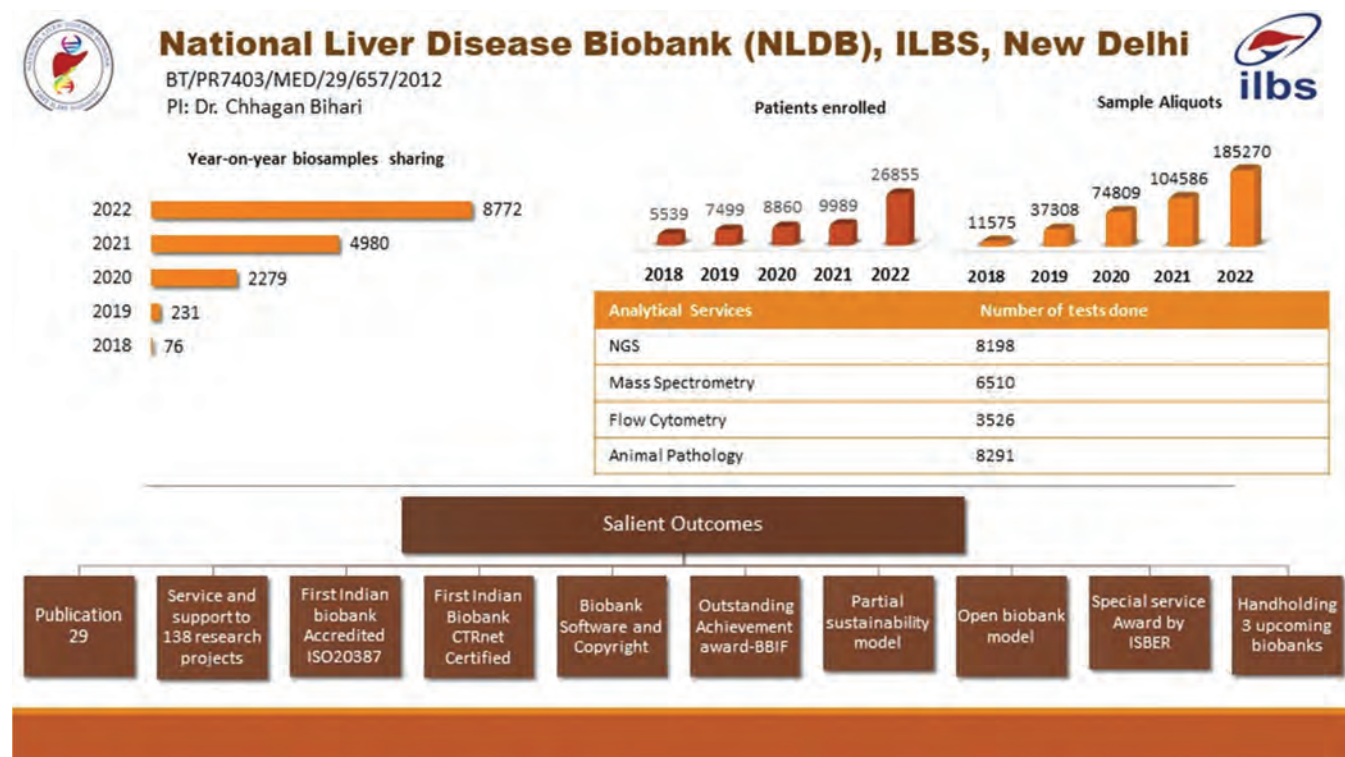


Fig. 3.C.15. National Liver Disease Biobank, ILBS, N. Delhi.

R&D Efforts

a) Centers of Excellence- DBT-supported “Centre of Excellence (CoE) on Antibody Technology Research for therapeutic and diagnostic application” at UDSC-CIIDRET has developed novel phage display-based platform for immunization-free antibody discovery.

This invention has been granted Indian patent & the technology is being employed for the discovery of therapeutic antibodies for COVID-19. This technology could also be used to obtain therapeutic antibodies against other infectious organisms such as Nipah virus, Zika virus and for treatment of snakebite and cancer (Fig. 3.C.16).

An effort to make India self-reliant (Atmanirbhar) for Therapeutic Antibody Discovery

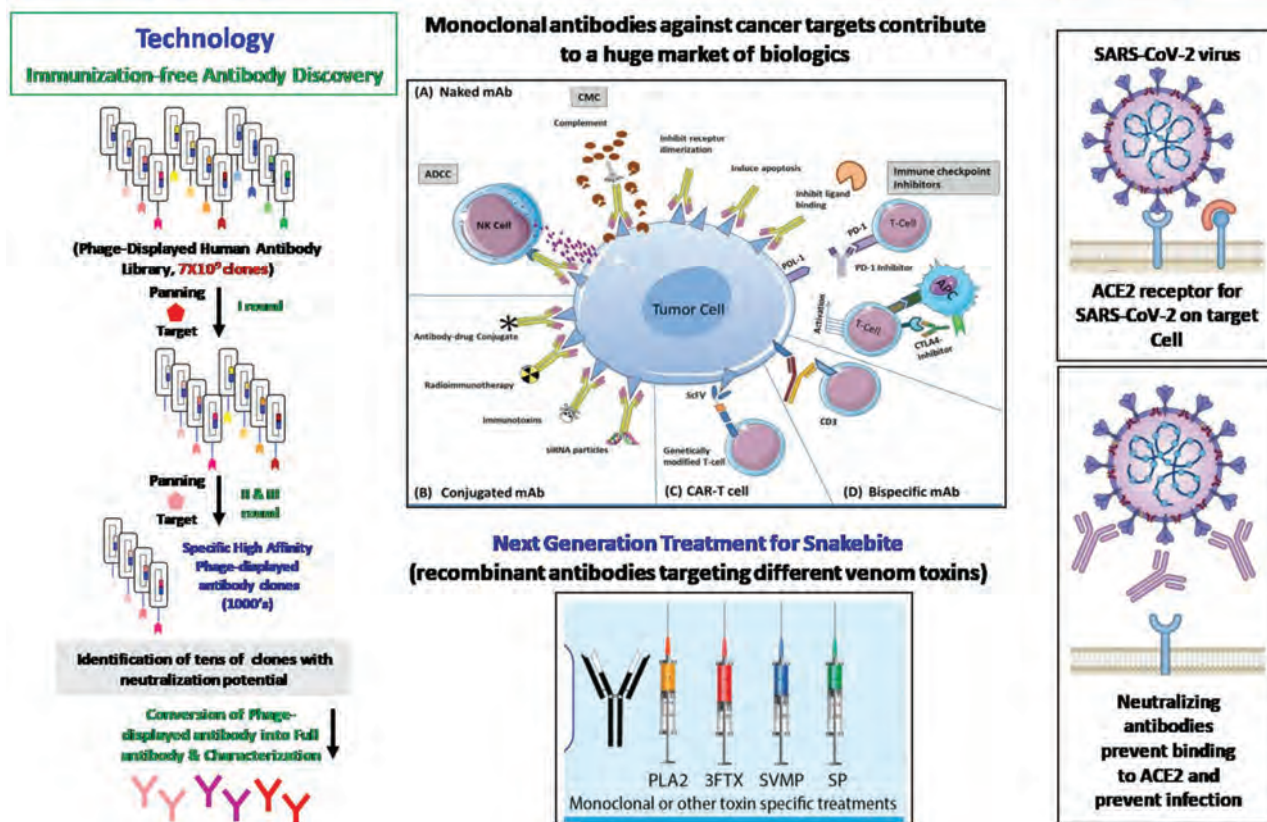


Fig. 3.C.16. Centre of Excellence (CoE) on Antibody Technology Research for therapeutic and diagnostic application.

Investigators from NCCS, Pune and University of Hyderabad in a DBT funded CoE project on Biomolecular Structure and Function on Host-Pathogen Interactions have characterized molecular interactions between different proteins of M.tb, HIV and the human host to gain insights into the host-pathogen dynamics. They have determined structure of Mycobacterium Ribonucleotide reductase (RNR) ternary complex via cryo-electron microscopy.

b) R&D efforts to study disease biology of protozoan pathogens – Investigators at ICGB, Delhi have biochemically-characterized compounds against the target enzymes Lysyl-tRNA synthetase (KRS), Prolyl-tRNA synthetase (PRS), Phenylalanyl-tRNA synthetase (FRS) and Dihydropteroate synthase (HPPK-DHPS) of *Plasmodium falciparum*. Investigators at ILS, Bhubaneswar for the first time have shown that artemisinin-induced ER stress leads to increased expression of the autophagy proteins

in *P. falciparum*. Scientists from NIAB, Hyderabad have identified novel immunodominant antigens and tested their potential for the diagnosis of *Toxoplasma* infection.

c) **R&D efforts to study disease biology of bacterial and fungal pathogens-** Research supported at RCB, Faridabad has for the first time shown a bacterial membrane targeting amphiphile that can mitigate Vancomycin-resistant Enterococci infections and inhibit emergence of vancomycin resistance. Research group at IISc Bangalore has resolved the cryoEM structure of a major antibacterial efflux transporter, QacA that is involved in Staphylococcal antimicrobial resistance. In a project supported at CDFD, Hyderabad it has been shown that Rv1168c (PPE17) can be used as a potential sero diagnostic antigen to detect patients with active and latent TB infection as well as PCR based diagnosis. Research group at Hinduja Hospital, Mumbai, in collaboration with South African counterparts have developed LCMS methods for second line TB drugs plasma levels. In a study at CDFD, Hyderabad, core histones H2A and H2B have been shown to be required for virulence of the human opportunistic fungal pathogen *Candida glabrata*. In a project supported at IMTECH, Chandigarh a novel mechanism of induction of autophagy by hydrogen sulphide has been established.

d) **R&D efforts to study disease biology of viral pathogens-** Investigators from ILBS, Delhi have developed a novel method for isolation, fractionation, and quantification of bacterial vesicles (BVs) from stool and urine samples of autoimmune hepatitis (AIH) patients. ILS, Bhubaneswar has discovered an E3 ligase as novel regulator of anti-viral immunity in HBV infection. Researchers from RGC and NIIST have synthesized three new classes of nojirimycin analogues having antiviral properties against DENV. Scientists at IIT Bombay have developed a method

for gene knockout/replacement for/to Mimivirus and Marseille virus in *Acanthamoeba castellanii* cells to understand the role of unique genes found in Mimiviruses. Scientists at AIIMS Delhi have generated an HIV-1 clade C based native like trimer, from an HIV-1 infected pediatric elite neutralizer. The trimer demonstrated binding to HIV-1 neutralizing antibodies and elicited protective anti-HIV-1 antibodies in rabbits.

Nanotechnology Applications in Healthcare

The Department of Biotechnology has been engaged in promoting research and innovation in the area of nanotechnology application in healthcare to develop new generation of diagnostic and therapeutic modalities for important diseases. Major thrust areas include development of new therapeutics and targeted drug delivery vehicles; enhancing efficacy of existing drugs; diagnostics for early disease detection and imaging; design and development of smart-nanomaterial for medical applications, tissue engineering, bio separation & nano-sensors for detection of chemicals and pathogens.

Major Achievements in 2022-23-

Research Publications	15
Patents Applied/ Obtained	3
Human Resources Trained	< 52
Other Achievement	Based on the technologies developed at DBT-inStem, a spin-off company, Sepio Health Pvt. Ltd. has been formed in Bangalore.

R& D efforts:

In a study supported at Amrita Centre for Nanosciences and Molecular Medicine, AIMS, Kochi an innovative nano-medicine product- Albumin-Sorafenib (ABSORF) was developed for the

treatment of liver cancer, renal cancer and leukemia (Fig. 3.C.17). ABSORF was nano-engineered with mucopenetrating and mucoadhesive layers which provided protection from the gastric environment, improved intestinal absorption and enhanced oral bioavailability of Sorafenib by 2-3 fold. In a project implemented at Indian Institute of Science, Bangalore researchers have developed magnetically-driven nano-motors to probe the microenvironment of cancer using a 3D tumour model. The model comprises both healthy and cancer cells embedded within a reconstituted basement membrane matrix, and mimic the breast cancer environment. In a study supported at inStem Bengaluru, a product has been developed which minimizes exposure to toxic pesticides through skin contact and inhalation, during the spraying of pesticides. This is of relevance to the health of the farming community. In a multi institutional study carried out at JNCASR, Bangalore, TIFR, Mumbai and CSIR-IICT, Hyderabad self-fluorescent, cell permeable glucose derived carbon nanospheres were developed as a brain targeting vehicle having implications in drug delivery and imaging for Alzheimer's disease. In a study undertaken at INST Mohali, the team has demonstrated magnetic nanoparticle (MNP)-mediated hyperthermia-induced antimicrobial therapy. The therapeutic efficacy of the MNPs to induce bacterial death with AMF alone was confirmed *ex vivo* using infected tissues. Proposed antibiotic-free approach for killing bacteria using intracellular MNPs is likely to evolve as a promising strategy to combat a wide range of bacterial infections.

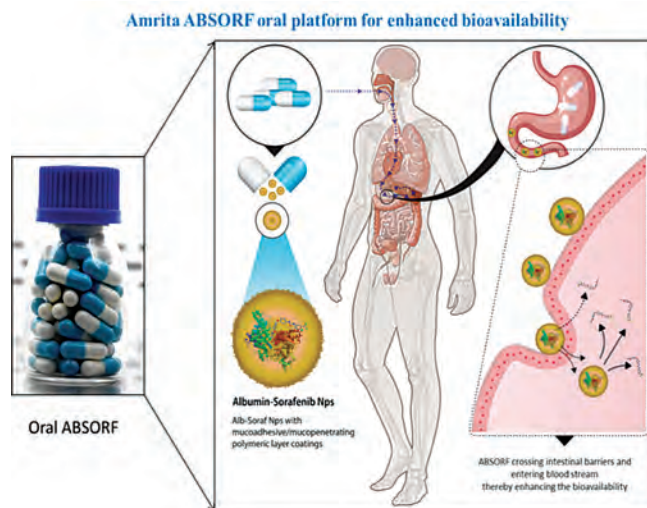


Fig. 3.C.17. Albumin based platform nanotechnology for enhancing the oral bioavailability of small molecule drugs such as Sorafenib, for anti-cancer applications.

The Department is also supporting a program 'Catalyzing research in nanobiotechnology: Essential concepts and hands-on modules in nanofabrication and characterization techniques for biologists and medical professionals' at Indian Institute of Science, Bangalore.

National Biopharma Mission

The National Biopharma Mission (NBM), is a government-industry-academia collaboration dedicated to 'Accelerating Discovery Research to Early Development for Biopharmaceuticals', funded at a total cost of INR 1500 Cr co-funded by the World Bank at 50% cost sharing. NBM's charter is being implemented by Biotechnology Research Assistance Council (BIRAC), a Public Sector Undertaking, set up by the Department of Biotechnology (DBT). Under this program there are 8 identifiable components namely: Vaccines, Biotherapeutics, Devices and Diagnostics, shared facilities, clinical trial networks, technology transfer offices, training and scientific research programs which are financially supported (Fig. 3.C.18).

NBM Interventions			IMPACT
Products	Biotherapeutics	Developing products closer to market and affordable	
	Vaccines	Developing Vaccines for public health, closer to market	70 projects supported in 3 verticals, 10 in clinical trials
	Medical Devices	Promoting Indigenously developed devices	
Ecosystem Strengthening	Shared Facilities	Bridge Infrastructural Gaps for early stage through Accessible and Regulatory Compliant Service Facilities	23 facilities >200 users of shared facilities
	Translational research consortia	Spurring product oriented research by building a pipeline of products	HTS Assays, Biorepository, Animal models established
	Clinical Trial Network (CTN)	Building Clinical Capacities for accelerated product development	46 GCP compliant trial sites
	Skill Development	Generating mass of critical talent to support product development	6747 people trained
	Tech Transfer Offices (TTOs)	Strengthen bio-cluster ecosystem and enhance translation capacities	7 TTOS supported, 14 term sheets executed

Fig. 3.C.18. National Biopharma Mission.

The achievements under various activities supported under NBM are enumerated below:

1. Shared Facilities: Facilities have been set up to provide end-to-end services catering to the needs

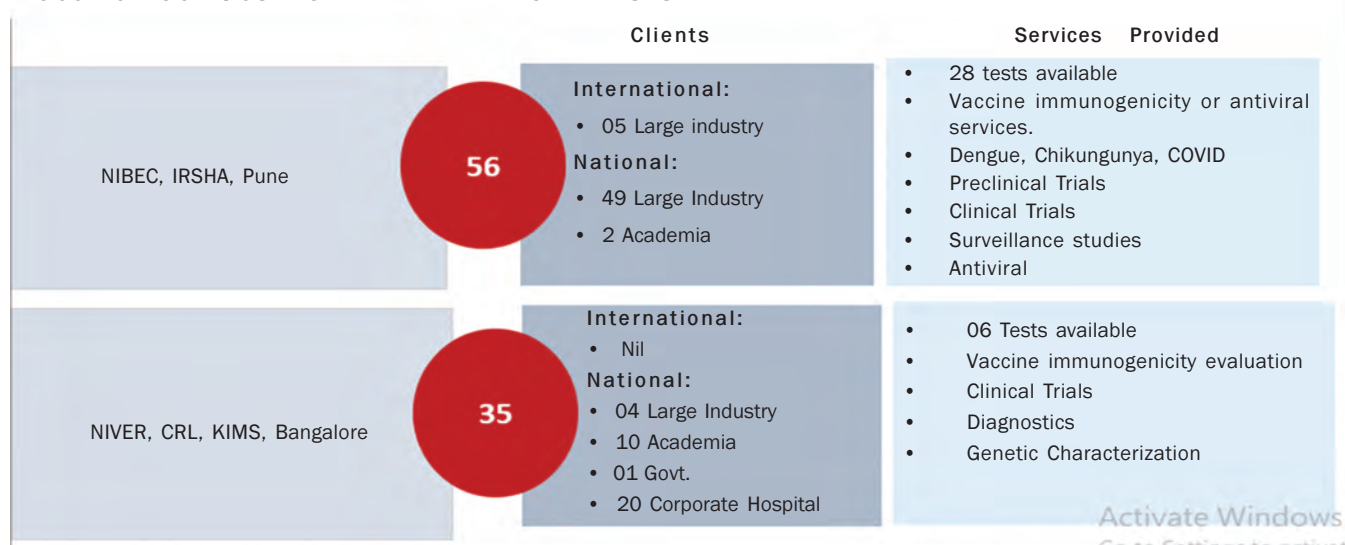
of the expanding biotherapeutics, devices and vaccine market. 14 of the 23 supported facilities under vaccines, devices and biotherapeutics are actively providing services details of which are given below.

Biologics Facilities 76 DIFFERENT CLIENTS SERVED

CGMP Accredited Shilpa Biologicals Pvt Ltd, Karnataka (Process Development and cGMP Manufacturing)	9	2 International 4 Large Indian Vaccine Companies 2 startup, 1 academia	<ul style="list-style-type: none"> Commercial lot of vaccines (Sputnik, ZyCoV D) Scale-up and generation of clinical trial batches of biosimilars Generation of MCB and WCB
GLP Compliant Syngene, Centre for Advanced Protein Studies, Bangalore (GLP Analytical Characterization)	44	27 International, 10 domestic large pharma clients and 7 start-ups	Biologics advanced characterization Services GLP studies and Regulatory dossier submissions
Entrepreneurship Development Centre, Pune (GLP Analytical Characterization)	13	13 Indian clients including Large industry, start-ups/academia	Biologics advanced characterization Services
CSIR-Indian Institute of Chemical Technology, IICT, Hyderabad	10	10 Indian clients	

M.J. Biopharma Ltd. (cGMP) and Gennova Pharmaceuticals facilities are providing services for process development

Vaccine Facilities - 91 DIFFERENT CLIENTS SERVED



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Devices 89 Different clients served

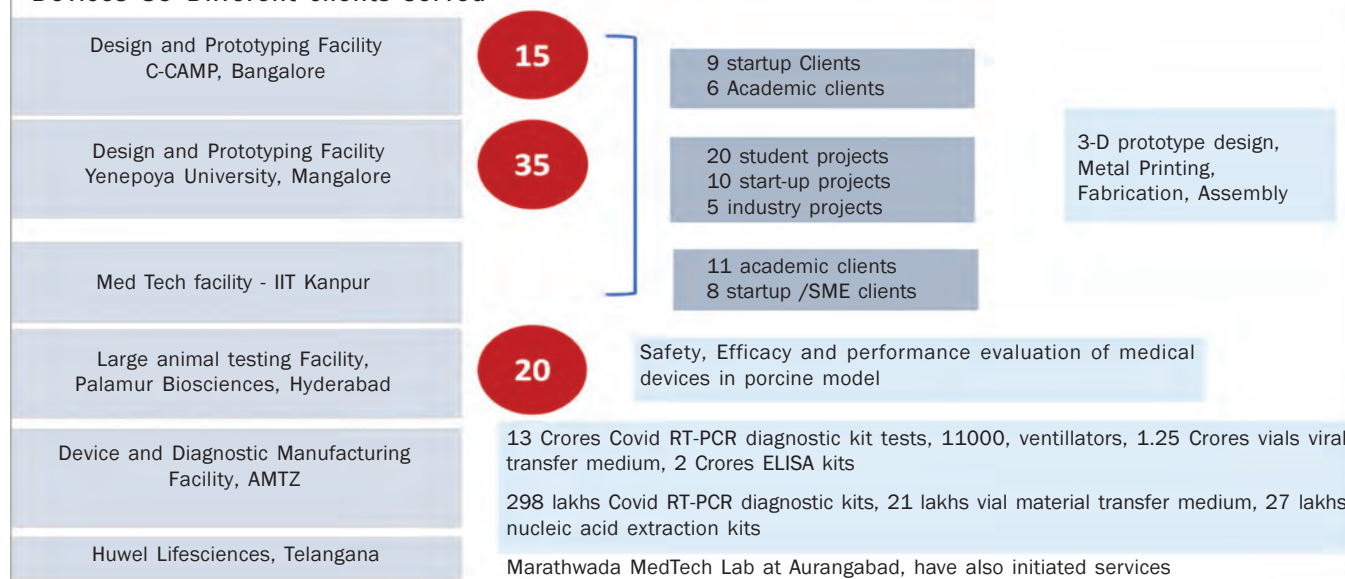


Fig. 3.C.19. Shared Facilities created under National Biopharma Mission.

2. Scientific Research- Under the broader aim of technologies for efficient and affordable processing to provide tools for product development, NBM has supported projects in early development and translation.

- Under the Hepatitis E virus consortium project, Hepatitis E vaccine candidate developed by Zydus Lifesciences Ltd completed Phase I clinical trial and DCGI approval has been

received for conducting Phase II/II trials in 304 subjects. The 3 clinical sites, SGPGI Lucknow, JIPMER and IICB Kolkata have harmonized the protocols for assessment of the humoral and cell mediated immunity generated by the vaccine candidate.

- The Translational Research Consortia for Dengue and Chikungunya have established serum biobanks, virus repositories with

sequenced and characterized isolates of Dengue and Chikungunya. The consortia have established assays ready for transfer to industry/ academia and disease models as fee for service.

- Lab Iconics LLP has launched the lite version of their LIMS- Laboratory Information Management System software in the market.

3. Clinical Trial Networks- i3 program is supporting the establishment of Clinical Trial Networks (CTN) and Strengthening Clinical Trial Capacity in the country.

- For strengthening the capacity of vaccine clinical trials via seroepidemiological studies for COVID, dengue and chikungunya, Eleven (11) GCP compliant Field Sites with access to more than 5,00,000 healthy population cohorts with harmonized SOPs and protocols and e-data management tools have been prepared. At 5 DHS sites across the country, serosurvey of COVID, Dengue and Chikungunya has been completed with ~ 1,00,000 population. Further testing (ELISAs and PRNTs) are currently ongoing. The data has been captured through the SOMAARTH platform.
- The clinical trial networks of 36 hospital sites have established disease Registries including but not limited to Common Cancers (Oncology network), Rheumatoid Arthritis, Psoriasis, Spondylarthritis (Rheumatology network), common ophthalmic diseases like age related macular degeneration, retinal vein occlusion (Ophthalmology network), Type -1 and Type - 2 Diabetes (Diabetes Network). The networks together have a patient Registry database of 41,212 population, with approximately 12,000 in Diabetes, 14,000 in Oncology, 8,000 in Rheumatology and 5,000 in ophthalmology.

4. Technology Transfer Offices: To set the tone

for an efficient technology transfer network in the country and fostering the translational research from academia, 7 TTOs were supported. These TTOs are working in association with the Sathguru management consultancy for coordination of policies. Workshop for Technology Transfer Offices (TTOs) was conducted in Hyderabad on 25th-26th April 2022. The workshop saw 31 participants including 14 female participants.

5. Products :

- A. Vaccines:** The vaccine component is focused on accelerating vaccine development for complex, emerging and high-priority infections in India. Currently 13 vaccine candidates for Flu, Cholera, Dengue, Pneumonia, and COVID, under different stages of development are being supported under the Mission.
- B. Biotherapeutics:** The Mission supports therapeutic proteins and monoclonal antibodies (mAbs) that are currently under development by the industry with an aim to bring them closer to market. About 11 mAbs which are not presently existing in Indian market and three (03) clones for diseases like cancer, diabetes, psoriatic arthritis, and wet macular degeneration are being supported. One CAR-T therapy and 05 therapeutic products for COVID-19 are also supported under this category.
- C. Medical devices & diagnostics:** With a view to reduce import dependency, improve affordability and increase the innovation quotient, the Mission is supporting development of products in the areas of hospital-use equipment, diagnostic imaging, implants, wound-care products etc. Many diagnostic devices and reagents used for diagnostic kits are also supported including Molecular diagnostics, ELISA, LFT, sample transport reagents etc. Currently 17 devices and 12 diagnostics are being supported.

Updates from Products

- Biosimilar Aflibercept of Lupin Ltd. received approval from DCGI for conduct of Phase III Clinical trial for Age related Macular degeneration.
- Liraglutide biosimilar by Levim Biotech LLP has initiated Phase 3 trials where 256 subjects have been recruited.
- Clone development projects by Enzene Biosciences Limited (Ramucirumab) and GenNext Genomics Limited (Golimumab) have been successfully completed.
- Pneumococcal vaccine candidate successfully completed the Stage-1 (Phase I/II CT) and is currently being supported for Phase III CT. 3+0 study is completed and the data has been submitted to DCGI for review and market authorization. Additionally, the grantee will soon initiate the 2+1 schedule clinical trial.
- For Chikungunya vaccine candidate, trial initiated in September 2021 and the enrollment completed (with 599 participants) in September 2022. Second DSMB was completed on 9th June 2022. Immunogenicity analysis is currently ongoing.
- Recruitment of patients for clinical trial of heart valves initiated by TTK Healthcare Ltd. Implantation is completed in 17 patients.
- Advanced Multi spectral Flexible Video Endoscope, a next generation, 4K+, 60 fps flexible video endoscopy system with multi spectral imaging and intelligent image fusion techniques for multi modal tissue visualization for improved diagnosis, set up by Health Care Technology Innovation Center at IIT Madras.

6. **Trainings-** Hands-on training programme on Bioprocessing at CoE, IIT Delhi was conducted between 20th-24th June 2022. The training had 04

modules and was attended by 58 participants including 29 female participants.

Neurobiology

Neurobiology is a multidisciplinary science that involves studying of structure and function of the nervous system for understanding the behavioural, cognitive and development aspects of the nervous system. The Department is supporting projects designed to understand the nervous system and its disorders or pathogenesis at the cellular & molecular level, development of neurological tools & techniques, supporting cohort studies in major neurological disorders and to build platforms for advancing the technological competency in the area.

Brief of Major initiatives taken

- A population based cohort study was supported to study the known as well as novel determinants (genetic, socio-economic, lifestyle and environmental factors) of stroke and cognitive function, and to examine unique Indian determinants as well as their consistency and variation among the Indian population. In this study it was found that hypertension is the most prevalent risk factor for stroke among the participants followed by diabetes mellitus and obesity.
- A multi-institutional 'Dementia Science Programme' was supported with the aim to estimate prevalence and incidence of Dementia in the country. Under the programme an Illiterate ICMR-Neurocognitive Toolbox has been developed. This illiterate ICMR-NCTB consists of tests from the domains of attention and executive function, episodic memory, language and Visuo-spatial test.
- A 'Collaborative Neuro-Engineering Platform for Excellence in Innovation and Translational Research' was supported under which three patents have been filed on Endoscopic

Endonasal Transsphenoidal Surgery Trainer (Fig. 3.C.20), 3D Tracking and Navigation Simulator

for Neuro-Endoscopy and Surgeon Specific Three-Dimensional Printed Protective Eye Gear with Prescription Glasses.

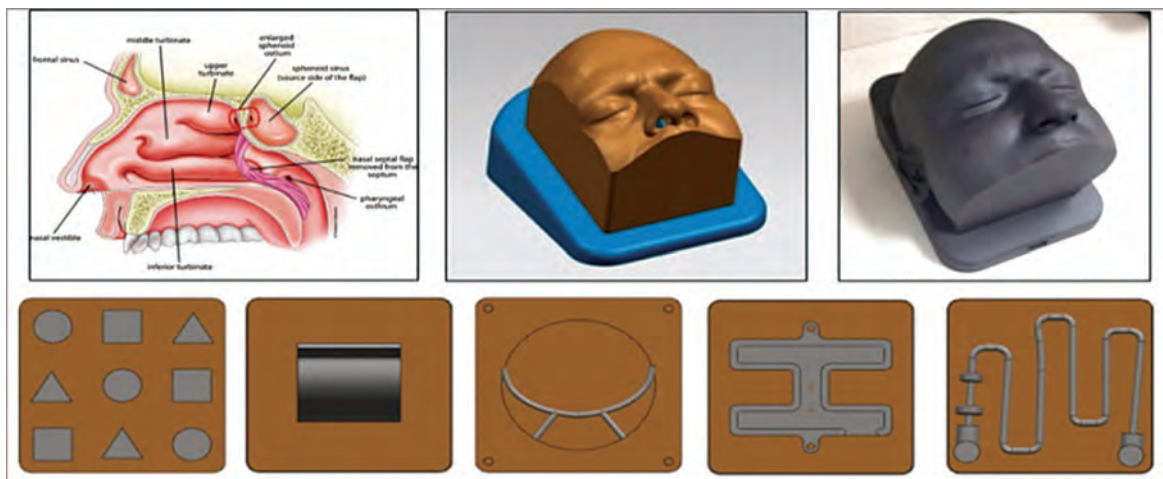


Fig. 3.C.20. Endoscopic Endonasal Transsphenoidal Surgery Trainer with Integrated Sensor based Evaluation of Surgical Skills

- Other R & D projects- In a study on exploring the role of hypertension in Parkinson's disease (PD) it was demonstrated that enhancing ACE2 activity could be a novel approach for ameliorating PD pathology. In another project, studying the molecular genetics of intracellular calcium signaling in neurons, a cell line has been patented which can be used to identify therapeutic targets for neuro-degeneration where intracellular Ca^{2+} signaling is affected.
- The Department also issued a call for submission of letter of intent in Neuroscience where Lols have been received in the diverse areas of neurobiology (brain function and its disorders, development of neurological tools & techniques, platforms for advancing technological competency, therapeutics, diagnostics, imaging technology, and biomarker discovery/validation for neurological disorders, learning, plasticity and aging). The Lols received are being screened.

New Drug Development and Biogenics

New Drug Development and Biogenics programme

of the Department of Biotechnology was initiated to foster R&D for new and cost-effective therapies directed towards improved health outcomes. The programme currently is focused on development of drugs from existing leads with established proof-of-concept; lead optimization; preclinical development and clinical therapeutic validation of lead molecules; for TB and Cancer. Few important projects being supported include: shortening TB therapy duration using chloroquine; investigating DZNepA (a methyl transferase inhibitor) as a therapeutic drug candidate for breast cancer; Pre-clinical development of CPMD-1049 targeting *Mycobacterium tuberculosis*, Development of specific single domain antibodies (sdAbs) against AMR Mastitis pathogens in dairy animals; development of therapeutic broadly neutralizing monoclonal antibodies against HIV & identification of novel therapeutic monoclonal antibodies against MDR and XDR *Klebsiella pneumoniae*.

The Department also supported a 'CoE in Biopharmaceutical Technologies', at IIT Delhi, which enabled creation of state-of-the-art, end-to-end continuous process infrastructure and platform for production of both microbial and mammalian derived

recombinant proteins. Notable achievements of this CoE project are: development of PAT interface using Near-Infrared spectroscopy and other available tools for upstream production process using *E. coli* and CHO cells; evaluation of different tools as PAT based controls for downstream processes for production of recombinant therapeutic products; establishment of a platform for analytical characterization of therapeutics and biosimilars; development of a novel continuous processing platform for the biosimilar Trastuzumab. More than 100 high quality publications, creation of IP portfolio (>10 patents filed), industry engagement (20+ industrial partnerships), have emerged from the project.

Public Health Nutrition

The vision of Public Health Nutrition is to develop technological and evidence based solutions for nutrition related problems like malnutrition, anemia, stunting etc. R&D is supported in areas of addressal of micro & macro nutrient deficiencies through development of fortified foods, health care products/ nutraceuticals/dietary food supplements; probiotics for holistic health; addressal of celiac diseases; addressal of vitamin B₁₂ deficiency; nutri-epigenomics; post-harvest processing and value addition; food safety & allergenicity, shelf life extension of perishable foods etc. For formulation of national nutrition policy technical recommendations are given to MoHFW and MWCD through Scientific Sub-Committee (SSC – NTBN) under the National Technical Board on Nutrition (NTBN). A call for proposals was issued on the Nutritional strategies for prevention and treatment of intra-individual double burden of anthropometric under-nutrition and metabolic over nutrition.

Major Achievements in 2022-23-

Research Publications	10
Human Resources Trained	42
Process/Product/ Technology Developed	6

R&D efforts-

Non-destructive process technology for simultaneous micronutrient fortification and bioavailability enhancement in dal through selective binding of phytic acid. Nutrient bioavailability in dal is hindered by the presence of phytic acid that is indigenous to Dal itself. Using combined hydrothermal and modified atmosphere treatments, process technology and process machinery for simultaneous phytic acid reduction and micronutrient fortification in pulses was developed.

Human milk oligosaccharides (HMOs) are complex sugars present in breast milk which have functional roles in infant development starting from establishment of gut microbiome and immune system to its maturation. Researchers from NABI Mohali and GBU Ahmedabad have cloned two enzymes that can synthesize initial building block of the HMOs, RtGH94 (CDP) and BpGH94 and are being used for HMOs synthesis. A novel enzyme from *B. product* has been identified and it is being used to add GlcNAc to glucose present in a HMO backbone. Studies are being undertaken to test whether the synthesized and fucosylated HMOs can promote growth of probiotics.

Grain Fe and Zn content study in wheat: Modern wheat varieties are generally poor in essential nutrients including grain protein and micronutrients like grain iron (GFe) and grain zinc (GZn). In total, 11 meta-QTLs (MQTLs) including nine novel MQTLs for GFe and GZn contents were identified in wheat. As many as 101 candidate genes (CGs) underlying MQTLs were also identified that may be utilized in marker-assisted selection (MAS) for improvement of GFe/GZn contents and also for understanding the molecular basis of GFe/GZn homeostasis in wheat. After multi-location evaluation, the high iron and zinc wheat genotype, EU-60, Far-1, and Far-4 were identified. For marker development and gene identification for high iron

and zinc, two different F2 population were developed in wheat.

Molecular mechanisms mediated by vitamin D signalling on skeletal muscle function were elucidated using vitamin D receptor ko mice (*vdr*^{-/-}) which exhibited normal growth during suckling stage, but showed severe growth retardation, bone deformation and skeletal muscle atrophy upon shift to chow. In the presence of a carbohydrate enriched diet, the skeletal muscles of *vdr*^{-/-} exhibited abnormal glycogen accumulation which led to energy deprivation and concomitant increase in AMPK activity (Fig. 3.C.21). Further, circumventing the carbohydrate utilization defect by weaning the pups to milk fat enriched diets led to the alleviation of metabolic and proteostasis defects and restored growth and muscle mass in *vdr*^{-/-} mice without fully restoring the serum calcium levels. The data revealed that vitamin D signalling plays an essential role in metabolic adaptation of mammals to a carbohydrate rich diet upon weaning by optimizing glucose utilization in skeletal muscles.

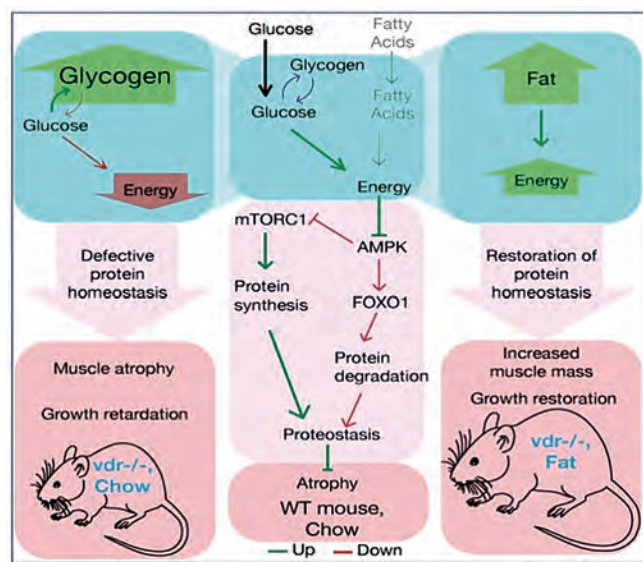


Fig. 3.C.21. Vitamin D signalling on skeletal muscle function.

A simple microfluidic diagnostic chip for rapid and sensitive evaluation of Vitamin D

deficiency was developed. An electrochemical based strip grafted with a nanomaterial was fabricated with a limit of detection of 1.9ng/ml. The nanomaterial exhibited the ability to oxidize the vitamin D3 selectively in presence of other competing analytes (in binary mixtures and in complex sample like plasma). The nanomaterial was found to be stable up to 11 months (tested period) and VD3 was selectively detected in human plasma.

Stem Cells & Regenerative Medicine

Stem cells & regenerative medicine has been identified as one of the thrust areas by the Department keeping in view its potential in therapeutic applications. DBT is supporting basic biology research, early and late translational research, developing gene editing technology for possible therapeutic applications, creation of animal models for various human diseases. In addition, DBT is also engaged in formulation of regulatory framework for stem cell research with stakeholders, including ICMR and also capacity building through trainings and workshops.

Significant outcomes and achievements

No. of Research Publications	20
No. of Human Resources trained	96
No. of Patents Applied/ Granted	5
Process/ Product/ Technology Developed <ul style="list-style-type: none"> • Hi-C technology to capture chromatin interactome and developed pipeline for the data analysis. • Gene edited hematopoietic stem and progenitor cells for B-hemoglobinopathies gene therapy • A method for base editing to correct structural haemoglobin variant HbE and other major beta-thalassemia point mutations 	

- New plasmid construct that expresses the toxic protein PEEL-1 which facilitates efficient selection of animals carrying the integrated transgene.
- Culture system for Preferential expansion of human CD34⁺CD133⁺CD90⁺ hematopoietic stem cells

Basic Research- Basic research focuses on understanding the mechanisms of stemness and differentiation of stem cells. A study conducted at SGPGIMS, Lucknow has shown that the exosomes from BM-MSC of Aplastic Anemia (AA) patients significantly impair the functions of umbilical cord blood-derived CD34⁺ HSC by reducing their proliferation and differentiation and elevating apoptosis. In another study, initial results by a team from RGCB, Thiruvananthapuram showed that excessively rigid microenvironments around neural stem cells (NSCs) leads to loss of caveolae. Mass spectrometry assisted proteomic analysis identified high SUMO2 expression in caveolae depleted NSCs. This identified SUMO2 as the ECM rigidity and redox-driven master regulator of GBM growth, hence act as a promising anti-GBM drug target. Researchers from IIT, Madras employed *C. elegans* germline stem cells (GSC) as a model system to investigate the self-renewal vs differentiation balance in adult stem cell systems in a whole-organism context. Through an RNAi screen of 439 potential common targets of PUF-8 and MEX-3 (conserved RNA-binding proteins that promote GSC proliferation), they identified seven genes that may mediate the effect of these two RBPs on GSC proliferation. They have also developed a new method that considerably improves existing method for transgenesis in *C. elegans* (Fig. 3.C.22).

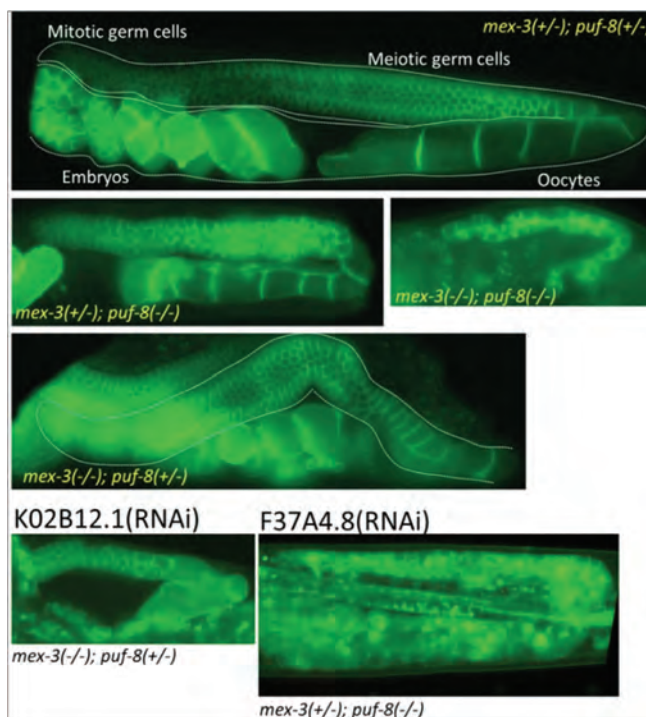


Fig. 3.C.22. RNA mediated depletion of K02B12.1 and F37A4.8 disrupt germ cell development.

Preclinical Research- To establish safety and efficacy of stem cells for potential therapeutic applications for various human diseases, concept proposals have been invited for generating animal models to study the same. As organoids and tissues differentiated from stem cells are promising resource for disease modeling, drug screening and regenerative medicine, researchers were encouraged to submit concept notes that use organoids and stem cell-based pipelines as standards for drug screening, disease modeling, etc. Through an ongoing effort at RCB, Faridabad it was observed that Myosin heavy chains (MyHC)-embryonic is important in adult muscle function, where its absence leads to congenital diseases such as spondylocarpotarsal synostosis (SCTS). Translational research being conducted at CSCR, CMC Vellore, revealed a combination of small molecules i.e. Resveratrol, UM729 and SR1 that preferentially expands CD34⁺CD133⁺CD90⁺ Hematopoietic stem cells (HSCs) over other subpopulations of adult

Hematopoietic Stem and Progenitor Cell (HSPCs) in ex-vivo culture which enhances the adhesion and results in a 6-fold increase in the long-term engraftment in NOD SCID gamma (NSG) mice. The culture enriched HSCs are more responsive to gene modification by lentiviral transduction and gene editing, increasing the frequency of gene-modified HSCs up to 10-fold *in-vivo*. These high frequency of gene-modified HSCs are crucial for the success of HSPC gene therapy.

Clinical Research- A multi-institutional collaborative project focusing on major disorders in Brain and Blood has been implemented at NIMHANS, inStem, NCBS and CSCSR CMC, Vellore. The study conducted at NIMHANS, Bengaluru focusing on Brain disorder have established a cohort of large dense families with major psychiatric disorders namely Addiction, Bipolar Disorder, Schizophrenia, Obsessive-compulsive disorder and Dementia. Among 7346 families screened, the team has recruited 2300 and 1277 individuals for brief and deep assessment, respectively. This clinical cohort currently has 10 pairs of twins from multiplex families with more than one affected individual which will be a useful resource for examining heritability in clinical, epidemiological, and genetic studies. Using blood samples from these patients, a total of 100 human iPSC lines have been generated and deposited at inStem, Bengaluru. Also, 20 Neural Stem Cell (NSC) lines have been generated from the above collection of hiPSC lines. At NCBS, Bengaluru an *in-vitro* “disease in the dish” model to study neuro developmental disorder has been developed which allows studying neural cell development through activity imaging and electrophysiology.

In a major thrust, the team of researchers from Centre for Stem Cell Research (CSCR), CMC Vellore has received regulatory approval from Central Drugs Standard Control Organisation (CDSCO) for conducting Phase I clinical trial in India for gene therapy of hemophilia A. The first subject recruited has been

infused with the final drug product manufactured at CSCSR, GMP facility. In another study, after completion of proof-of-concept studies for AAV vector-based gene therapy for haemophilia B, the research team is working towards establishing an industry partnership for this AAV3-hFIX vector production in India. Lentiviral vectors created at CSCSR, CMC Vellore for both, gene (beta globin and gamma globin genes) addition as well as enhancement of HbF production through shRNA based modulation of Bcl11 (a transcription factor), for treatment of beta-globinopathies with proof-of-concept studies completed in suitable *in-vivo* models.

The Department is also supporting control & management program in Odisha focusing on major haemoglobin disorders, sickle cell anaemia and thalassemia. Two major field components of this program are, to increase awareness (using all forms of media) on major haemoglobin disorders along with comprehensive testing of the population at risk for carrier status with a single blood sample right up to genetic diagnosis and provide training to healthcare workers for improved diagnosis and treatment. This is the first comprehensive program from screening and diagnosis (including prenatal diagnosis) combined with an extensive behaviour change and communications campaign. The team has established novel MALDITOF-based automated technology for diagnosis of haemoglobin variants through globin chain analysis. For outreach activity, hoardings, wall paintings, leaflets, banners, calendars and posters have been printed/installed. 310 doctors have been trained on clinical management, also programmatic training given for 3150 Antenatal women (ANMs), 68 laboratory technicians and 68 counsellors and administrative staff. ASHA orientation program completed in 6 districts with 8783 ASHA workers trained. Another translational aspect in which this research team is working is haplobanking of HLA-homozygous iPSCs. So far 15 GMP cell lines have been produced with the help of National and International co-operation.

Vaccine Research and Development

Vaccines are one of the most cost-effective health interventions for combating infectious diseases. Hence, vaccine R&D is one of the thrust areas of DBT, whereby, concerted efforts, have been made over the past three decades, to build a robust vaccine R&D ecosystem, through both national and international efforts. A multi-pronged strategy of building human capacities; enabling industry linkages through innovative funding mechanisms; strengthening infrastructural capabilities; forging international partnerships; was adopted to foster new and advanced candidate vaccine development. Key supported areas include: Candidate vaccine development for which earlier leads are available; pre-clinical and clinical vaccine development; research on human immunology of infectious diseases; strengthening vaccine development for epidemic preparedness.

Major national mission programmes such as NBM, Ind-CEPI Mission and Mission COVID Suraksha, were implemented to strengthen industry-academia linkages and early translation and commercialization of the lead products.

Outcomes and achievements of the program: These programmes have enabled strengthening of clinical trial sites, setting up of immunoassay laboratories, animal challenge facilities, development of harmonized protocols and enhancing manufacturing capabilities, thereby, fostering a conducive end-to-end vaccine development ecosystem. As an outcome of these efforts, nearly fifteen vaccine candidates for diseases such as Dengue, TB, Chikungunya, Influenza, Pneumococcal Disease, Cholera, Malaria and COVID-19, are in various stages of development. Development of India's 1st indigenous qHPV vaccine against cervical cancer (Cervavac) was supported which has received market authorization. Further, four COVID-19 vaccines supported under Mission COVID Suraksha, received EUA.

The Ind-CEPI Mission, enabled support for development and generation of clinical trial material of inactivated viral vaccine candidate (BBV87) for Chikungunya, by BBIL. Under the GCCDP, Phase II/III clinical trials are underway by BBIL, India and IVI, Korea, in 5 countries: Colombia, Costa Rica, Thailand, Guatemala, Panama (Fig. 3.C.23). Further, the Ind-CEPI mission is facilitating support for development and implementation of QMS in the immunogenicity laboratories and facilities for animal challenge studies for achieving ISO/IEC 17025:2017 and GLP certification, respectively, by national accreditation bodies (Fig. 3.C.24).

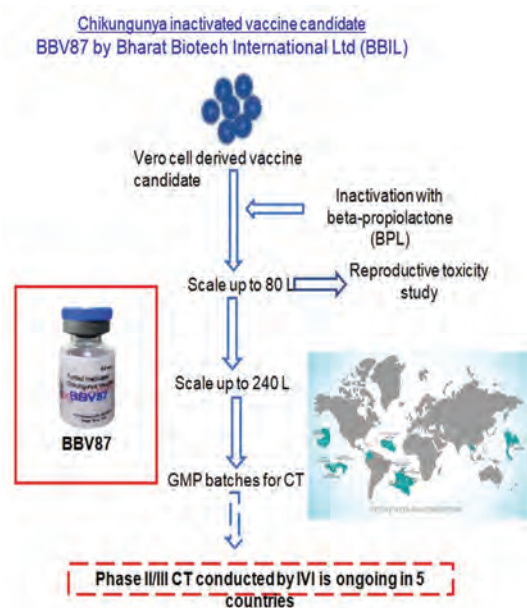


Fig. 3.C.23. Inactivated viral vaccine candidate (BBV87) for Chikungunya.

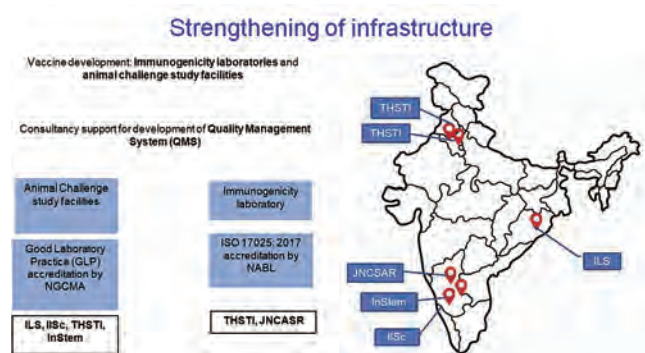


Fig. 3.C.24. Support for development of QMS under Ind-CEPI.

Researchers at BHU have reported development of a novel adjuvantation method that can potentially increase the protective efficacy of the existing parasitic vaccines, against virulent *L. donovani* parasites. The researchers have identified that *Leishmania* induces the expression of two inhibitory receptors i.e., CD200 and CD300a on the surface of immune cells to dampen their effector properties and promote its own survival and proliferation. Another study reported two different mechanisms mediating RNA sensing of viruses and the induction of anti-viral pathways and the cytokines, viz., novel anti-bacterial and anti-viral role of a GTPase Rnd1; DNA sensor molecule IFI-16 and its role in triggering the innate immune response against the RNA viruses. These have potential for development of vaccines against Dengue Virus (an RNA virus).

Indo-U.S. Vaccine Action Programme (VAP)

The Indo-U.S. Vaccine Action Program (VAP) is a bilateral program, under implementation since 1987, with an aim to support: novel vaccine research, human immunology, vaccine-related technologies, translational research, and other activities of shared scientific interest supported jointly by both sides (Fig. 3.C.25). This is a unique bilateral program implemented by the Department of Biotechnology (DBT) and the Indian Council of Medical Research (ICMR), of the Government of India on the Indian side, in collaboration with the National Institute of Allergy and Infectious Diseases (NIAID), National Institutes of Health (NIH), on the US side. Major achievements of the VAP include research, development, and deployment of India's first indigenous vaccine ROTAVAC against the rotavirus which is now part of India's Universal Immunization Program. The adjuvant used in Bharat Biotech's COVID-19 vaccine COVAXIN was funded exclusively by the NIAID Adjuvant Development Program and accessed by Bharat Biotech through VAP-sponsored interactions. The program has taken major strides toward the development of vaccines for diseases

like dengue, tuberculosis, influenza, malaria and COVID-19.

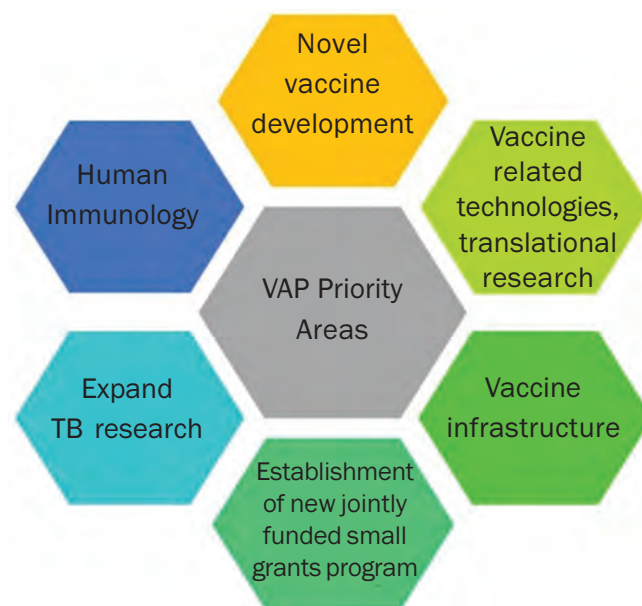


Fig. 3.C.25. VAP Priority Areas.

Major initiatives under Indo-US VAP

1. RePORT-India (Regional Prospective Observational Research on Tuberculosis)- The Regional Prospective Observational Research in Tuberculosis (RePORT) India initiative has been under implementation since 2013 with a focus on the establishment of a TB consortium with pan-India representation, involving long term longitudinal cohorts of TB patients and their household contacts in India. Basic and applied research for development of newer diagnostics and identification of novel improved biomarkers for targeted therapy are being conducted under the RePORT India initiative. RePORT India is the first multidisciplinary, multi-institutional clinical and translational TB research consortium for India, whereby nine clinical research sites are being supported. A central biorepository is being supported at NIRT, Chennai. RePORT India common protocol Phase II involves overarching aims to evaluate and discover newer TB diagnostics for identifying diverse states of TB infection, markers of treatment response, lung injury and resistance/acquisition of

TB infection. Following the completion of training sessions in October 2021, study enrolment was initiated on December 13, 2021. By January 2022, study enrolments were initiated in all three cohorts among eight of the nine sites. About 25% (n=371) diagnostic cohort, 30% (177) Cohort A and 15% (n=116) Cohort B participants have been enrolled

so far. Samples including blood, saliva, urine, stool, sputum (raw, treated and M.tb isolates) are being collected for performing local evaluations and aim specific assays as well as for storage in the biorepository. A dedicated data coordination centre was established at JIPMER for centralized sample and data management. Key achievements of RePORT India initiative are highlighted in Fig. 3.C.26.

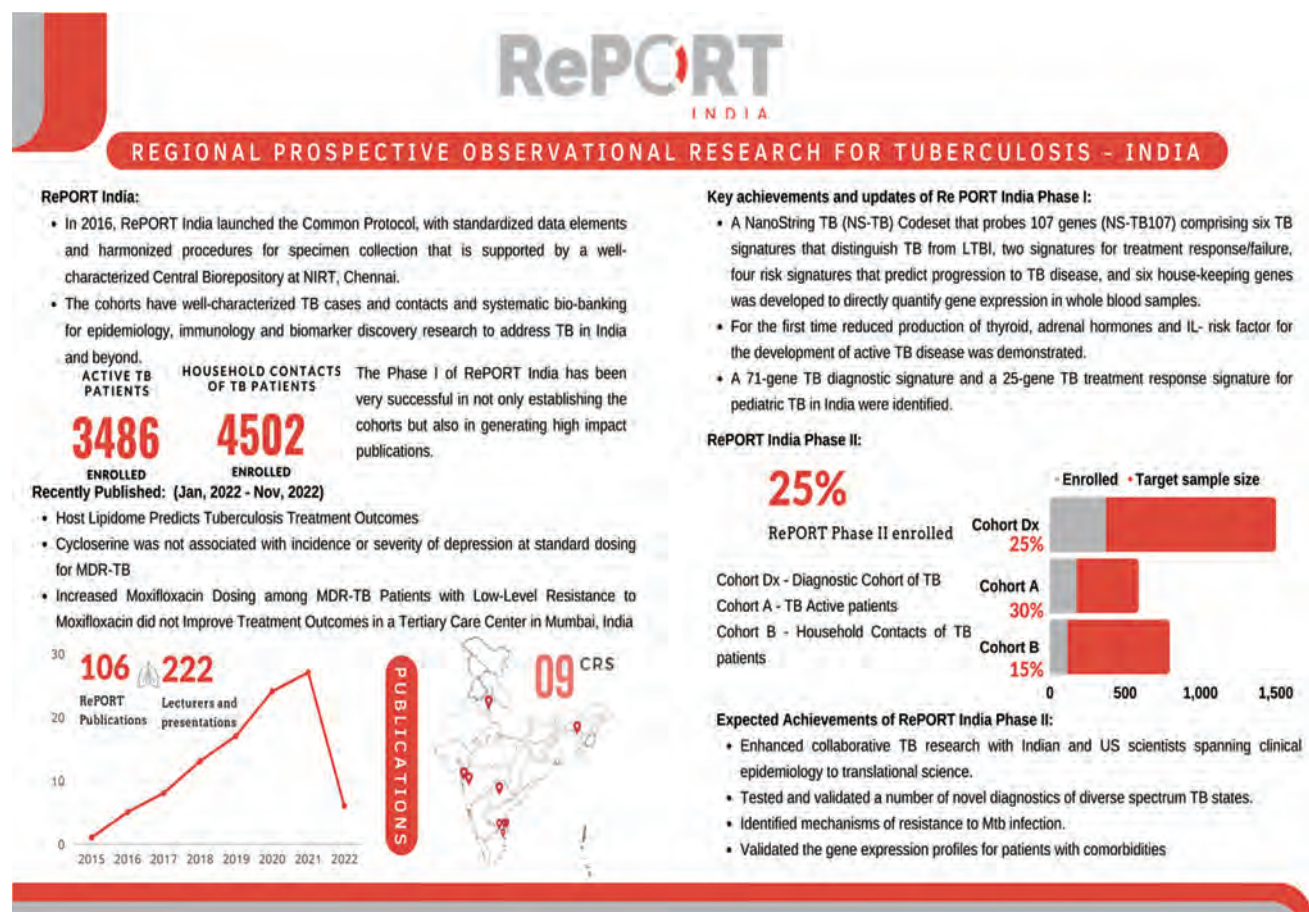


Fig. 3.C.26. Key achievements of RePORT India.

2. Candidate Vaccine Advisory Committee- Established in 2016 under the aegis of Indo-U.S. Vaccine Action Program (VAP), the Candidate Vaccine Advisory Committee (CVAC) provides recommendations to VAP leadership concerning the technical aspects of research and development (R&D) related to vaccine candidates approaching readiness for clinical trials in India. The Department

organized the 5th Meeting of the Candidate Vaccine Advisory Committee (CVAC) on 23rd -24th September, 2022 at the National Institute of Immunology, New Delhi. Vaccine candidates for Tuberculosis, COVID-19, Influenza and Dengue were reviewed. The meeting was attended by DBT officials, vaccine researchers, policy experts from India and U.S. and participants from Indian industry.

3. Human Immunology Programme in collaboration with Human Immunology Project Consortium (HIPC) - The Human Immunology Project Consortium (HIPC) program was established in 2010 by NIAID. The goal of this program is to promote collaborative research between Indian and U.S.-based HIPC investigators to conduct human phenotyping in the context of infectious diseases or vaccines of public health importance to both the U.S. and India. DBT and NIAID sponsored two funding

opportunities under this collaboration, first in 2013 and the second in 2018. Five awards were made in each cycle. The outcomes of the HIPC awards have been shown in Fig. 3.C.27. The 34th VAP JWG business meeting held on 11-12th October, 2022 at NIH, US recommended renewal of the program. The meeting was attended by experts and the policy makers from India and US, Co-Chaired by the Secretary, DBT from the Indian side.

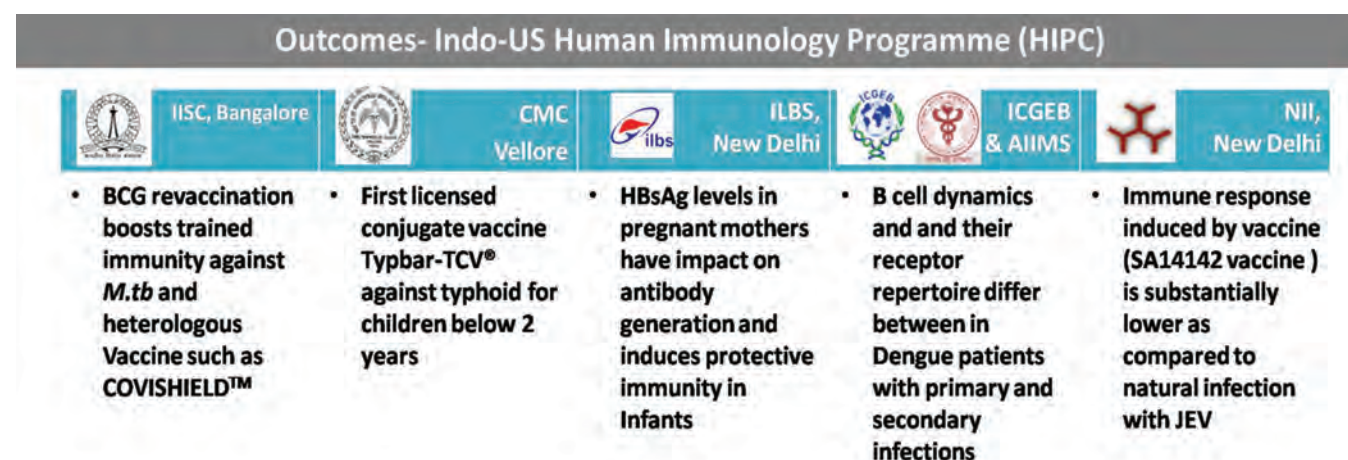


Fig. 3.C.27. Outcomes of projects supported in collaboration with HIPC consortia.

4. Vaccine Adjuvant Development Program - In August 2019, DBT issued a joint funding opportunity announcement with NIAID for collaborative adjuvant research projects to bring together researchers in India and the US. Four R&D projects were selected for funding. The pathogens for which vaccines with novel adjuvants are being developed are MTb, Respiratory Syncytial Virus (RSV), Flaviviruses, and Foot-and-Mouth Disease. Kikkeri *et al* have synthesized a series of toll-like receptor 4 and 2 agonists derived from glycosaminoglycans structures and evaluated their activity in dengue *in vivo* mice model. They have discovered a novel heparinoid adjuvant for vaccine development against DENV. Researchers from THSTI have established assay platforms and animal models for RSV research.

5. Initiative on Bioethics - The Department of Bioethics of the US NIH Clinical Center in

collaboration with DBT initiated the Bioethics program as per recommendation of 31st JWG meeting in November, 2019. An RFA soliciting proposals for the Indo-U.S. Clinical Research Ethics Fellowship was advertised in current year.

Woman and Child Health Programme

In order to advance research and scientific knowledge in the areas of unmet societal health needs, programmes have been supported on aspects of woman's health from menarche to menopause including reproductive biology, pregnancy complications, placental biology, mechanistic paradigm governing the outcomes of pregnancy, osteoporosis, autoimmune disorders specific to women. In the area of child health, projects have been supported on congenital anomalies including congenital heart diseases (CHDs), diseases of

neonatal period and early childhood as well as developmental disorders.

Major programs and achievements

GARBH-Ini: Inter disciplinary Group for Advanced Research on Birth outcomes -DBT India Initiative- An inter-institutional and interdisciplinary programme was established by the Department of Biotechnology 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 to reduce the associated morbidity and mortality. Under this program, a cohort of pregnant women known as the GARBH-Ini Cohort was established at the Civil Hospital in Gurugram, Haryana, India. Over 10,000 women have been enrolled within 20 weeks of gestation and are followed until delivery and once post-partum. A birth cohort has also been initiated in the second phase to study growth and development in different phenotypes of preterm birth, small for gestational age and low birth weight as compared to the normal babies. The study has provided some valuable insights:

- In the cohort, the frequency of preterm birth has been found to be 13%, with high rates of other adverse birth outcomes.
- In addition to the well-known risk factors like prior PTB, short Inter-pregnancy (IP) interval and short cervix at 3rd trimester, some less reported factors such as biomass fuel use and passive smoking as risk factors of preterm birth have been identified. A U-shaped association has been found for BMI at enrolment with both underweight and overweight/obese women having a higher risk of PTB.
- Gestational weight gain and fetal growth charts which describe the longitudinal growth and allows comparison with the global standards have been generated for the first time in India.

- Indian population specific dating models have been developed with improved accuracy over the commonly used Hadlock formula which is based on the Caucasian population. Initial leads have been obtained in dynamic risk prediction models (using clinical & imaging markers) for preterm birth to help clinical decision making. These are being externally validated.
- Models have also been developed for automated detection of fetal body parts, biometry measurement and gestational age estimation. These models are also being validated in external cohorts. The ultrasound image-based pregnancy dating tools are about 40% more accurate than the currently used biometry-based models in external validation studies.

Healthy Life Trajectories Initiative (HeLTI): Early Interventions to Support Trajectories for Healthy Life in India (EINSTEIN) - The Healthy Life Trajectories Initiative (HeLTI) was launched as a joint initiative between Canada, India, China and South Africa in collaboration with the World Health Organization to address the increasing burden of Non-Communicable Diseases (NCDs) – including obesity, diabetes, and cardiovascular disease. In the Indian part of the study set in rural Mysore called HeLTI EINSTEIN (Early Interventions to Support Trajectories for Healthy Life in India), women of reproductive age were to receive a longitudinal multi-faceted intervention comprising of multiple micronutrients; a group parenting program; hygiene and infection prevention measures; and reduction of environmental pollution exposure. So far, ~2200 participants have been recruited and baseline data collected on ~1900 recruits. Biospecimens have been collected on ~900 women pre-conceptionally and ~275 during pregnancy. Currently, around 325 pregnant women and 200 infants are being followed up. Detailed anthropometry data is available on ~150 patients and DEXA data on ~90 infants.

Placental Biology Research- Initiatives have been taken to understand the human placenta using a multipronged approach (Fig. 3.C.28). Untargeted discovery metabolomics using placental tissue has yielded 30 metabolites that are being verified/

validated on targeted platforms. Interestingly, the study participants show the presence of a low-biomass microbiome in the placenta which contradicts the sterile womb hypothesis.

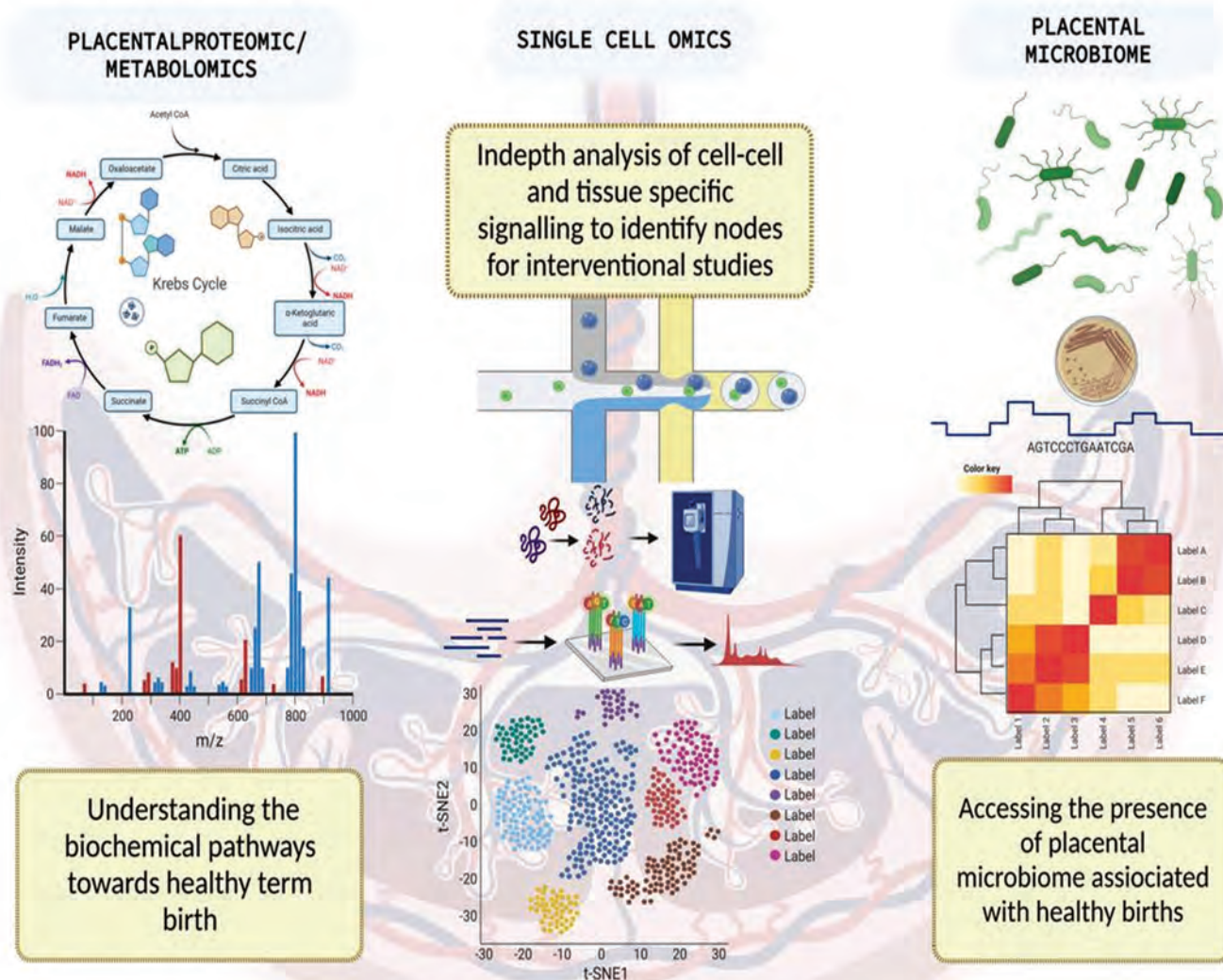


Fig. 3.C.28. A multipronged approach to unravel placental dysfunction in adverse pregnancy outcomes.

Among the 23 core genera, 18 genera were found to be unique compared to preterm. Transcriptome analysis of the placental exosomes isolated across different gestational stages of pregnancy indicates that there is a temporal regulation of gene expression of the genes involved in early embryonic development such as actin cytoskeleton

organization, appropriate cell positioning, and B-cell regulation. Protein cargo analysis of these exosomes so far, points to the presence of 63 differently expressed proteins in term and preterm delivery mothers. The levels of one of these proteins, Human Leukocyte Antigen-G (HLA-G), which is expressed on the fetal-origin extra-villous trophoblasts (EVTs) and

is a crucial factor towards establishment and maintenance of an immune-tolerant zone in the placenta for a healthy pregnancy outcome was higher during early pregnancy in mothers delivering SGA neonates. This may possibly be a mechanism to compensate for any adverse outcomes.

The Department has also taken initiatives towards early prediction of preeclampsia, a hypertensive disorder that commonly puts women and their foetuses at risk for further complications, as well as life-long sequels. A comparative analysis of the DNA methylome, miRNA transcriptome and proteome of placental exosomes is being carried out to identify potential biomarkers. Transcriptomic analysis reveals the presence of differentially expressed miRNAs associated with adipocytokine signaling pathway, peroxisome function and biogenesis. The DNA methylome data indicate differentially Methylated CpGs (DMCs) in the genes associated with oxidative phosphorylation, oxidative stress and electron transport chain pathway.

Reproductive Biology Research

Infertility has become a pressing problem worldwide in the recent times affecting about 15% of the couples. Studies have been supported to understand the development, function and regulation of the male and female reproductive systems. One study in this area has revealed that alterations in HOXB1 expression correlates with male infertility, which may result from HOXB1 mediated changes in the signalling pathways important for spermatogenesis, particularly cell proliferation, differentiation and meiosis. In another study on assisted reproductive technology (ART), it was noted that women of the ART group have a higher blood pressure and are in the older age group. A study on PCOS has revealed that genes involved in circadian clock are disrupted in women with PCOS leading to androgen excess. This explains the increasing preponderance of PCOS due to enhanced exposure to artificial lighting,

rotational and night shift work. A preclinical study on the management of polycystic ovary syndrome (PCOS), showed that treatment with 4-Hydroxy isolucine obtained from fenugreek seeds can significantly improve the ovulation potential /rate in rats, indicating a potential of the natural product, 4-HIL in the management of PCOS.

Developmental Biology Research- In order to elucidate the gene regulatory mechanism governing the differential fate commitment of mesoderm into anterior and posterior subtypes, stem cell derived gastruloids, also called as the embryo organoids have been set up. These cutting edge in vitro models will enable delineation of the functions of various transcription factors involved in the mesoderm fate specification. In another ongoing study trying to understand how embryonic skin mounts an immune response, it has been established that crosstalk between the epidermis and the macrophage is an initial step in setting up inflammatory conditions in the embryonic skin.

Neonatal Sepsis study- India accounts for nearly 40% of global burden of sepsis-related deaths in newborns and is a leading cause of mortality and morbidity among infants. Department is supporting a multi-institutional and multidisciplinary network programme to advance understanding of the causative and confounding factors associated with neonatal sepsis, and towards reducing the burden of sepsis (Fig. 3.C.29). The program follows a hub and spoke model and involves four clinical study sites in Delhi, namely, Dr. B.R. Ambedkar Hospital, LHMC, VMMC, and UCMS, and research institutions including, THSTI, ICGEB, NII, JNU, IIIT and IGIB. Electronic case record forms have been created for capturing all the clinical data being collected. So far, around 1000 mothers and 1200 neonates have been enrolled. Samples have been collected from 200 neonates suspected of sepsis.

Sepsis-related mortality in neonates in India: A multidisciplinary, multi-institutional research program for context specific solutions

Implementing Institutes: AIIMS, THSTI, ICGEB, NII, IGIB, CDSA, IIIT; Clinical Collaborators: LHMC, MAMC, UCMS, Safdurjung Hospital

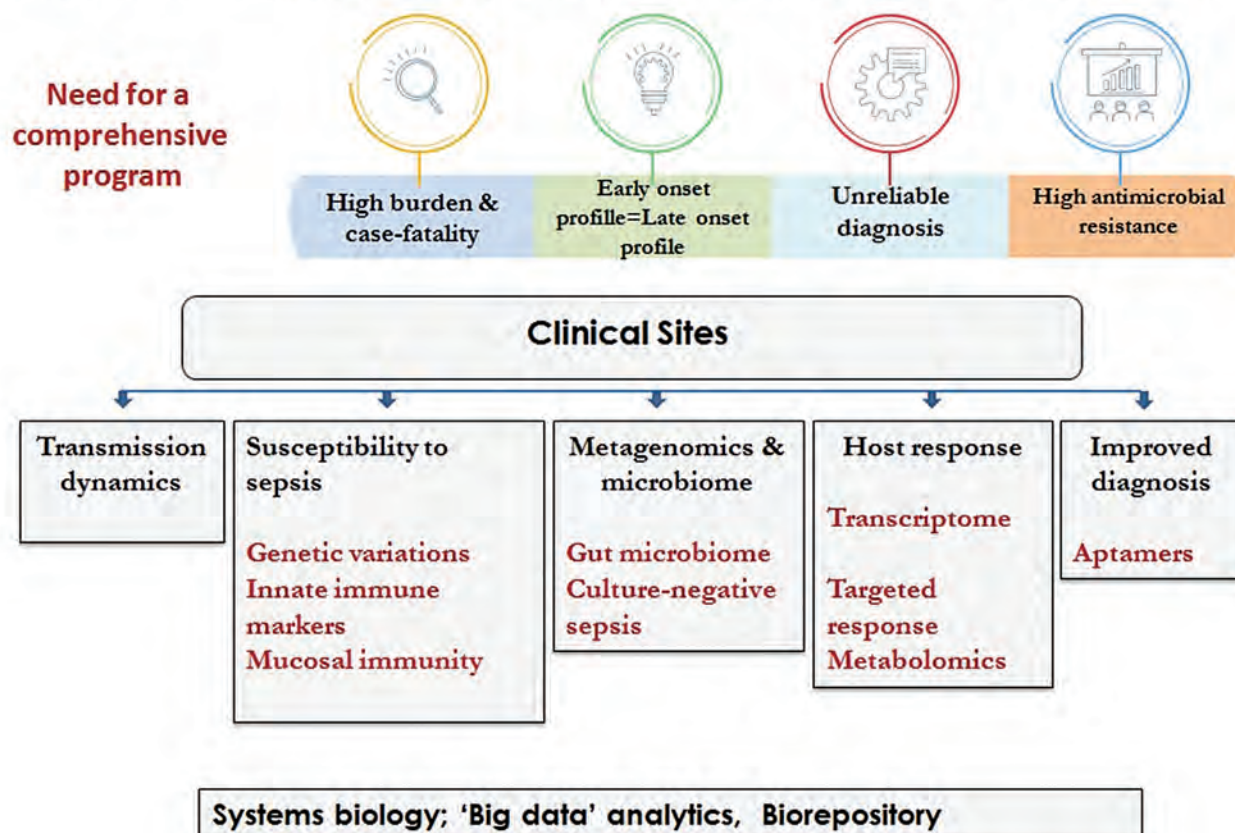


Fig. 3.C.29. An overview of the Neonatal Sepsis study.

3.D

KNOWLEDGE GENERATION, DISCOVERY RESEARCH, NEW TOOLS AND TECHNOLOGIES

Theoretical & Computational Biology (Bioinformatics, BTISNet, AI & Big Data)

Bioinformatics, Artificial Intelligence (AI) and Big Data are concerned with solving biological and biomedical problems using mathematical and computational methods and allow us not only to collect, connect, and analyse data at unprecedented scales, but also to build comprehensive predictive models that span various sub-disciplines. The branch plays an important role in understanding biological processes that currently cannot be studied with experiments. Department of Biotechnology is supporting projects under Theoretical and Computational Biology (Bioinformatics, AI and Big Data) to bridge the interdisciplinary gaps in Biotechnology information and establish linkages between scientists in organisations involved in R&D and manufacturing activities in the country and also to build information resources prepare databases on biotechnology and to develop relevant information handling tools and techniques. One of the major broad objectives of this programme is to perform research into advanced methods of computer based information processing for analyzing the structure and function of biologically important molecules and also to evolve and implement programmes on education of users and training of information scientists responsible for handling of Biotechnology information and its applications to Biotechnology research and development. Projects are also being supported on AI applications for affordable and accessible healthcare programme in the area of cancer, tuberculosis and pulmonary diseases, diabetes and cardiovascular disease, ophthalmological and neurological disorders. These projects are being supported to develop mainly AI

based diagnostics for different types of diseases.

DBT has revamped Biotechnology Information System Network (BTISNet) programme in 2020 for establishment of Bioinformatics and Computational Biology Centers involving data driven research, applications of artificial intelligence, machine learning, high-throughput data related informatics etc. Currently, more than 45 centers are being supported in the areas of Structural Bioinformatics, Drug discovery and drug development, Cheminformatics, Database, Tools, Machine Learning, Genome Informatics, Metagenomics, Systems Bio/Microbial, Agriculture, Plants, Animal, Aquaculture and Marine, Human diseases, Disease informatics, Biodiversity, Proteomics and Metabolomics. At some of the centres National Network Projects (NNPs) have been implemented to inter-link different centres/institutions/research groups to bring them to a common platform. The NNP projects focus on Network mode development of computational methodology/analysis, multi-scale modelling tools, novel scientific methods and highly efficient algorithms, combining principles of chemistry and biology with information technology for genome analysis, protein structure prediction, target directed lead molecule design and also validation of the computational approach, experimental/ wet-lab testing on the predictions emerging from the computational tools and methods.

DBT Apex Biotechnology Information Centre (BTIC) has also been supported at the International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi for coordination of Biotechnology Information System Network (BTISNet) centres

situated across India.

Major achievements during 2022-23:

Major Quantitative achievements during the year 2022-23:	
Projects completed	17
Process/Product/ Technology Developed	34
Databases/Online tools developed/ upgraded	05
Research Publications	108
Patents Applied	04
Patents obtained	03
Human Resources Trained	846

Under AI programme, a project on AI-based approach to predict the drug biotransformation by human gut

microbiome: A step towards personalized therapeutics is being supported at IISER, Bhopal. It is reported that they have developed “GutBug”, a web-based resource that predicts all possible bacterial metabolic enzymes that can potentially biotransform xenobiotics and biotic molecules using a combination of machine learning, neural networks and chemoinformatic methods (Fig. 3.D.1). They have also developed a machine-learning tool “MP4” that predicts and functionally classifies pathogenic proteins into their respective pathogenic classes. The tool can make reliable and accurate functional annotation of pathogenic proteins with comparatively higher sensitivity and specificity. Based on the probability of prediction, users can estimate the pathogenicity and annotation of proteins under scrutiny.

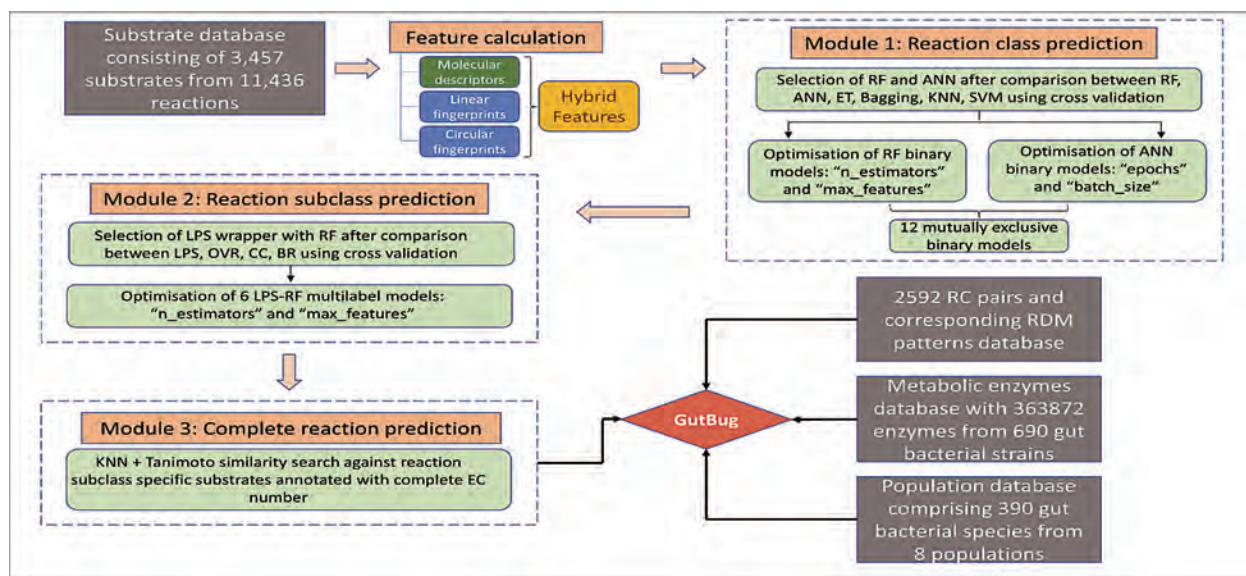


Fig. 3.D.1: Complete work flow of GutBug

Detection of Polycystic Ovary Syndrome (PCOS) using Artificial Intelligence Based Algorithms is being carried out at Sathyabama Institute of Science and Technology, Chennai for development of user friendly software. It is reported that they have developed Graphical User Interface (GUI) (Fig. 3.D.2) and Android App, which provide a perfect classifier approach for detection of PCOS with high accuracy.

An algorithm has also been built to compare the parameters such as testosterone and progesterone along with ultrasound images to generate a PCOS status. A mobile application is under progress for identifying PCOS. This will help the doctors to identify the cyst accurately and also saving considerable time in examining the patients and hence reducing the delay in diagnosing the risk of PCOS.

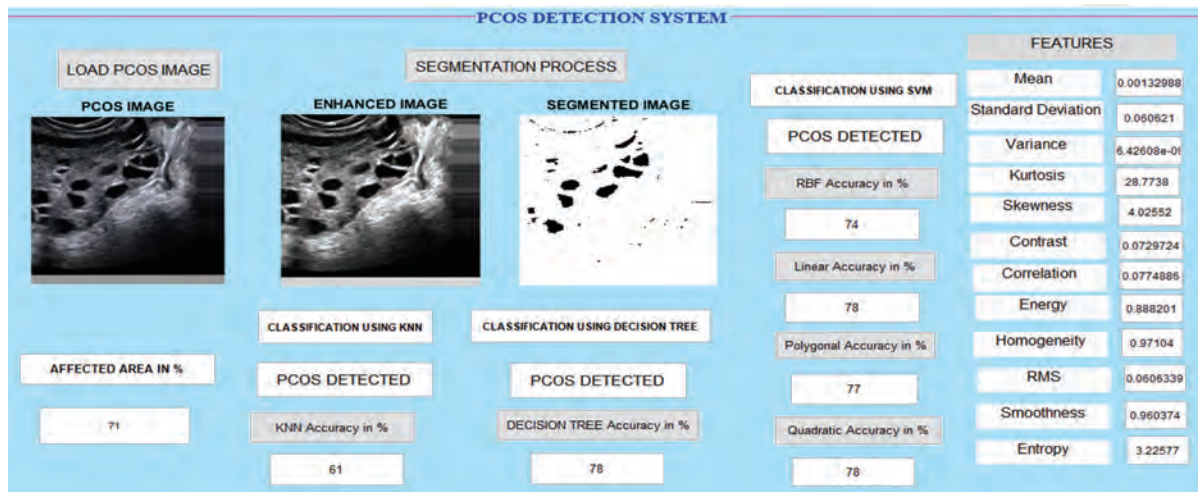


Fig. 3.D.2 Development of GUI

A network project on Artificial intelligence for affordable screening and prediction of diabetic retinopathy in the framework of big data is being carried out at MDRF, Chennai, ISI, Kolkata, NIT, Durgapur, VIT and VRF, Chennai. In this study, an anonymised retinal image grading platform has been created that can handle Big Data both fundus and optical coherence tomography (OCT) images for uploading the images to the DBT-AI platform which will assist in annotating and grading the retinal images and maintaining all annotated images for training the AI algorithm (Fig. 3.D.3). The diabetic retinopathy grading was performed based on the International Clinical Classification of Diabetic Retinopathy (ICDR) Severity scale. So far, MDRF and

Sankara Nethralaya have uploaded about 2400 images and about 2000 images grading have also been completed. Two major approaches have been developed, which include Detection of Red Lesions from color fundus images where position of the red lesion from the given image will be detected and Segmentation of Red Lesions from color fundus images where pixel-wise classification was localized of the affected region in an image. Various algorithms used to detect Diabetic Macular Edema using Optical coherence tomography (OCT) and Fundus images have been analyzed and presented as a Meta- Analysis. This study would help to predict risk factors for DR, disease status and disease progression using deep learning algorithms and other tools of Artificial Intelligence.

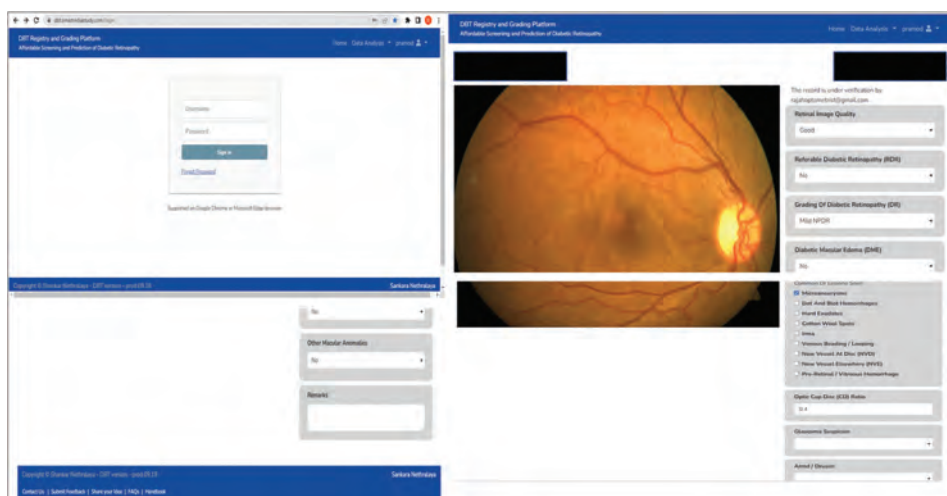


Fig. 3.D.3 DBT AI Platform

Another study on Spiral Dx: Tremor diagnosis and quantification using artificial intelligence is being carried out at AIIMS, New Delhi, SCTIMST, Thiruvananthapuram and NIMHNS, Bangalore. It is reported that they have developed a preliminary machine learning algorithm to analyse the existing spiral drawing datasets. They applied classical machine learning classifiers such as Support Vector Classifier (SVC), Random Forest (RF) and K-Nearest Neighbour (KNN) to the derived spiral parameters to predict classification into normal and patient spirals. They have analysed 180 spirals [50 Dystonic Tremor (DT), 50 Essential Tremor (ET), 30 Parkinson's Disease (PD) and 50 healthy volunteers] and found that KNN classifier was better than RF in distinguishing patients from controls using spiral data. They also applied these algorithms on combined tri-axial accelerometer-EMG analysis parameters such as Peak frequency (PF), Peak Power (PP) and Total Power (TP) from the power spectral density data (1-30Hz) for 8 different positions and found that trained models were able to classify between tremor patients and controls in the test data with considerable accuracy.

Another project on Use of Artificial Intelligence to detect breast cancer on mammograms and its use in the Indian population is being carried out at AIIMS, New Delhi and IIT, Delhi. It is reported that AI powered Reporting tool for mammography has been developed and copyright for the same has been filed. They have trained and tested a neural network entirely on Indian data for detection of small cancers at a stage when they are treatable. It is expected that the project would reach a level of accuracy for clinical deployment, in order to enable screening of cancer.

Application of artificial intelligence and optimal control in optimizing protein/vaccine production in bioreactor system: A step towards affordable biomolecule production is being carried out at IIT, Hyderabad. The study has developed a protocol for measurement of

Reactive Oxygen Species (ROS) generation in suspension adapted insect cells and also a computational tool to identify the optimal profile for media addition, oxygen addition as well as cell density level to be maintained to achieve optimal condition. Using dynamic data acquisition, the real time data generated can improve the standardisation and quality control aspects of bioreactor expression. The results will contribute greatly towards a better control strategy on the large scale and commercial bioreactor expression complying industrial standards. The study can lead to the faster and increased production of recombinant proteins/ vaccines at considerably lower cost in short period of time, which can help to improve rates of mass vaccination or low-cost recombinant therapeutics.

Work on Development of an Artificial Intelligence System for Comprehensive Stroke Imaging and Prognostication is being carried out at SCTIMST Trivandrum, NIT, Karnataka and IIT Patna. A deep learning algorithm for classification of stroke from Non-contrast computerized tomography (NCCT) scans has been developed. Outcome prediction tool for Stroke thrombectomy and web-based application tool for stroke outcome prediction have been developed. The study showed that high accuracy could be obtained in the diagnostic classification of acute stroke scans and these encouraging results have the potential to reduce therapeutic dilemmas and help non-expert physicians too to be involved in the management of an acute stroke emergency.

A project on development of an artificial intelligence (AI) based accurate refractive outcome prediction model post cataract surgery is being implemented at LV Prasad Eye Institute, Hyderabad. It is informed that AI models have been developed, which will predict intraocular lens (IOL) power and post-operative refraction outcome of cataract surgery. They generated 12803 clean data corresponding to all lenses used in the LV Prasad Eye Institute, of which 7384 corresponds to SA60AT and SN60WF lenses.

Further, they have also developed web-based interface of the proposed model to enable clinical validation and deployment.

A project on Intelligent System for Computer-Assisted Diagnosis (CAD) of Canine Mammary Tumours is being carried out at ICAR-IVRI, Izatnagar. A database has been prepared for canine mammary tumour histopathological images comprising of approximately 8000 images from clinical cases of canine mammary tumors referred at Referral Veterinary Polyclinics, ICAR-IVRI, Izatnagar. An intelligent CoMHiSP expert system has also been developed which can

differentiate between benign and malignant Carcinoma in mixed tumor (CMT) images with an accuracy of 97.25% (Fig. 3.D.4). “MobiHisNet,” an efficient and lightweight Convolutional neural networks (CNN) model was successfully deployed on a Raspberry Pi, as well as three mobile devices, demonstrating its ability to run on a lightweight and portable processor. In addition, MobiHisNet is computationally faster than VGG16, ResNet50, Xception, and Inception V3 by twenty-seven, eight, six, and five times, respectively. This also outperforms all the baseline models with the moderate model size and FLOP counts (Fig. 3.D.5).

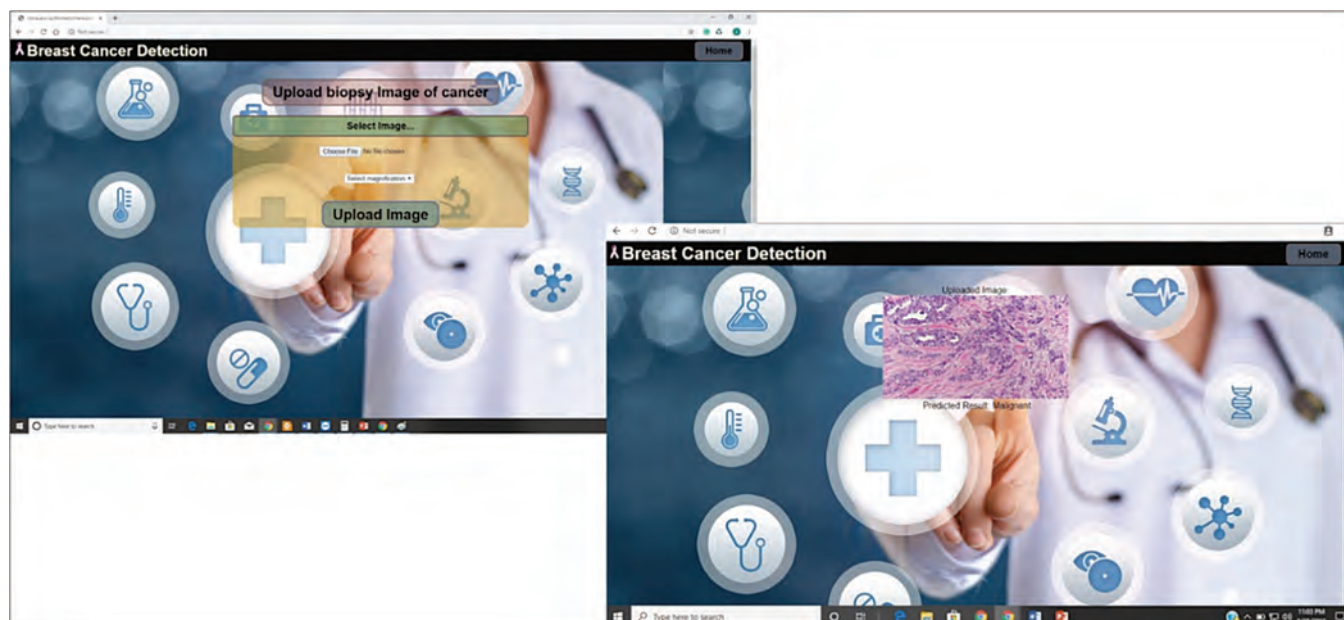


Fig. 3.D.4 App developed for detection and differentiation of benign and malignant histopathological images

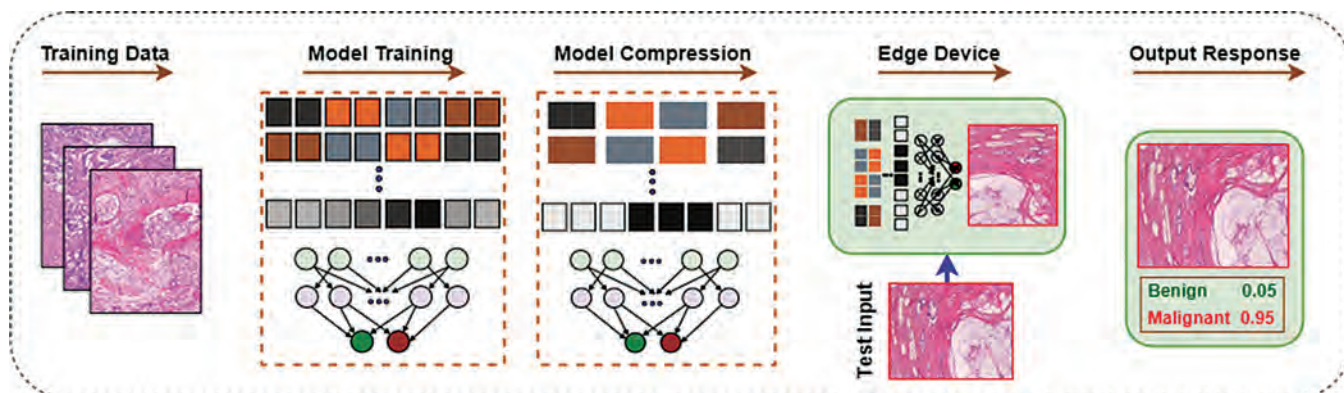


Fig. 3.D.5 Development of MobiHisNet, A Lightweight CNN in Mobile Edge Computing for Histopathological Image Classification

A project on 'Imaging BioBank for Cancer' is being carried out at TMC-ACTREC, Mumbai, AIIMS, Delhi, IIT, Bombay & RGCIRC, Delhi to develop AI tools and database for cancer diagnosis/ prognosis, cancer care and also for advance research in cancer. Two types of cancer i.e. Head Neck Cancer and Lung Cancer are being considered for radiology and pathology images linked to their clinical information and to drive the AI based algorithm/application development using the BioBank infrastructure and data. A website has been developed for popularization, facilitating data entry, management and hosting the data for public use (<https://caib.org.in/>). The study will help to make comprehensive and timeline information of cancer patients journey (from diagnosis to 1st progression/death) alongwith linked radiology and pathology images, ready to be used for Artificial intelligence based applications and other machine learning/bioinformatic methods. Pathology Recaptcha based crowd sourcing platform has been developed for collecting labels for image patches from Whole slide imaging (WSI) pathology images from "Expert" to "Semi-expert" pathologists scattered across the country. A Pathology Recaptcha has been deployed on Tata Memorial Centre's Synoptic Reporting Platform across 9 centres scattered throughout the country which is currently being used by about 150 pathologists.

'MANAV: Human Atlas Initiative' project was implemented for construction of a comprehensive and integrated human map by assimilating all the known macro-level and micro-level information from scientific literature and public databases. The proposed human map refers to a computational representation, which helps to deliver an open source annotation platform, organ (skin) model development, up-skilled manpower and community. In this programme, 1708 students, 64 faculty and 61 reviewers have been enrolled across 58 cities in 20 states of India. The MANAV platform has been developed to facilitate the annotation process

including auto and manual annotation wherein the output data is generated in the form of a knowledge graph. The outcome areas of the project include annotation methodology, annotation tool, knowledge base, and upskilling of human resources. Almost 250 Sessions on "How to read scientific literature" & Introduction to Project Manav in colleges across the country were conducted. More than 26000 students & 400 Teacher were signed up. 17 sessions (4 onsite and 13 Webinars) were conducted, and 2400 students and 120 teachers were signed up from all 8 states of North East India. Sessions were also conducted for 71 DBT Star colleges and engaged with 13 DBT star colleges under DBT Science Setu Program. Under the Biocuration Workshops (Beta testing), one Physical workshop was conducted for 2 colleges and one online workshop was also conducted for 18 colleges from 6 states. Four National level Online Quizzes to spread Covid 19 awareness among the youth were also conducted with a participation of around 2000 students. A strong base of interested students and faculty were built to work on and use the annotation platform.

A study on a novel approach to docking and identification of prospective drug-like compounds is being carried out at IISER, Pune. An algorithm has been designed, which is capable of designing drug molecules for any protein from scratch. It uses a Configuration Bias Monte Carlo approach to add one atom at a time in an orientation that would eventually maximize the interaction between the ligand and the protein. Work is also being carried out on getting the molecules to be synthesizable.

A study on computational structural biology approach for inhibitor discovery to target soluble human chloride intracellular channel-1 for novel anti-cancer therapy is being supported at ICGB, New Delhi. Structure-based computational approach is being used to target the active site of CLIC1 which is involved in Vitamin-C recycling. Targeting CLIC1 enzyme form may result in novel targeted anti-cancer

therapeutics to alleviate the suffering and help in saving of millions of lives. 72 new compounds have been procured from the NCI and *in vitro* validation using high throughput enzyme inhibition assay with single concentration (100 μ M) is being performed to further shortlist the compounds for cell-based assays.

At JNU, New Delhi, a study on data driven modeling of pathogen-specific host responses mediated by nucleic acids sensing proteins is being carried out and reported that they have developed a method for the prediction of novel pathogenic nucleic acid strand specific toll-like receptor (TLR) genes using machine learning. They have also identified nucleic acid strand (single- or double-stranded) specific molecular features indispensable for host-pathogen interactions in TLRs. A method for screening drug lead compounds for TLR5 using connectivity map data, mimicking the infection by flagelin has been developed and it is shown that these compounds are also structurally compatible and hence provide an alternative to docking based screening by way of transcriptome analysis.

A study on integrated meta-omics analysis to study the modulation of gut microbiota for better prognosis of gastro-enteritic complaints is being carried out at Bharathiar University, Coimbatore. A NGS (Next Generation Sequencing) based bioinformatics methodology has been developed using fecal metagenomic profiles in three health status (healthy, gastritis, and gastric cancer) to determine the shift in gut microbiota diversity by α and β diversity analyses. The analysis of 16S fecal metagenomic profiles revealed three distinct gut microbiota profiles for the selected three states healthy, gastritis, and Gastric Cancer (GC). Taxonomic composition analysis and functional prediction revealed three taxa in particular: *Akkermansia*, *Gammaproteobacteria*, and *Veillonella* all of which may play a role in the progression of GC.

Significant Achievements in Biotechnology Information System Network (BTISNet) Programme:

DBT supported Supercomputing Facility for Bioinformatics and Computational Biology (SCFBio) at IIT Delhi is working on the theme of “Development of Genome to Hit (Dhanvantari) pipeline: Genome à Gene à Protein à Drug. The genomics group at SCFBio is currently exploring the physicochemical space of DNA by taking into consideration the higher nucleotide steps (tri and tetra nucleotides) mapped over micro-second molecular dynamics (MD) simulation data. Using the mapping data, the current objectives include optimizing the previous version of the Promoter prediction tool (SEProm). The data for the complete analysis is available on www.scfbio-iitd.res.in/Tri_Tetra/data.html. In proteomics, all in one java based, standalone protein software suite “Protobench” has been developed for customized protein design, analysis, prediction, and refinement. The suite involves a user-friendly platform, attractive visualizations, and features and properties of proteins like energy calculations, volume and solvent-accessible surface area calculations, secondary structure predictions, geometrical features, physicochemical properties, etc. The protobench also provides options for customized protein modeling and design by customizing protein sequences and angles.

In C-DAC-Pune, the DBT-BIC is aiming to develop a cloud based supercomputing facility called Integrated Computing Environment (ICE) to cater the needs of computational biologists. Proposed facility will have various tools for Bioinformatics preinstalled and will be equipped with in-house developed Big Data analytics tools for both genomics and molecular modeling data. The center is also providing services in the area of genome analytics including NGS, and molecular dynamics simulations and encompasses skill development through training/ workshops/ symposium. A web-based cloud Graphical User

Interface (GUI) development is on-going using Angular 12 and NodeJs and micro services pertaining to authentication, user login, storage, user interface application and VCF file analysis have been implemented.

DBT-BIC being supported at IISc Bengaluru is working toward development of a framework for multi-scale modelling of biological systems. They have been developing new bioinformatics algorithms to cater to data at multiple levels- gene and protein

sequences, protein structures, 3D substructures at functional regions of the molecules, protein-ligand, protein-protein interactions and biochemical pathways. Efforts are being done towards combining them into computational pipelines. **SiteMotif**, a graph-based algorithm for deriving structural motifs in Protein Ligand binding sites and Fast Local Alignment of Protein Pockets (FLAPP): A System-Compiled Program for Large-Scale Binding Site Alignment has been developed to aligns binding site structures (Fig. 3.D.6).

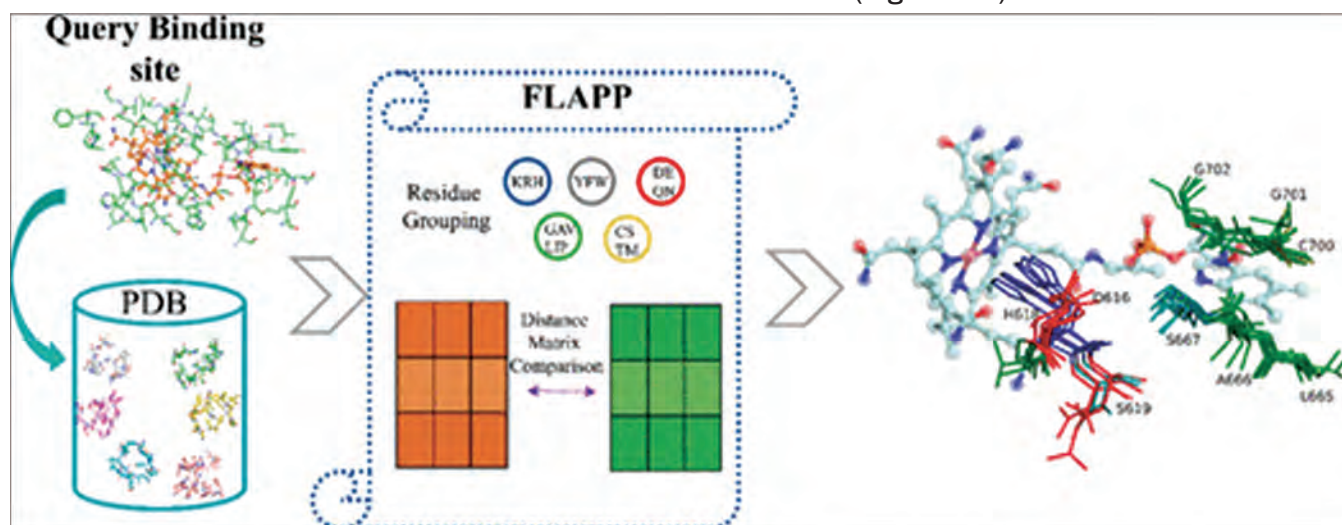


Fig. 3.D.6 FLAPP is developed to aligns binding site structures. It takes <“1.msfor one pair of sites on a standard desktop machine, and 1-2 min for PDB-wide scan

In DBT-Bioinformatics centre (BIC) at NCBS, Bengaluru, a workshop on NGS sequencing analysis was carried out in collaboration with TNAU Coimbatore. Pipelines were developed for genome-wide analysis, cross-genome comparisons, genome and transcriptome sequencing. Medicinally important metabolites containing enzymes were mined from fenugreek transcriptome and functional properties of cyclotides were studied viz. amyloid fibril formation prevention in neurodegenerative diseases, Structural domain analysis of interacting and non-interacting homologues was carried out and tools for RNA-protein complexes were reviewed.

In DBT-BIC centre being supported at Aligarh Muslim

University, the major objective of the project is to spread awareness regarding the menace of antimicrobial resistance (AMR). To fulfill this objective, three awareness camps were organized in the year 2022 in order to sensitize the masses regarding AMR. In addition to organizing the awareness camps regarding AMR, the project also involves comprehensive research in the domain of antimicrobial resistance and allied fields of research. Development of a database on AMR is under process.

In DBT-BIC at ICgeb, has performed different studies addressing important problems in healthcare, agriculture, drug discovery, and Covid-19 using the

state-of-the-art application of AI technologies, bioinformatics and computational approaches. Centre has developed an artificial Intelligence-based classification tools for cancer staging, for assisting doctors and surgeons in decision-making for the appropriate treatment interventions and for Covid-19-associated prognostics biomarkers. DriverFuse tool has been developed for studying the driver fusion genes in cancers, enabling the identification of recurrent complex rearrangements that provide intuitive insights into disease-driver events. Centre has also developed a deep learning-based prediction model trained on image data for facilitating clinicians in deciding the appropriate laser or surgical intervention in Open-angle glaucoma. It highlights the translational potential of image-based diagnostic alternatives when deployed for screening patients and family members for identifying angle dysgenesis.

DBT-BIC at NIPGR, New Delhi have performed big data analysis to identify tRNA fragments (tRFs) and fusion transcripts in Arabidopsis and rice and developed the pipelines for the same. With the help of *in silico* data analysis, stress-responsive tRNA fragments (tRFs) and fusion transcripts in Arabidopsis and rice have been identified. Further, the experimental validation of stress-responsive tRFs and fusion transcripts was done in both plants. Databases have also developed plant specific databases for tRNA (www.nipgr.ac.in/PtRNAdb). PTPAMP, the first plant-based approach for predicting Anti-Microbial Peptides (AMPs) web server has been developed (<http://www.nipgr.ac.in/PTPAMP/>) which provides a platform for peptide categorization among four defined activities and a module to generate their mutated sequences in the hope of getting better bioactive peptides.

In a DBT-BIC at Anna University, Chennai, a computational study on designing of effective siRNAs to silence structural proteins associated genes of Indian SARS-CoV-2 strains was carried out. In this study, four siRNA molecules were predicted to be

effective against the envelope gene (E), membrane gene (M), nucleocapsid phosphoprotein gene (N) and surface glycoprotein gene (S) of 811 Indian strains of the SARS-CoV-2 virus. Apart from research activities centre is also involved in education and training services in Bioinformatics and Computational Biology.

DBT-BIC at NEHU, Shilong is working on enhanced efficacy for commercialization of vaccines to control fascioliasis in livestock. Immuno-informatics approach are being used for high-throughput immune-computing for development of a multi-epitope-based subunit vaccine by using six major proteins (paramyosin, thioredoxin reductase (NADPH), cathepsin B, cathepsin L, fatty acid-binding protein-3, and 14-3-3 protein epsilon). Further Botanical carnivory in identified species of north-east and the chemical ecology of insectivorous plants, eg *Nepenthes khasiana* is also being explored.

In BIC at NIIRH, Mumbai, has developed CAMPR4 (Collection of Anti-Microbial Peptides) database (<http://camp.bicnirrh.res.in/>) for providing curated information on natural and synthetic antimicrobial peptides (AMPs) such as AMP sequence, protein definition, accession numbers, activity, source organism, target organisms, protein family descriptions, N and C terminal modifications and links to databases for the benefit of users. CAMPR4 holds 24243 AMP sequences, 933 structures, 2143 patents and 263 AMP family signatures (179 HMMs and 84 patterns). In an updated version of the CAMP database, there are separate algorithms for the prediction and rational design of natural and synthetic AMPs. Multimorbidity Risk Prediction for Schizophrenia (MRPS), a web-based tool <http://www.mrps.bicnirrh.res.in> has also been developed to provide list of shared genes and diseases and a network of associations between schizophrenia and the selected disease/s. This tool is can be used for the prediction of risk of morbidities in schizophrenia based on shared gene-disease associations. There

are 53 associated diseases of which 18% belongs to cellular proliferation category.

In DBT-BIC at CSIR-IHBT, Palampur, major strides were made in the area of Deep-Learning and Machine-Learning with implementation of novel algorithms to discover long noncoding RNAs in plants (DeepPInc) and studying various stress condition specific networks in rice with DInet. Both these software are freely available. Transcriptome studies of two different Himalayan species, *Rhododendron* and *Jeevak*, were carried out revealing the molecular system behind the evergreen status of *Rhododendron* at one side while revealing the $\hat{\alpha}$ -sitosterol and eugenol biosynthesis in *Malexix* while suggesting that the endangered species can be spared of its bulbs and rather its leaves can be a better source for its prized secondary metabolites. A-HIOT named framework was implemented into software to virtually screen the potential drug

molecules and their re-purposing. Using high-end software potential active compounds against various diseases were also identified during this period.

DBT BIC at Alagappa University, Karaikudi, Tamil Nadu have computationally studied the interaction of the SARS-CoV-2 spike protein in both wild-type and B.1.1.7 variant with hACE-2 receptor using combined molecular dynamics and binding free energy calculations using molecular mechanics-Generalized Born surface area (MM-GBSA) approach. In another study selected phytochemicals such as Chebulagic acid, Geranine and Repandusinic acid act as multitargeting drug-cocktail by effectively inhibiting 3CLpro, PLpro and RdRp targets and also weakening protein-protein interaction between spike protein and hACE-2 and showed a compared efficacy with two reference drugs, Nafamostat and Acalabrutinib which are under clinical trials to treat SARS-CoV-2 (Fig. 3.D.7).

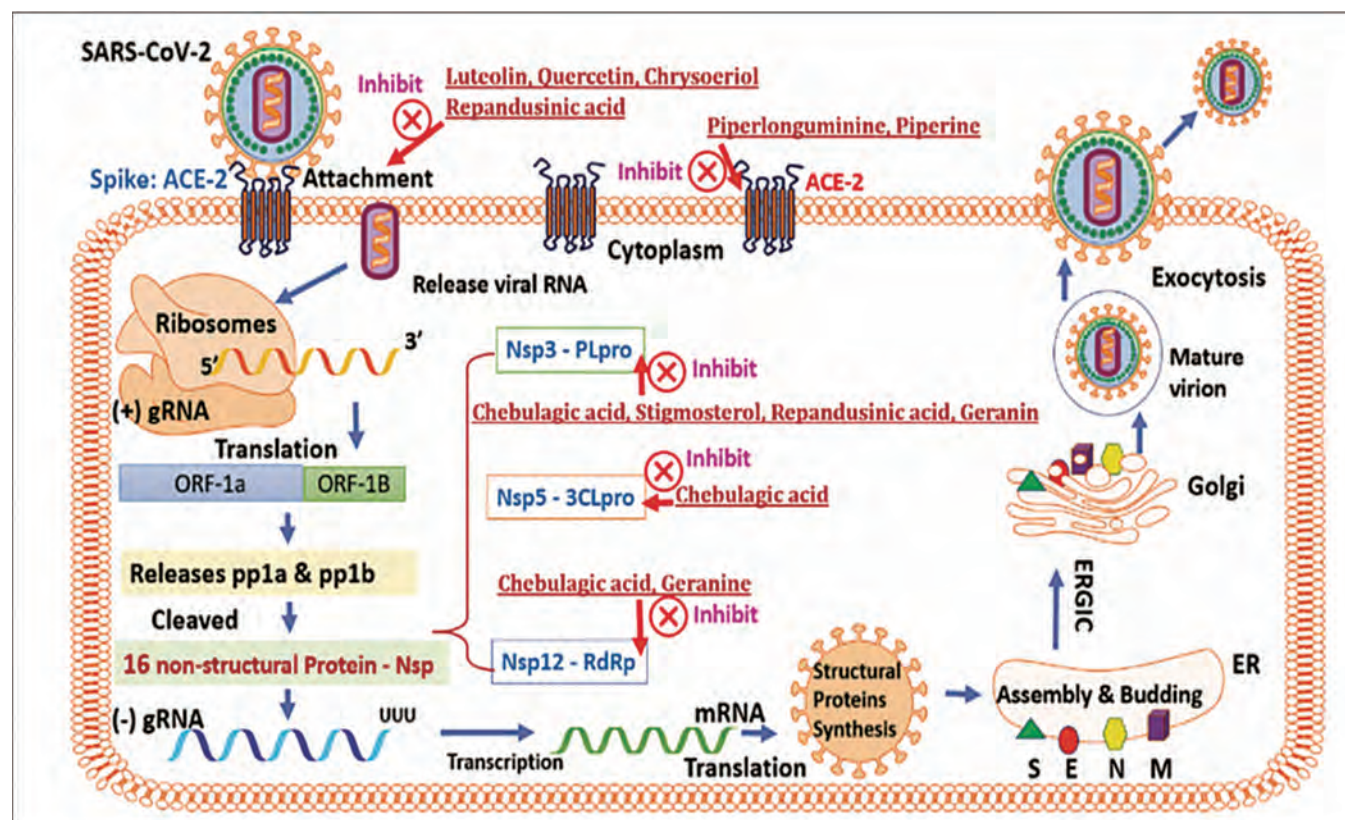


Fig. 3.D.7 Mechanism of multi-targeting potential of selected phytochemicals

DBT Apex Biotechnology Information Centre (BTIC) is a centre of the Department of Biotechnology (DBT) located at the International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi. The primary objective of centre is the coordination of Biotechnology Information System Network (BTISNet) centres situated across India. DBT Apex staff has developed software to monitor the progress of BTISNet centres and thus, help in the decision-making regarding the future funding and directions of research and development in Bioinformatics (Fig. 3.D.8). To ensure the continuous functionality and regular updation of all the resources developed by BTISNet centres (through DBT funding), these resources are being hosted at a

centralized server (at DBT Apex, ICGEB, New Delhi) by the DBT Apex BTIC staff. Also, the centre staff is responsible for updating the BTISNet coordinators and staff about the recent technologies in Bioinformatics research through regular workshops. The Apex BTIC also develops software for measuring the performance indicators of various DBT initiatives, for example, Nidan Kendras and Unique Methods of Management and treatment of Inherited Disorders, or UMMID project. Scientists at the Apex BTIC are also participate in various bioinformatics-related research activities. DBT Apex BTIC staff members are also involved in public outreach activities by delivering lectures at various institutes, universities, schools and by arranging student and faculties (from outside) visits.

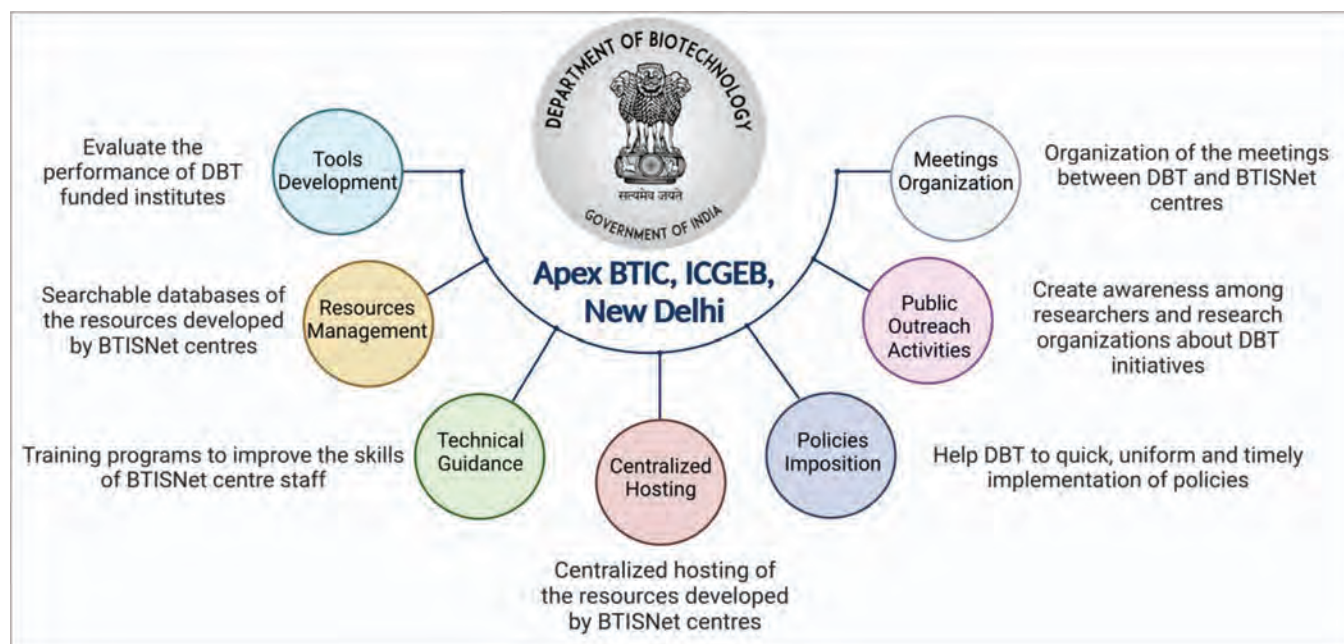


Fig. 3.D.8 Major activities performed by DBT-Apex BTIC, New Delhi

DBT- Partnership Centre for Research (DBT-PaCeR) Programme:

The Department of Biotechnology (DBT) has been supporting basic/applied/translational research in life sciences through individual, multi-PI, institutional and multi-centric funding mechanisms for research

and development with its commitment towards self-reliance. To further catalyze and incentivize the multi-centric research programs and develop capacity building in terms of infrastructure and human resource for life sciences and provide able mentorship to the small and emerging Institutes, Department is planning to institutionalize a new

program under R&D Scheme: DBT Partnership Centres for Research (PaCeR) in Life Sciences & Biotechnology. The main aim of the program will be fostering and mentoring smaller institutes in tier I and tier-II cities by the established partner Applicant Institute who have the state of the art facility and cutting edge platforms for facilitating the interdisciplinary research programs. PaCeR grants will provide funding to augment and strengthen institutional research capacity harnessing their excellence to evolve robust interdisciplinary research programs and also mentor the smaller institutes in near geographical area.

Biotech-PRIDE (Promotion of Research and Innovation through Data Exchange) Guidelines:

Department has released Biotech-PRIDE (Promotion of Research and Innovation through Data Exchange) guidelines of India to facilitate and enable sharing and exchange of high-throughput, high-volume biological data, knowledge and information generated within the country for promotion of research and innovation as per the existing laws, rules, regulations and guidelines of the country (Fig. 3.D.9). These guidelines will be implemented through Indian Biological Data Centre (IBDC) - the National repository, established at RCB, NCR Biotech Science Cluster, Faridabad. As per these guidelines, if any biological data are being generated in the Govt. funded project, then Project Investigators should submit the data generated in the project to Indian Biological Data Centre in compliance with the Biotech-PRIDE Guidelines 2021.



Fig. 3.D.9 Biotech PRIDE Guidelines

Setting up of the Indian Biological Data Centre (IBDC):

The Indian Biological Data Centre (IBDC) is being set up for the purpose of deposition, storage, annotation and sharing of biological data. IBDC is mandated to archive all publicly funded life science data generated at national level. The data centre would archive the data coming from various fields of life science research. It will perform quality control, curation, and annotation of data. These efforts will help establish benchmarks for the quality of data deposited and thus improve the quality of experimental research conducted in the country. IBDC is also mandated to conduct training programs on data storage and analytics to help increase the number of manpower skilled in Data Science in the country. Other datasets/ data centres will be bridged to the IBDC which will be called Bio-Grid. The Bio-Grid will be a National Repository for all biological knowledge, information and data generated through

research within the country and will be responsible for enabling its exchange to facilitate the research and innovation, developing measures for safety, standards and quality for datasets and establishing detailed modalities for accessing data. The data centre has started its services by providing nucleotide data submission services via two data portals viz. The 'Indian Nucleotide Data Archive' (INDA; <https://inda.rcb.ac.in>) and the 'Indian Nucleotide Data Archive- Controlled Access' (INDA-CA; <https://ibdc.rcb.res.in/inda-ca>). IBDC has developed a dashboard for the Indian SARS-CoV-2 Genomics Consortium (INSACOG) and so far 2,16,221 datasets have already been submitted to the IBDC. This dashboard provides real-time status of the prevalent Covid19 virus variants in different parts of the country. IBDC has also developed the online dashboard for the GenomeIndia project, which involved in sequencing of the genomes from Indian ethnic human population. Further, data submission

and visualization portals for other types of data sets are also under development. IBDC offers access to its High Performance Computing (HPC) facility-'Brahm' for researchers who want to perform compute intensive data analysis tasks, storage and analysis services for the users on request (ibdc.rcb.res.in/tutorial-sop). The data center regularly conducts workshops for researchers of different organisations to guide and sensitise them the data submission process. So far more than 43 workshops have been conducted. Dedicated user support in the form of video tutorials, portal-specific SOPs (ibdc.rcb.res.in/tutorial-sop) are available on the data center website and users can contact IBDC at 'support@ibdc.rcb.res.in' for resolving any of their queries. Recently, Indian Biological Data Centre was inaugurated and dedicated to the nation by Dr. Jitendra Singh, Hon'ble Minister of State (IC), Ministry of Science and Technology & Earth Sciences, Govt. of India, on November 10, 2022 (Fig. 3.D.10).



Fig. 3.D.10 Dr. Jitendra Singh, Hon'ble Minister of State (IC), Ministry of Science and Technology & Earth Sciences, Govt. of India, inaugurated and dedicated IBDC to the Nation on November 10, 2022.

3.E

BIOTECHNOLOGY SCIENCE CLUSTERS

Considering the importance of building synergy and promoting networking in the biotech sector in the country, the Department conceptualized the idea of setting up Bioclusters in its National Biotech Strategy Document. Following this, the Department has established four Bioclusters at Faridabad (Haryana), Bangalore (Karnataka), Kalyani (West Bengal) and Pune (Maharashtra).

The significant achievements made under ongoing Biocluster program includes establishment of high end facilities such as National structural biology facility with Electron Cryo-microscope; an Advanced Technology Platform Centre with a Bioincubator; a platform to study on a large data analysis on problems ranging from plant pathogen interactions to understanding neuronal circuits and establishment of a system medicine platform for generating required biological and medical evidence to accelerate systems medicine. These facilities are fully functional and are serving as National facilities catering to researchers across the country. The mechanisms to access these facilities are in place.

NCR Biotech Science Cluster-Faridabad

The establishment of “NCR Biotech Science Cluster” by the Department of Biotechnology is an ambitious project of Govt. of India to give impetus to the development of Biotech industry in the region and would put Faridabad on the world map as a biotechnology hub. This is the largest Biotech Science Cluster in India planned on 200 acres of land and is expected to become a major magnet to attract biotech research, Industry and related investments making NCR a potent future force in the Biotech Sector.

NCR Biotech Science Cluster has been conceptualized by the Department of Biotechnology to conjoin knowledge and infrastructure amongst five (5) partner institutions of national importance including the National Institute of Immunology (NII), Regional Centre for Biotechnology (RCB) under the auspices of UNESCO, Translational Health Sciences and Technology Institute (THSTI), National Brain Research Centre (NBRC), and National Institute for Plant Genome Research (NIPGR).

Facilities like laboratories, common infrastructure, pilot facilities, clinical research and data management centres, animal houses, instrumentation facility, as well as an incubation centre for innovative start-up companies have been established to be the part of NCR Biotech Science Cluster.

Office of Connectivity has been conceptualized as the cluster office for the NCR Biotech Science Cluster and is responsible to establish a governance structure for the management and utilization of common facilities. It is working towards creating an innovative and efficient management structure, so that the advantage of having different institutions co-located in a cluster, with their respective competencies can be nurtured through systematic sharing of knowledge and resources. Office of Connectivity is acting as a hub for the whole cluster to focus on seamless connectivity for accomplishing best results by bringing together NCR Biotech Science Cluster stake-holders by facilitating, coordination, collaboration and sharing of efforts within the Cluster setting for various multidisciplinary collaborative research programs across the partner institutions along with the establishment and management of Common

Facilities of the NCR Bio-cluster.

The NCR Biotech Science Cluster has ensured development of the following common facilities:

a) Office of Connectivity Building equipped to accommodate Indian Biological Data Centre (IBDC), DBT HRD Project Management Unit (HRD PMU) and a few project offices for THSTI.

b) Biosafety Level-3 Facility

c) Vertical Extension of Hostel Building



Office of Connectivity



BSL-3 Facility

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

The Systems Medicine Cluster (SyMeC) was formed as a collaborative project among the following national institutions and clinical centre located in

Kolkata:

- i. National Institute of Biomedical Genomics (NIBMG), Kalyani (*Nodal institution*)
- ii. Indian Statistical Institute (ISI), Kolkata
- iii. Bose Institute (BI), Kolkata
- iv. CSIR-Indian Institute of Chemical Biology (IICB), Kolkata
- v. Tata Medical Centre (TMC), Kolkata
- vi. Indian Institute of Science Education and Research (IISER), Kolkata

The targets of this biocluster were to:

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

The SyMeC biocluster has successfully achieved the following:

(a) Oral Cancer

- A biological molecule (peptide) has been designed to block the adverse impact of a DNA change in a key cancer gene (TP53).
- Identified known drugs that can reverse the direction of dysregulation of some important cancer-causing genes caused by epigenetic effects.
- Five genomic features have that can predict the spread of oral cancer (metastasis) to other

organs with a high accuracy have been identified.

- Sequential genomic lesions that occur from the progression of a normal tissue to a precancerous state (leukoplakia) to frank cancer have been identified.
- A diagnostic gene panel for oral cancer has been developed and is being validated.

(b) Cervical Cancer

Cervical screening of a large number of women who were recruited in the Kalyani Cohort Study (an initiative of NIBMG) has been carried out for enhancement of awareness. This screening programme has provided precise estimates of relevant epidemiological parameters for prediction of cancer risk and also deeper understanding of the biology of the disease.

(c) Methodologies developed for used in human disease research

Novel statistical methods have been developed for integrating multiple types of data (genomic, epigenomic and transcriptomic); and clustering single-cell gene expression data to identify cell types and their numbers in a collection of cells from a tumour. Software packages implementing these methodologies have been placed in the public domain. These include “dropClust2” and “Structure-Aware PCA” implementing novel statistical methodologies for analyses of various types of omics data.

- (d) Publications:** A total of 41 peer-reviewed papers have been published in national and

international journals on various basic and translational aspects of human diseases, particularly of cancers.

Pune Biotech Cluster: “Model Organisms to Human Disease”

Department is supporting a project on Establishment of a Pune Biotech Cluster, “Model Organisms to Human Disease” to NCCS and IISER, Pune. The aim of Pune Biotech cluster is to develop the state-of-the-art technology platforms that will allow detailed analyses of molecular events leading to pathogenesis and use of model organisms to develop solutions to address problems in human disease biology and thereby paving the way for lab-to-bed translational research. The scientific communities that will benefit from this endeavor include Public and Academic Institutions, local hospitals as well as the Biotechnology Companies in and around Pune. A major focus of the Biocluster is to generate highly skilled manpower in the biomedical imaging and develop a national training framework for generating much needed human resources in biomedical image analysis and processing. One Confocal Laser Scanning Microscope (Zeiss LSM 880 with Airyscan) and the Spinning disk High Resolution microscope have been set up at NCCS, Pune. The Whole Animal Imaging and Tissue Processing Facility has been established at IISER, Pune. The Infrastructure for the Electron Microscopy Facility has been set up at IISER Pune. About 400 beneficiaries have utilized the resources established in the Pune cluster. 62 personnel have been trained and few start-ups from IISER Bhopal also have utilized the facilities.

04

**SPECIAL SECTION:
COVID-19**

4

SPECIAL SECTION: COVID-19

4.1 COVID-19 DIAGNOSTICS

To address gaps in indigenous diagnostics development during the COVID-19 pandemic, the Department has sanctioned 16 projects through a special call of “DBT-BIRAC Covid-19 Research Consortium”. 5 kits for SARS COV2 (three antibody based, one antigen based, one RT-LAMP) have been developed and three have been commercialized. Some of the salient developments of the programme are reported below:

Translational Health Science and Technology Institute (THSTI) has developed a rapid and stable Receptor Binding Domain (RBD) - based IgG ELISA test. The test has shown higher sensitivity compared to few of the kits available in market. The initial version of the test has been transferred to Xcyton Diagnostics Ltd. The test should be a very useful tool in monitoring the sustainability of IgG response after the infection and vaccination and will have value even when the pandemic is over. The team has also developed a lateral flow rapid POC assays for detecting anti-SARS-CoV-2 antibodies. The developed rapid test has higher sensitivity than the commercial assays in the same format and has been found to be in high concordance between serum neutralization test titers and the signals (UCNP fluorescence) from the LFA. The aim is to further develop this assay as a surrogate virus neutralization test for the point of care settings keeping in mind the utility of this test for assessing the vaccine response and to determine the need for the booster dose in future.

IISc, Bangalore has developed RT-LAMP assay against the S-gene of SARS-CoV2 having significant

analytical sensitivity. The specificity of the assay lies in the strength of designing of the primers, which are unique in the genome of SARS-CoV2 and are absent in other related coronaviruses. Thus, it would ensure that the LAMP reaction would proceed by loop formation exclusively in the presence of SARS-CoV2 target RNA, leading to high specificity of the assay. Pilot validation has been performed and the working prototype of the kit is ready for ICMR evaluation. Also, a Start-up/spin-off company Papyrus Diagnostics Pvt. Ltd. has been incorporated at IISc Bangalore based on the research leads of RT-LAMP assay for SARS-CoV2

The Department supported **Centre for Human Genetics, Bangalore** to develop an IgG ELISA Test kit for sero-surveillance. The kit which has been submitted for ICMR evaluation/validation will help to check for the immunity by testing SARS-CoV2 antibodies generated by individuals with a history of SARS COV2 infection or downstream of receiving the vaccination. The team has developed two ELISA tests Lady Bird and Paras, which identifies SARS CoV2 antibodies with high specificity and sensitivity. The peptides (RBD) arrays could be used to develop quantitative estimates/ titres of IgA Antibody as an indicator of the immune response (protection) or neutralising activity.

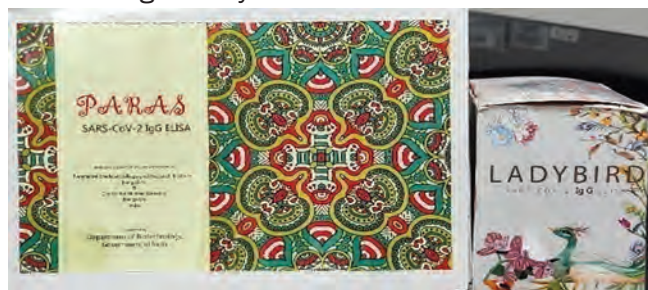


Fig. 4.1 IgG ELISA kits (one for pooled peptide antigen and another for recombinant nucleocapsid antigen)

A long- term study at PGI Chandigarh has established stool as a diagnostic marker especially for long-term COVID-19.

4.2 COVID-19 TESTING

DBT has identified 21 City /Regional clusters to scale up Covid testing in the Hub and Spoke model. Nine Autonomous Institutes (AIs) of DBT have been approved as testing centres for COVID-19 diagnosis. These DBT AIs have also been identified as hubs for their respective regions. Some of the salient developments are:

- Till date, more than 82.79 lakh tests have been performed by these Clusters.
- To ramp up the COVID-19 testing in rural and inaccessible areas, India's first I-lab (infectious disease diagnostic lab) which was launched in June 2020 and attached to the THSTI, Faridabad hub have tested more than 39883 samples in total, till date from the Faridabad region. Also, I-Lab having both RT-PCR and ELISA testing has been launched in the NER at Mizoram for Covid testing in its rural and inaccessible areas in the month of January, 2022



Fig 4.2: Mobile Infectious disease diagnostic lab (I-Lab)

- Andhra Pradesh Med Tech Zone (AMTZ) is a common shared facility to manufacture

diagnostic kits and ventilators. AMTZ is operationalizing indigenous manufacturing of kits and reagents for testing. Through DBT-BIRAC support following products have been manufactured indigenously for Covid testing and management by support provided to AMTZ:

- RT-PCR tests (Trunat, Covidsure, ErbaMDX) – 16.25 Cr tests,
- Critical care Ventilators (Swasit, Swasit +, Numo, LV 100, LV 1000) – 11000 units
- ELISA based tests (ERBA LISA - Covid-19IgG): 5.5 Cr
- Viral Transport Media (Vi Sure) – 2.8 Cr

4.3 COVID BIOREPOSITORIES

The Department has supported 5 COVID-19 Bio repositories at NCR Biotech Cluster- Translational Health Science and Technology Institute & Regional Centre for Biotechnology, Faridabad; Institute of Life Sciences, Bhubaneswar ; Institute for Stem Cell Science and Regenerative Medicine, Bangalore; Institute of Liver and Biliary Sciences, New Delhi and National Centre for Cell Science, Pune with total sanctioned budget of Rs. 10.94 crores. The samples in these COVID-19 bio repositories have been used to develop validated diagnostics, therapeutics and vaccines etc against COVID -19. These samples are also a valuable resource for R&D to understand the early predictors of disease severity, immunopathogenesis of the disease etc. THSTI's indigenous anti-SARS-CoV-2 IgG ELISA developed using the bioresource at the biorepository has been transferred to Xcyton Diagnostics, Bengaluru. More than 40 peer reviewed publications have also resulted from these bio-repositories.

S. No.	Name of Biorepository	No. of samples deposited till date	Nature/ type of samples	Samples shared with academia	Samples shared with industry
1	Institute of Life Sciences, Bhubaneswar	407	Serum, Plasma, PBMC, Urine, Stool, Nasopharyngeal swab, Oro-pharyngeal swab	970	175
2	Institute of Liver and Biliary Sciences, New Delhi	36503	Serum, Saliva, Stool, Urine, Plasma, Ascites fluid, Nasopharyngeal swab, Oro-pharyngeal swab, Pleural fluid, Buffy coat, Blood(Whole) Ficoll mononuclear cells viable	2199	200
3	Institute for Stem Cell Science and Regenerative Medicine, Bangalore	6416	NPS/OPS in medium; BAL; Serum; Dry Swabs; Whole Blood; Saliva, SARS-CoV-2 (alpha and delta variants)	235	7
4	NCR Biotech Cluster- Translational Health Science and Technology Institute & Regional Centre for Biotechnology, Faridabad	21396	Serum, NP/OP swab, plasma, PBMCs	17627 (aliquots)	4668 (aliquots)
5	National Centre for Cell Science, Pune	127	Plasma and PBMCs	121	15

4.4 THERAPEUTIC INTERVENTIONS

Considering COVID 19 crisis, the Department took immediate initiative on COVID-19 Research Consortium to support R&D efforts through all sorts of technological interventions in terms of diagnostics, therapeutics, vaccines, repurposing of drugs and other mechanism to understand the clinical and pathological aspects of this pandemic agent. The Department has supported 14 R&D projects aimed at developing therapeutics against the following target molecules of COVID-19 under the DBT-BIRAC COVID-19 research consortium:

- Spike protein: HR1 and HR2 domain, Receptor Binding domain and 6 helix bundle core of spike protein
- NSP 14 protein (RNA dependent RNA polymerase)

- Human protease Angiotensin Converting Enzyme (ACE)-2
- Human proteases transmembrane serine protease (TMPRSS)-2

In an effort to develop therapeutics against SARS CoV-2, Moorthy *et al* designed potential peptide based fusion inhibitors as a means of prevention of coronavirus entry into host cells. Researchers from ICGB and Madurai Kamraj University designed and developed anti-viral peptide aptamers against SARS-CoV-2. Kondapi *et al* have shown Epap-1 inhibits SARS CoV-2 and ACE2 interaction through interaction with RBD region thereby preventing SARS CoV-2 entry. Mahajan *et al* have filed Indian patent for a device for the nose only exposure of dry powder inhalation containing biodegradable nanoparticles of Niclosamide to combat COVID-19 infection in

experimental animals. Manga *et al* have developed two Spiropyrrolidine-2,3-Oxyindole derivatives that inhibit the fusion of HEK-Spike and VERO-hACE2/TMPRSS2 in SARS-CoV-2.

4.5 COVID-19 VACCINE DEVELOPMENT

In view of the Coronavirus pandemic, the Government has taken several measures to address the challenges posed by the pandemic. The pandemic brought in a new sense of urgency to research and innovation efforts. The DBT initiated an integrated response to overcome the unprecedented COVID-19 pandemic. From the development of indigenous vaccines, novel point-of-care diagnostics and therapeutic formulations based on traditional knowledge, to establishment of research resources and offering services, DBT, Autonomous Institutions (AIs) of DBT and BIRAC, have worked relentlessly to develop effective interventions for combating the pandemic. DBT also pro-actively engaged in strategic international partnerships, to respond to the emerging pandemic situation and support the advancement of vaccines and other biomedical interventions.

DBT's efforts are especially recognized in the area of vaccines whereby, the Department has been identified as the central coordinating agency by the PMO constituted Task Force on Vaccines. Both national efforts and international partnerships were leveraged for vaccine development and manufacturing. The efforts were focused on strengthening end-to-end vaccine development ecosystem so as to bring about a rapid and accelerated candidate vaccine development and manufacture, as well as regulatory facilitation.

Major initiatives: DBT led the implementation of 'Mission COVID Suraksha –The Indian COVID-19 Vaccine Development Mission', by BIRAC, under AtmaNirbhar Bharat 3.0 package. The focus of this mission was to facilitate accelerated development of safe, efficacious, affordable, and accessible COVID

vaccines, with a focus on Atma Nirbhar Bharat. COVID-19 vaccine development efforts by academia were supported under the DBT BIRAC COVID-19 research Consortium and under the Ind-CEPI mission.

Significant outcomes of the aforementioned programmes are enumerated below.

Four COVID-19 vaccines supported under "Mission COVID Suraksha-the Indian COVID-19 Vaccine Development Mission", received EUA. These are: World's 1st and India's indigenously developed DNA Vaccine, ZyCoV-D; Protein subunit vaccine, CORBEVAX™; mRNA vaccine GEMCOVAC-19™; India's 1st Intranasal COVID-19 Vaccine (iNCOVACC). CORBEVAX™ has also been approved for use in children (5 years and above) and as a heterologous booster (18 years and above). iNCOVACC also received EUA for use as homologous & heterologous booster.

19 clinical trial sites have been supported under Mission COVID Suraksha, whereby, an electronic volunteer database with 150000+ subjects, has been established. Mission COVID Suraksha also supported 11 immunogenicity and animal challenge facilities.

Augmentation of manufacturing facilities for enhanced COVAXIN® production, was supported at BBIL, Malur facility; IIL, Hyderabad; Gujarat Biotechnology Research Centre and Hester Biosciences Ltd., Ahmedabad. BBIL has achieved a production capacity of 4.5 Cr. doses equivalent of DS per month; IIL has achieved a capacity of 20 lakh dose equivalent DS/month and ~1.8 Cr. doses equivalent DS has been transferred to BBIL.

A broadly protective coronavirus vaccine candidate is being developed by THSTI, Faridabad and Panacea Biotech, New Delhi, with support from CEPI. The bioassay lab at THSTI, recognized as one of the seven laboratories, globally, for centralized assessment of COVID 19 Vaccines, performed neutralization assays

for the COVID-19 vaccines of Biological E, India; Medigen Vaccine Biologics Corp, Taiwan; Nanogen Biopharmaceuticals, Vietnam.

Two AIs of DBT, NIAB, Hyderabad and NCCS, Pune, have been upgraded as CDLs, with support from PM-CARES Funds, for enhanced testing and lot release of vaccine batches from the manufacturers.

The DBT India Consortium for COVID-19 research, at THSTI, Faridabad, conducted a study on 'Effectiveness of Chadox1 nCov-19 Vaccine Against SARS-CoV-2 Infection During the Delta (B.1.617.2) Variant Surge in India', with part support under the Ind-CEPI grant. This was the first study in India to show vaccine effectiveness of Covishield against the delta variant (63% in fully vaccinated individuals; 46% in individuals vaccinated with a single dose; 81% in wholly vaccinated against the moderate-to-severe disease; 79% in those vaccinated with a single dose against moderate to severe disease). The study was published in Lancet Infect Dis. (Impact Factor 46.750).

The team of researchers at THSTI, Faridabad, studied the neutralisation of omicron (B.1.1.529) variant by antibodies induced by vaccine alone or SARS-CoV-2 Infection plus vaccine (hybrid immunity) post 6-months. The study partially supported under the Ind-CEPI grant, was the first report from India to demonstrate significant drop in neutralization of the Omicron variant by pre-existing antibodies to SARS-CoV-2, in individuals who were either vaccinated or had hybrid immunity. The study was published in E BioMedicine (Impact Factor 11.2).

Researchers at IISc, Bengaluru, generated SARS-CoV-2 VLPs in a baculovirus expression system, for the prototype Wuhan sequence along with spike protein mutants like D614G and G1124V and the significant RG203KR mutation in nucleocapsid. This platform permitted the assessment of the role of all viral structural proteins in the context to viral entry and triggering immune response. An Indian Patent Application No. 202141022412 "Coronavirus based Virus Like Particles (VLPs), methods and applications thereof", has also been filed.

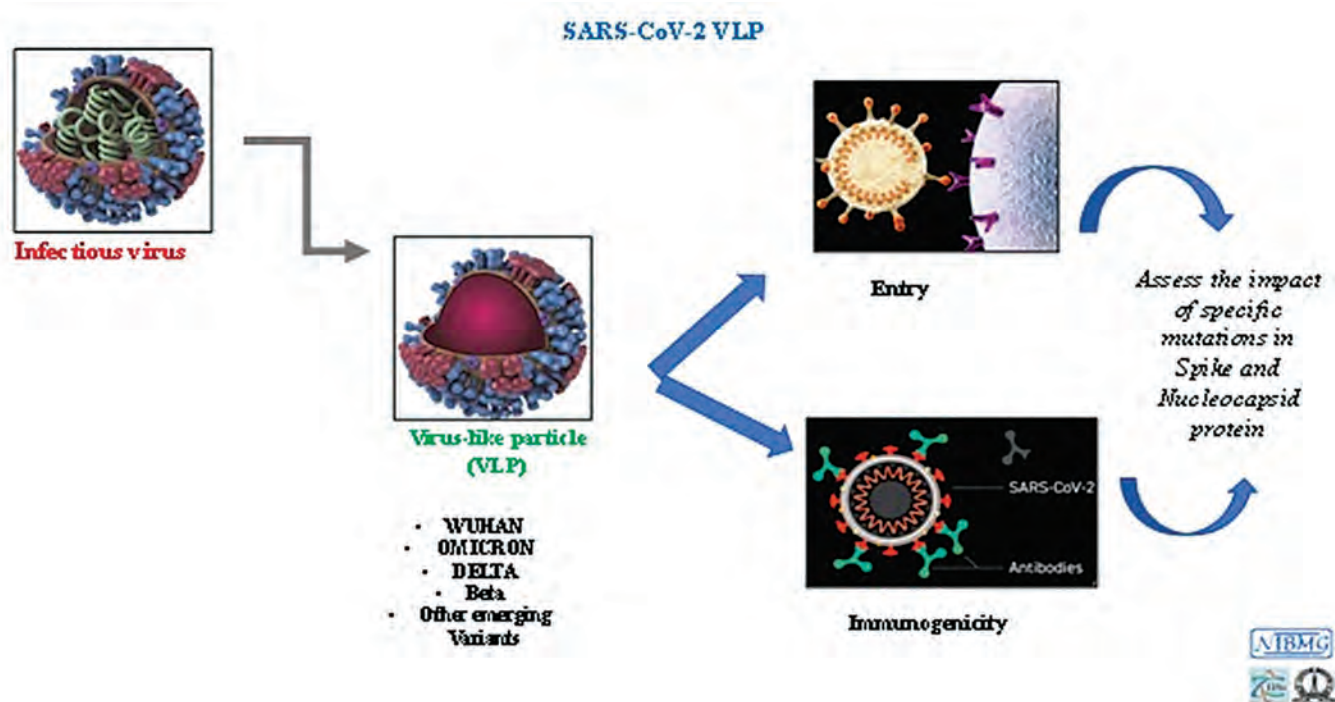


Fig4.3: Development of SARS-CoV-2 VLP system

4.6 INSACOG: INDIAN SARS-COV-2 GENOMICS CONSORTIUM

The SARS-CoV-2 Genomics Consortium (INSACOG) was established in December 2020 with the overarching aim to expand whole genome sequencing of SARS-COV-2 virus across the nation. The sequenced viral genomes analyzed by the respective sequencing laboratory are regularly shared with the Central Surveillance Unit (CSU) works under Integrated Disease Surveillance Programme (IDSP) at the National Centre for Disease Control (NCDC). The NCDC further correlates this data with the field data trends and establish the associations (if any) between the emerging SARS-COV-2 variants and epidemiological data based on COVID data generated by State and District Surveillance Units of IDSP.

INSACOG was established with 10 National laboratories and has expanded to 59 laboratories across the country in Hub and spoke model, where the 10 National laboratories act as mentor organizations for the other laboratories which have been added to the network, as part of infrastructure and genome sequencing capacity building efforts. The cumulative total number of samples sequenced by labs associated in INSACOG (~2.70 lakh) and their efforts in MoU with states (~0.37 lakh) is over 3.07 lakh. More than 2.7 lakh sequences have been uploaded from India in data repository of global database GISAID portal. The Consortium also submits all genome sequencing data in Indian Biological Data Centre (IBDC), located in Regional Centre for Biotechnology RCB, Faridabad.

By end of 2021, India witnessed heightened preparedness during the introduction of Omicron in the country. The first case of Omicron case was detected by South Africa and reported to the WHO on November 24. Union health ministry revised the guidelines for international travellers arriving in the country and sent directive to conduct stringent screening at airport and take necessary

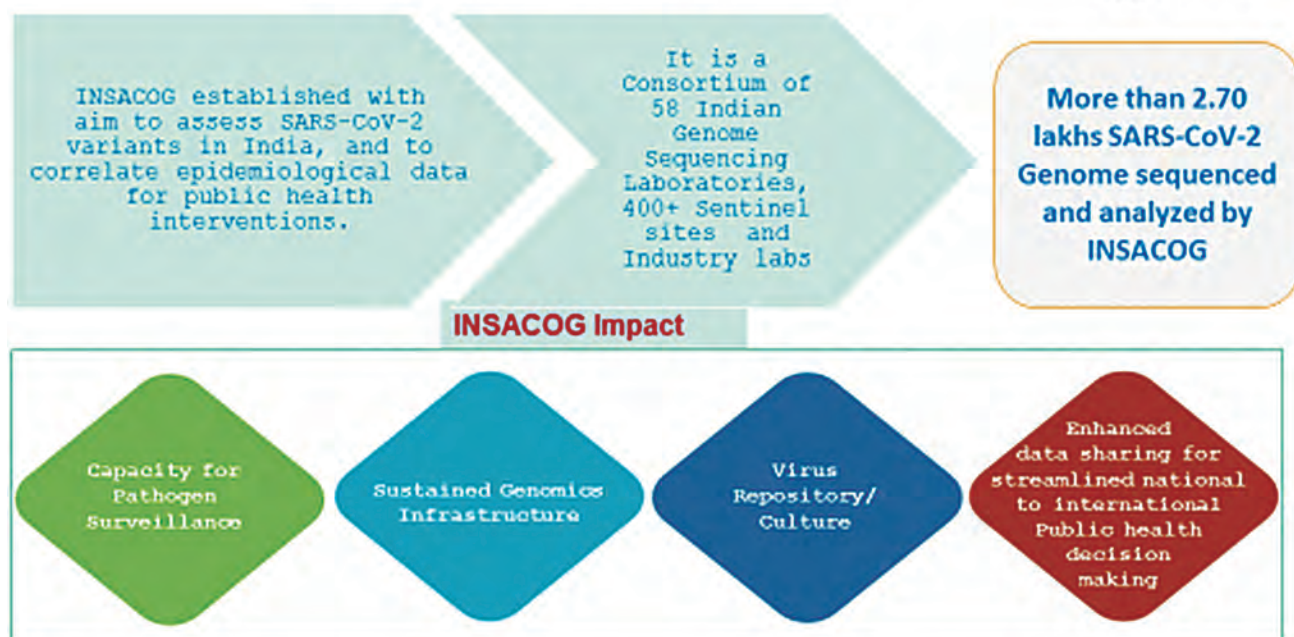
precautionary action. The RT-PCR positive samples were sequenced by INSACOG labs on priority basis to contain the spread of the variant in India. The first case of Omicron was detected by INSACOG in Karnataka from an International traveller whose sample collection date was 28th November 2021. The sampling strategy was revised to scale up sequencing in all metro cities to detect Omicron, as international airports were located in most of them and thus at risk of introduction of variants which could then spread to the rest of the country.

In order to gain more detailed insight into transmissibility and immune evasion potential of Delta, investigations have been carried by INSACOG and its collaborators, which have been published in high impact Journals like Nature and Science. In the first publication, the virus replication kinetics and spike-mediated infectivity assay shows that Delta (B.1.617.2) variant had higher replication efficiency and spike-mediated entry than Kappa (B.1.617.1) variant, thus, its possibly elucidation the dominance of delta variant. In second, it has been reported that the high transmissibility and partial evasion of immunity by the Delta variant contributed to an overwhelming surge in various states like Delhi, Maharashtra and Kerala.

In order to establish clinical correlation, understand disease severity, INSACOG has also established a dedicated Hospital-IGSL network. The overall project is conceptualized as a longitudinal cohort study of two cohorts. Two approaches to enrol participants with SARS CoV2 infection are being followed up. The first approach (Group 1) enrol participants from testing centres, and the second approach (Group 2) enrol hospitalized patients. Both the cohorts are being followed up for immediate outcomes and post COVID sequelae and complications. Patients who report and test positive for SARS-CoV-2 infection at testing centres are being included and followed up for studying their clinical course and need for hospitalization. The hospitalized patients who test

positive for SARS-CoV-2 being studied for the risk factors for moderate-severe disease, clinical course and outcomes. Data is being collected from 14 participating institutions. Exposure assessment and detailed clinical history being documented. Nasopharyngeal swab samples collected at the time the recruited patients tested positive for SARS-CoV-2 being sent for genome sequencing to detect SARS-CoV-2 variants.

In an effort to mitigate the SARS-CoV-2 genomic surveillance disparities in South-East Asia, it is proposed that INSACOG extend and share its Genomic surveillance expertise in India's neighborhood by hand-holding and mentoring scientists in these countries. This will strengthen the regional surveillance network and capacity building by imparting relevant training.



05

**BUILDING
INTERNATIONAL
COLLABORATIONS AND
PARTNERSHIP**

5

BUILDING INTERNATIONAL COLLABORATIONS AND PARTNERSHIP

The Department of Biotechnology is actively engaged through multifaceted approaches of international collaboration programmes and partnerships such as bilateral collaboration, multilateral collaboration, international NGOs and partnerships with non-profit organizations in the mutually agreed areas to strengthen research & development as well as science diplomacy. These engagements are nurturing Indian scientific community by filling gap of technology and capacity building in frontiers areas of natural sciences. Currently the Department has ongoing joint R&D programmes with USA, Canada, Australia, UK, Spain, Sweden, Switzerland, Netherlands, Denmark, Belgium, Finland and Germany, BRICS, QUAD, G20, TaSE, Globalstars (EUREKA), partnership HFSPo, EMBO, Bill and Melinda Gates Foundation (BMGF) and the Wellcome Trust (WT) in the areas of vision research, life sciences, digital health, tele-medicines, COVID-19 health impact, Antimicrobial resistance, circular economy, system medicines, climate smart agriculture, capacity building and fundamental research in biotechnology etc.

Major Quantitative achievements during the year 2022-23:	
Projects completed	193
Research Publications	296
Human Resources Trained	360

Bilateral Cooperation:

A. Indo-Australia: Since its establishment in 2006, the Indo-Australian Biotechnology Fund (IABF) has supported collaborative, cutting-edge research between scientists in Australia and India across a range of jointly agreed priority areas. So far, 14 calls

have been announced and this partnership has supported 56 joint projects in various areas of life sciences. Current Joint Call is proposed on AMR and RNA Vaccine to be announced in January 2023. Some of the salient outcomes achieved under this joint collaboration is as below:

- **An advanced therapy for ocular surface disease:** Researchers from India's LV Prasad Eye Institute and the Centre for Eye Research Australia have collaborated to develop techniques to lower the costs and increase the availability of treatments for limbal stem cell deficiency.
- **A new hepatitis C vaccine:** A team of Australian scientists, based at the University of Adelaide and Indian Institute of Science, Bangalore, India worked together to develop a vaccine ready for clinical trials.
- **A new frontier in HIV/AIDS vaccine research:** Australian researchers at the University of Melbourne have teamed up with their Indian counterparts at NARI, Pune, India, to study Elite Controllers and their ADCC antibodies for a game changing discovery in the fight against HIV.
- **New drugs to help fight the diabetes pandemic:** With support from the Australia-India Strategic Research Fund, the University of Queensland's Institute for Molecular Bioscience worked with Indian Institute of Chemical Technology, Hyderabad to identify potential new anti-inflammatory therapies for type-2 diabetes.

B. Indo-Belgium: Under Indo-Belgium bilateral partnership program, the Department had announced a joint Call for proposal between with Belgian Federal Science Policy Office (BELSPO), Belgium in thematic areas related to Life Sciences with focus on Micro-organism and Marine Biotechnology in 2021. 4 projects approved for joint implementation from both the sides.

C. Indo-Canada: Under and overarching Agreement between India and Canada, Network of Centres of Excellence (NCE) program, India-Canada Centre for Innovative Multidisciplinary Partnership to Accelerate Community Transformation and Sustainability (IC-IMPACTS) program was created in the year 2013 to develop and implement community-based solutions to the most urgent needs of both the countries. Through 3 joint Calls, the Department has supported 13 projects with IC-IMPACT, Canada. A Joint Call was announced in July 2022 in the area of “Building Resilient and Carbon-Neutral Communities Post Covid”. 27 proposals received under this Joint Call are under process of evaluation.

A team at McMaster University, Canada and University of Delhi has been working to develop a portable point of care diagnostic tool to detect infectious diseases from swab samples without the need for laboratory analysis based on isothermal amplification.

D. Indo-Denmark: Under the broader Bilateral MoU between India and Denmark in the fields of Science, Technology and Innovation, a programme of cooperation (PoC) was signed between Department of Biotechnology, Government of India and the Agency for Science and Higher Education (SFU), Ministry of Higher Education and Science (UFM), Kingdom of Denmark in the mutually agreed areas of

cooperation of Energy, Water, material Sciences and Life sciences & Biotechnology in 2018.

MUSTER: Musculoskeletal Stem Cells Targeting project team from Indian Institute of technology Kanpur, SCTIMST, Thriuvananthapuram and CMC, Vellore from India and University of Southern Denmark has reported BMP signaling up regulation which establishes that this signaling mechanism can be a potential therapeutic target for osteoarthritis.

E. Indo-Finland: The Department has signed MoU with Tekes and Business Finland, however, in the year 2018, Tekes merged into Business Finland. Hence, Department has an active collaboration with Business Finland since 2018. So far 40 joint projects have been implemented through 11 Joint Calls.

A scientific team of IIT, Chennai and VTT Technical Research Centre of Finland have developed a machine learning model that can use genome sequencing data to detect cancerous mutations in the body. The model will help in identifying the most appropriate treatment strategy for a patient through an approach known as “precision oncology” and “tailoring treatments” not only to a specific illness but also to a person’s genetic make-up is challenging and requires extensive cataloguing of the ‘driver’ variants of interest.

F. Indo-German: The Department has an active collaboration with German Federal Ministry of Education, Science Research and Technology (BMBF) and Deutsche Forschungsgemeinschaft (DFG) under the overarching S&T agreement between India and Germany. The Department has jointly implemented 42 projects till date successfully with these agencies in Germany through Joint Call mechanism in the thematic areas of Life Sciences, Biodiversity, recycling

of bio-degradable waste and use of Bio-informatics in health. The Department had announced a joint Call with DFG in 2020 in the area of Fundamental research and 4 projects approved for joint implementation. Further, Program of Cooperation (PoC) with DFG is extended up to October, 2030.

Under an ambitious R&D program between DBT and DFG, a multi-centric institutional study is under joint implementation on The Rural-Urban Interface of Bangalore: A space of Transitions in Agriculture, Economics, and Society from both India and Germany. Some of the salient findings are as below:

- Urban irrigation water quality falls under the doubtful to not acceptable category, transition samples fall under the permitted to doubtful category, and rural irrigation water falls under the ideal to permissible categorization.
- Rural zone of both southern and northern transect contains higher amount of heavy metals.
- Rural zone contains higher pesticide contents than the urban rural transect.
- A significant difference was noticed in socio-economic changes among agricultural households of rural gradient of north and south transect of Bangalore region due to adoption of modern agricultural technologies between the years 2011 and 2021.
- The proportion of women empowerment was high in urban area followed by transition and rural area.
- Significantly higher available iron and manganese content was recorded in transition soils as compared to rural and urban areas.
- Species richness of flowering plants was highest in urban sites by a wide margin.

In a joint project between DBT and DFG a group of scientists from both the sides are trying to bring together complementary expertise in Biochemistry and Drosophila genetics from CDFD and TIFR, Hyderabad from India and Chemical Synthesis from Institute of Organic Chemistry, Freiburg, Germany to address the shortcomings in the understanding of polyP biology in multicellular eukaryotes.

A team of scientists from both Central Scientific Instruments Organisation, Chandigarh, India and IWE1, RWTH Aachen University, Aachen, Germany tested nMOF/drug mixtures against *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus lentus*, and *Listeria monocytogenes*, the nMOF/drug mixtures demonstrated synergistic (IRMOF-3/kanamycin) or additive (other nMOF/drug combinations) effects compared with the nMOFs or antibiotics alone (Fig. 5.1).

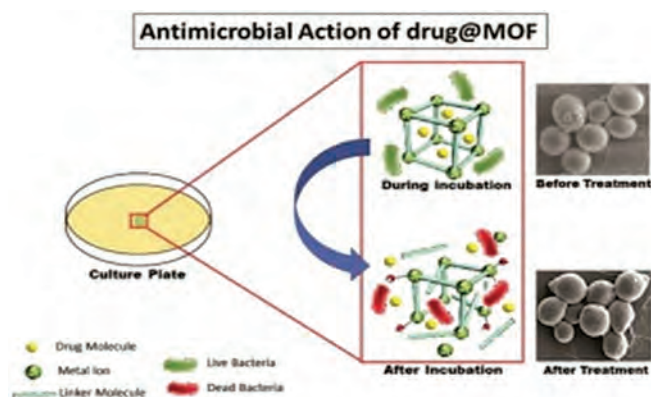


Fig. 5.1: MOF: Antimicrobial Action of drug

G. Indo-Netherlands (Dutch): Under an overarching S&T Agreement between India and Netherlands in 2008, a programme of cooperation (PoC) was signed between Department of Biotechnology, Ministry of Science & Technology, Government of India and 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 in 2011. Till date 6 projects have been successfully implemented and 4 are under implementation under this bilateral program through 4 Joint Calls in the areas of Crop sciences; Technology for a sustainable Healthcare Minimally Invasive Techniques; Water for health and; Climate Smart Agriculture. The Program of Cooperation (PoC) is extended with Directorate General for Enterprises and Innovation, Netherlands up to May, 2027.

- Under Indo-Dutch joint collaboration, DBT with NWO, Netherlands is implementing a flagship program on LOTUS: Local Treatment of Urban Sewage Stream for Healthy-Reuse (LOTUS-HR) with the aim to demonstrate a novel holistic waste water management approach to produce clean water and that can be reused for various purposes (e.g. industry, agriculture, construction etc.), while simultaneously recovering nutrients and energy from the urban waste water, thus converting drain into profitable mines. This joint effort is an excellent example of combining Indian low cost innovation with the Dutch multi-disciplinary approach undertaken at IIT, New Delhi, TERI, Gurugram and NEERI, Nagpur in India and TU DELFT and Wageningen University in Netherlands.
- On the successful implementation of small lab scale Anaerobic Hybrid Reactor (volume 0.1 m³/d) by IIT Delhi, an Anaerobic Membrane Bioreactor (AnMBR) by TERI and a Diffusion Afflotation Bioreactor (DAF) by Netherlands have been installed at the Barapullah site, New Delhi. Reactors are being used to produce treated water with production of energy, potable water and water for various purposes like agriculture, sanitation and Construction. Based on the studies of small bioreactor, a pilot plant (10 m³/d), at the Barapullah site, and further

scaling it upto 100 m³/d – 1000 m³/d have been approved for Phase II of this project.

- H. **Indo-Spain:** Under a broader MoU between India and Spain signed in 2007, a Programme of Cooperation (PoC) for technological co-operation in biotechnology has been signed between DBT and Centre for the development of Industrial Technology (CDTI), Government of Spain in 2011 with an aim to promote and fund innovation-driven research and technology development as well as to encourage partnerships and business-led R&D&I collaborative projects in the field of biotechnology. Till date, 6 Joint Calls have been announced and total 9 projects have been successfully implemented from both the sides.
- A scientific team from Natural Remedies Pvt. Ltd, Bangalore and Plants Medicinales de Catalunya S.A. Avdapat de la Riba, Spain has developed a fluorescent based aptasensor with “turn off” principle for both Aflatoxin B1 (AFB1) and Ochratoxin A (OTA).
 - Another group of scientists from Jay Research and Biotech India Pvt. Ltd, Pune and Aclalde Domingo Torres, Valencia, Spain has developed a bio-organic preparations as per the requirement of farmers (Rain fed, flood irrigation and drip irrigation).
 - A scientific team from Loyola College, Chennai & Madras Diabetes Research Foundation, and Chennai with University of Valencia Science Park, Spain has designed a new small instrument for the production of sugar free juice at household scale. Immobilized yeast cells were used for the successful production of sugar free and non-alcoholic juice from pomegranate, watermelon, sweet lime, orange and apple without affecting their nutritional constituent.

- I. **Indo-Sweden:** Under an overarching S&T agreement signed between India and Sweden in 2005, the Department of Biotechnology has signed a Programme of Cooperation with VINNOVA, a Swedish Innovation Agency, Sweden on 21st August 2018. DBT with DST, MoES and BIRAC has signed another PoC with Swedish agencies FORMAS (the Swedish government research council for sustainable development), Vinnova (Sweden's Innovation Agency), Forte (the Swedish Research Council for Health, Working Life and Welfare), the Swedish Research Council and the Swedish Energy Agency and announced a Joint Call in the area of Circular Economy in the year 2022. 30 projects received under this joint activity are under process of evaluation. The Program of Cooperation (PoC) with VINNOVA, Swedish agency is extended up to August, 2024.

Pursuant to the overarching S&T agreement between India and Sweden, a Joint Program of Cooperation (PoC) has been signed in June 2022 between Department of Biotechnology, DST, MoES, BIRAC from Government of India and Formas, the Swedish government research council for sustainable development, Vinnova, Sweden's Innovation Agency, Forte, the Swedish Research Council for Health, Working Life and Welfare, the Swedish Research Council and the Swedish Energy Agency from Sweden.

Under DBT-VINNOVA joint partnership, an ambitious project on AFFECT: AI for Long-term Monitoring of Hemiparetic Patients is under implementation at Christian Medical College Vellore, India and Lund University, Sweden. The team has started designing and building the inertial measurement unit (IMU) – based wristwatch for measuring arm movements. A scientific team from IEST, Shibpur, India and Uppsala University, Sweden have initiated a joint effort on AI based Detection of Acute

Respiratory Distress Syndrome (AI-DARDS) with the aim to develop and complete a new medical technology system AI-DARDS, to enable healthcare in rural areas and in smaller towns to be diagnosed, monitored, and treated for non-cardiogenic pulmonary edema, a disease that is fatal to many patients.

- J. **Indo-Swiss:** Under the broader umbrella of MoU between India and Switzerland in the area of Science & technology, the Department has an active collaboration with Swiss National Science Foundation (SNSF) since 2017. 2 rounds of Joint Calls have been announced till date.
- Under an Indo-Swiss joint research a group of scientists from NIPGR, New Delhi and Université de Lausanne Switzerland have demonstrated an efficient method to produce marker-free gene-edited rice plants using CRISPR/Cas9. Such innovations would accelerate the production and use of gene-edited crops.
 - In an another joint study, a scientific team from IIT, Delhi and Kanpur from India and University of Basel, Switzerland is working on articular cartilage regeneration which can significantly contribute to pave the way of treating articular cartilage degeneration to lead a quality of life.
 - In a collaborative project with University of Lausanne, Amrita Centre for Nanoscience and Molecular Medicine is developing novel cancer vaccines and immunotherapeutic by utilizing the nanotechnology. The team developed three immune therapeutic components: A cancer nano-vaccine loaded with model tumour antigens and nano-adjuvants targetd to TLR/STING agonists (n-ITC1); a locally injectable nano-hydrogel platform for the slow and controlled release of anti-tumor cytokines (n-

ITC2); and an intra tumoural nanoparticle gel implant that can release immune checkpoint inhibitors and immune suppressor cell inhibitors locally in the tumor micro environment (n-ITC3). These three components will be used to optimize a combinatorial strategy addressing three critical aspects of cancer immunotherapy.

K. **Indo-UK:** The Department has active collaboration with the Innovate UK, and seven research councils (Biotechnology and Biological Sciences Research Council (BBSRC), Economic and Social Research Council (ESRC), Engineering and Physical Sciences Research Council (EPSRC), Medical Research Council (MRC), Natural Environment Research Council (NERC), Science and Technology Facilities Council (STFC), Innovate UK) under the UKRI.

- The DOSA Project (Diagnostics for One health and user driven Solutions for Anti-microbial resistance) is an interdisciplinary research project which brings together nine leading academic institutions, five from India and four from the UK being led by scientists from University of Edinburgh and IIT Delhi. The team developed innovative diagnostics to curb antimicrobial resistance (AMR) for three different settings (community healthcare, dairy and aquaculture settings) in India (Fig. 5.2).



Fig. 5.2: UTI diagnostic bundle.

- In another project under DBT-UKRI collaboration, a group of researchers from IIT, Bombay and University of the West Scotland jointly developed an optical fiber based sensor for Ciprofloxacin.
- For the pollution assessment, a preliminary sampling campaign for a dry season confirmed that polluted sites from River Adyar showed more antibiotic resistant genes from microbial communities compared to sites from River Musi.
- Another INDO-UK project aimed at collecting different sample types such as poultry, livestock, humans, fish and environment from three pre-determined sites in Guwahati, Assam. The research outcome has highlighted the persistence of ESBL-producing *E. coli*, *K. pneumoniae* and MRSA in the fishery environment through different seasons.
- Under another Indo-UK project, two analytical methods were standardized for 9 and 3 antibiotics each (Enrofloxacin, Ciprofloxacin, Tylosin, Erythromycin, Oxytetracycline, chlortetracycline, Lincomycin, Virginiamycin and Penicillin G) and (Dimetronidazole, Metronidazole and Ronidazole) in broiler meat samples.
- The Department joined hands with Department of International Development (DFID), the Economic and Social Research Council (ESRC) and the Medical Research Council (MRC) of UK in order to initiate Global Research Program, a flagship program under India-UK bilateral cooperation aiming to facilitate global health research addressing the health needs of women and children globally. 6 projects are under joint implementation at LMIC settings for different health and nutrition related trials.

- A cluster randomized trial of mHealth consists of an electronic decision support system (EDSS), provided to healthcare providers at primary-level facilities in India and Nepal to deliver enhanced ANC with improved detection and management of pregnancy-induced hypertension (PIH), gestational diabetes mellitus (GDM) and anaemia.
 - Another study, Comprehensive Anaemia Program and personalized therapies, is designed to evaluate the effect of two home-counseling visits to pregnant women with tailored iron folic acid supplementation, plus monthly participatory learning and action women's groups, on haemoglobin levels at 28-32 weeks of pregnancy.
 - In another trial, a team of scientists is studying the effectiveness of incentives, either involving directly paying cash amounts or providing free services in private health facilities, are successful in improving some of the most important indicators related to improved health care services directed at pregnant women and young children.
 - A multi-centric clinical trial across India and Zambia aims to determine whether recognition and accurate diagnosis with delivery (bringing on labour within 48 hours or caesarean) or 'watch and wait' management is better for women with pre-eclampsia living in India and Zambia.
 - Another trial aims to evaluate the efficacy of yoghurt consumption and increased PA (daily walking) in reducing GDM incidence in high-risk pregnant women. The study is a 2x2 factorial, open-labelled, multicentre randomised controlled trial.
 - Following contextual analysis, a team of experts developed an educational/behavioural intervention for GDM delivered through a package of culturally tailored films. This trial is under implementation to evaluate whether the intervention can improve the timely detection and management of GDM in two LMIC settings {Uganda (Entebbe) and India (Bengaluru)}.
- Indo-UK: Agricultural Food sector in reference to Post Harvest losses:** 3 innovative R&D projects were supported under this Joint Call to enhance rice milling and maximized valorization of rice milling by products at IIT Roorkee; development and optimization of fresh produce supply chain and storage systems at CIAB, Mohali; and bio-based packaging for fresh food at MIT, Pune.
- Indo-UK: Industrial waste management:** 4 Joint projects were implemented to address valorizing waste from sugar cane at ICGEB, New Delhi & VSI, Pune and analyzing the biorefinery value from industrial waste at IICT, Hyderabad; and integrating bio-refinery for converting paper mill waste into chemical wealth at IIPM, Dehradun.
- L. Indo-USA:** The mandate of Indo-US bilateral cooperation is to strengthen research focusing on ophthalmic disorders, diabetic retinopathy; genetics of ophthalmic diseases and ocular inflammation. Under Indo-USA Vision Research program, DBT-NEI Funding Opportunity Announcement (FOA) in the area of "Vision Research" has been announced in June 2022. 7 proposals received under this FOA are under process of evaluation. The current effort under this program targets the rod and cone cell photoreceptors to understand the underlying concepts behind blinding retina conditions.

- The Indo-U.S. Vaccine Action Program (VAP) is a bilateral program, under implementation since 1987, with an aim to support: novel vaccine research, human immunology, vaccine-related technologies, translational research, and other activities of shared scientific interest. This is implemented by the Department of Biotechnology (DBT) and the Indian Council of Medical Research (ICMR) on the Indian side in

collaboration with the National Institute of Allergy and Infectious Diseases (NIAID), National Institutes of Health (NIH) on the US side. A Joint statement of Indo-US VAP was signed by Dr. Rajesh S. Gokhale, Secretary, DBT and Dr. Anthony Fauci, Director, NIAID in the presence of the Honorable Indian Ambassador to the United States, considering the five year extension accorded to the programme till 2027.



Fig. 5.3 The Joint statement of Indo-US VAP was signed by the Secretary, DBT and Director, NIAID in the presence of the Hon'ble Indian Ambassador to the United States.

Multilateral Cooperation:

- A. European Union:** The Department has partnered with the European Commission in areas like waste-water treatment, vaccine development, Tuberculosis Research, etc. Recently the Department has partnered with the EU to support research to develop Rapid Solutions and Higher Preparedness to COVID 19. The details of scientific outcome of the DBT-EU collaboration have been summaries below:

Influenza Vaccine: To overcome the need to modify the flu vaccine every year and to increase its breadth and length of protection the Indian scientific community is actively

engaged in the development of the vaccines through multifaceted approaches of three projects under DBT-EU collaboration.

- The “INCENTIVE” consortium is working towards developing a computationally optimized antigen-based universal vaccine that can protect against seasonal and pre-pandemic strains of influenza. It has completed pre-clinical studies in mouse and ferret animal models that showed promise for protecting against flu viruses.
- The ENDFLU project have tested several novel subunit vaccine designs in mouse immunizations and shown to protect against high-dose viral challenge. Novel MVA constructs containing polyepitopic sequences designed to

elicit broad T-cell immunity have been designed and tested *in-vitro*. A new ferret facility has been created at THSTI, Faridabad to test vaccines for respiratory viruses.

- The INDIGO project has transferred technology of MDPA adjuvant system formulation to Gennova biopharmaceutical. Additionally, as a part of INDIGO initiative CMC Vellore successfully conducted and concluded a five-day ISIRV respiratory virus school which included more than 70 participants across the globe.

Maternal and Child Health: The ORCHESTRA (Connecting European Cohorts to Increase Common and Effective Response to SARS-CoV-2 Pandemic) project has observed that 68% of the pregnant women were seropositive to SARS-CoV2 in studied Indian cohort. Developmental changes identified by histopathology of the placenta and placental membranes reveal mal perfusion and presence of intravillous & intrafibrinous particulate microcalcification that has been observed more in COVID + mothers.

Water Cooperation: The Water Cooperation under DBT-EU collaboration through three projects is looking for innovative ways to fulfil SDG6 by unlocking the environmental and economic potential of municipal wastewater treatment and reuse solutions for urban and peri-urban areas in India.

- PAVITRA GANGA provides solutions to increase treated effluent quality at optimised cost, which

will result in more sustainable and extended water reuse (and in particular reuse as irrigation water being the largest water consumer), contributing to resolving water quantity issues especially during extended dry periods. Project demonstrates the developed treatment methods and trains in the field at two sites and some of the low-cost mobile monitoring solutions suitable for participatory monitoring that promote the awareness of water issues and solutions.

- SPRING intends to develop innovative bio-oxidation systems and real-time monitoring tools as affordable and innovative solutions for implementing good water practices for treatment of water bodies. In this regard, high resolution thematic maps of the Godavari and Ganga study areas have been developed and the enzymes required for the bio-oxidation system has been cloned and is undergoing scale-up studies.
- The INDIA-H₂O project is to develop, design and demonstrate high-recovery low-cost water treatment systems for saline groundwater and for domestic and industrial wastewaters. Under this project CSIR CEERI accessed groundwater quality and the effect of seawater intrusion at Lodhva village (pilot field site) through indigenously developed low-cost IoT-enabled wireless device. The pilot plant for low-cost ground water and domestic waste water treatment is installed at PDEU for research and demonstration purposes.

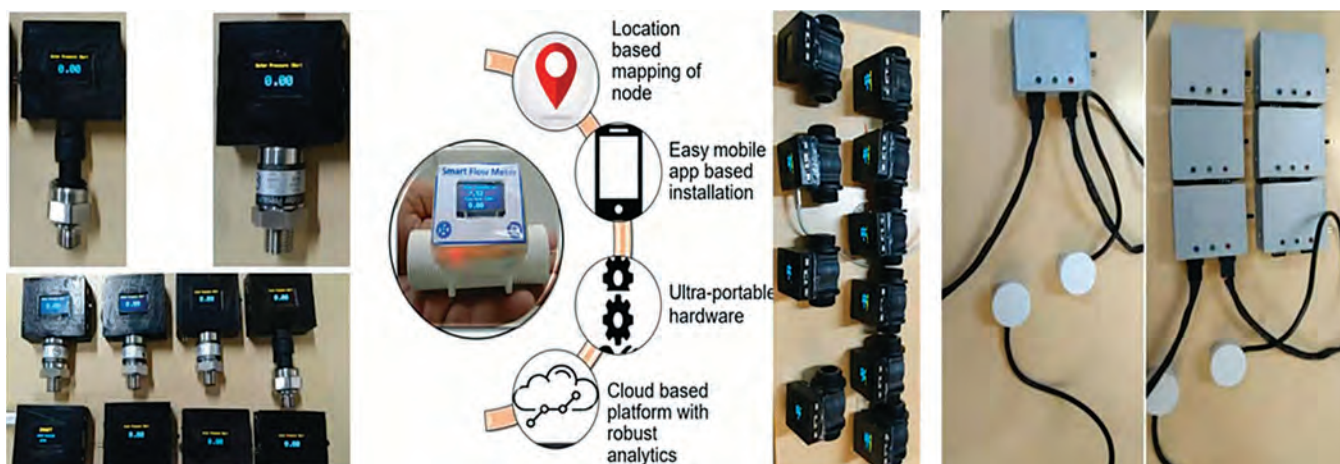


Fig. 5.4: Development of sensors under Water Co-operation

- **Tuberculosis:** The ARREST-TB project is working towards developing simpler, affordable, accurate diagnostic test for TB and Multi-Drug Resistance (MDR) TB, with a colorimetric read-out that can be interpreted and conveyed via a mobile phone app. The ICMR-NIRT, Chennai team is trying to approach TB diagnostics through Rapid 'specific' staining of Mycobacteria in sputum (no wash probes), rapid molecular tests for TB and MDR TB (using DNA extraction), blood-based biomarkers for TB (miRNA detection device), and development of study based RedCap Database for data collection.
- Under *in-silico* trial for Tuberculosis Vaccine Development (STriTuVad) project therapeutic vaccine trials at AIIMS, New Delhi and AGMC, Agartala for RUTI® vaccine are going on. This study will randomize a total of 140 patients of

MDR-TB and Pulmonary DS, between the placebo arm and the RUTI® arm.

- DBT-EUREKA:** EUREKA is an inter-governmental organization of 44 countries that funds market driven industrial R&D. The department under 'GlobalStars Initiative' is implementing four projects with UK, Netherlands and Spain on 'One Health' and 'key enabling technologies for healthcare, agriculture and water'.

The ExoLiv study has designed DNA EpCAM aptamer and RNA/DNA hybrid aptamer along with positive aptamer, negative aptamer and linker for the conjugation of aptamer with the extracellular vesicle. This was followed by analyses of the effect and penetration of aptamers in HepG2 spheroids.

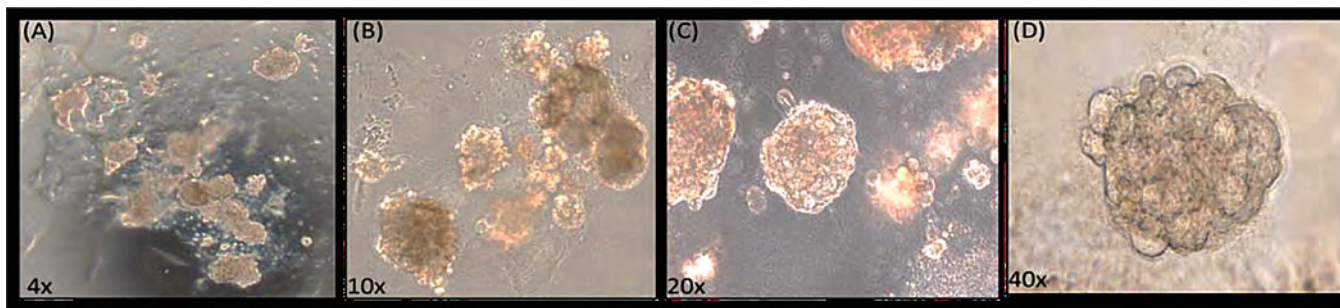


Fig. 5.5: The phase contrast image of HepG2 spheroids at various magnification (A) 4X, B) C) and D) 40X.

The EggsTEND project is to develop the first sustainable and economically viable bio-coating technology to extend the shelf-life of eggs. The coating technology will reduce the risk of contamination by microorganisms, metals, and chemicals and will make egg supply chain more sustainable and resilient to climate change. The field trials for assessment of effectiveness of liquid seal coatings to maintain internal quality of stored fresh eggs is underway.

C. DBT-BRICS: The Department of Biotechnology has implemented multilateral two projects on COVID-19 under BRICS STI Framework Programme for two-year duration as a proof of concept. Further, the department has participated in the 5th coordinated call for BRICS multilateral projects under BRICS STI Framework Programme. The NGS-BRICS consortium aims to accelerate the translation of genomic data into clinical and public health research and interventions by allowing a more comprehensive and accurate detection of COVID-19 lineages from clinical and surveillance samples, the genomic technologies and epidemiologic and bioinformatic tools. It has standardized a method for detection of Omicron and Delta variant using dd-PCR. The method is applicable for quick detection of known variants, especially helpful in case of surge like situations.

D. DBT-TaSE: The Natural Environment, Economic and Social, Arts and Humanities Research Council of UK Research and Innovation; Japan Science and Technology Agency; National Natural Science Foundation, China and The Swedish Research Council for Sustainable Development alongwith the

Department of Biotechnology (DBT) created Towards Sustainable Earth (TaSE) multilateral joint collaborative platform. It focuses on 'Human-Environment Interactions and the Sustainable Development Goals'. This partnership has implemented six projects for the duration of two years. The reported insights from these projects are given below which may be useful as inputs for policy planning on sustainable earth and environment.

- The OPTIMISM (Opportunities for Climate Mitigation and Sustainable Development) study is an international multi-stakeholder partnership and research network addressing the challenge of ensuring rapid and extensive action to mitigate climate change can be leveraged to deliver both United Nations Sustainable Development Goals (SDGs) (Agenda 2030) and a well below 1.5° C world. It has conducted Critical Assessment of Udaipur's LCMP and Surat's CMP along with GHG Inventory calculations for 2016 and 2030.
- The Opportunities and trade-offs between the SDGs for food, welfare and the environment in Deltas study for has developed an integrated assessment framework to examine SDG interactions within a sub-national delta level.
- SEELARI (Social-Economic-Environmental Trade-offs in Managing the Land-River-Interface) study has developed a multi-hazard susceptibility assessment map based on landslide and flood susceptibility. The ecosystem services delivered by a holistically-managed LRI would support the attainment of Sustainable Development Goals-SDGs 1, 2, 6, 7, 11, 13 & 15.

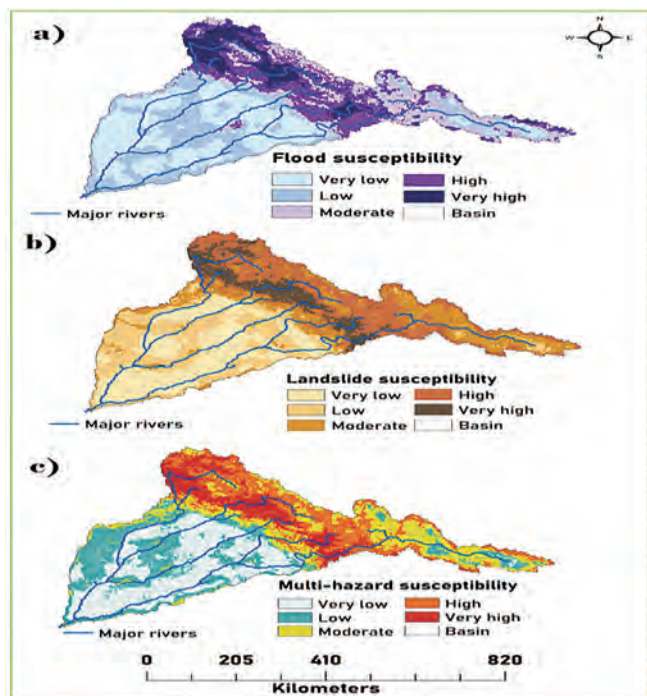


Fig. 5.6 Spatial distribution of susceptibility: a) floods, b) landslides and c) multi-hazard

- The PODCAST (Pathways of Dispersal for Cholera and Solution Tools) study has reported that chlorophyll-a concentration, sea surface salinity, sea level anomalies and land surface temperature are key predictors of the cholera outbreaks in the region. The sanitation survey in the coastal districts of Kerala shows that the coastal community is well aware of the essential hygiene practices and they adhere to safe practices of water consumption, but natural calamities upset normal life, and in many a case, lead to communicable diseases. It has recommended for better prediction, management and mitigation of natural disasters such as flooding and incursion of sea water into coastal homes to eliminate water-borne diseases in the study area.
- E. **QUAD:** The Quadrilateral Security Dialogue (QSD), commonly known as the QUAD is a strategic security dialogue between Australia, India, Japan, and the United States. Under this

cooperation the Department is participating in QUAD Critical & Emerging Technology Working Group (CET WG) Science and Technology “Horizon-scanning, Vaccine Manufacturing, Supply and Delivery Sub-group and Pathogen Genomic surveillance sub-sub group under Science & Technology Sub-group. Currently under the Pathogen Genomic surveillance the proposal for Extension of INSACOG Activities for the Neighboring Countries is under way.

Additionally, the Department is leading technical discussions on synthetic biology on potential developments among QUAD members, opportunities for research collaboration in emerging areas of Biotechnology areas are being explored on Track 1.5 Dialogue on Biotechnology Governance and Government-to-Government (Track 1.0) dialogue on synthetic biology.

- F. **G20:** The Department of Biotechnology under the Indian presidency of the G-20 actively engaged in the **Research and Innovation Initiative Gathering (RIIG)**. Under this activity the Department will lead discussion on ‘Circular Economy’ and will be organising RIIG side event on Circular economy. In this meeting delegates from G-20 countries, neighboring countries and international organizations will participate and share their expert views.

International Non-Governmental Organizations (NGOs):

- A. **DBT-BMGF Partnership (Grand Challenges India):** The Department of Biotechnology (DBT) and the Bill & Melinda Gates Foundation signed a Memorandum of Understanding (MoU) on cooperation in health and development issues on 18th July, 2012. This MoU has been renewed on 7th June 2022 for next five years to continue to explore and expand funding

arenas to tackle health and developmental issues. This joint partnership has supported programs in maternal and child health, nutrition, sanitation, infectious disease, data science, agriculture development and Vaccines in alignment with the Government of India priorities such as the National Health Mission Atmanirbhar Bharat, Swachh Bharat Abhiyan, National Nutrition Mission, Make in India etc.



Fig. 5.7 The renewal of MoU between DBT and BMGF (Secretary, DBT and India-Country Head, BMGF).

In the current year the qHPV vaccine project supported under GCI received marketing authorization approval from the Drug Controller General of India (DCGI) for CERVAVAC on 12th July 2022. Aligned with Government of India's accelerated plan to eliminate Lymphatic Filariasis (LF), GCI has launched an open call on "Diagnostics for Neglected Tropical Disease (NTD) – Lymphatic Filariasis (LF) to support diagnostics development intended for field use in the National LF Elimination Programme, primarily in India and globally.

06

**PROMOTING
ENTREPRENEURSHIP
AND INDUSTRIAL
GROWTH**

6

PROMOTING ENTREPRENEURSHIP AND INDUSTRIAL GROWTH

6.1 Biotechnology Parks

The Department of Biotechnology has established Biotechnology Parks/ Incubators to translate research into products and services across the country by providing necessary infrastructure support. It provides facilities to scientists, and Small & Medium sized Enterprises (SMEs) for technology incubation, technology demonstration and pilot plant studies for accelerated commercial development of biotechnology sector in the country. So far, the Department has supported 11 Biotechnology Parks in various States for 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. 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) Two Industrial Biotechnology Parks (IBTPs), Jammu & Kashmir; ix) Chhattisgarh Biotech Park, Naya Raipur, Chhattisgarh and (x) Biopharma Growth Phase park and a common Scale up manufacturing facility with training provision in Genome valley, Hyderabad .

Major achievements of ongoing projects of Biotech Parks during 2022-23 are as follows:

Biotech Park, Lucknow, Uttar Pradesh

Biotech Park, Lucknow was set up jointly by the Department of Biotechnology, Government of India

& Department of Science and Technology, Government of Uttar Pradesh and is functioning from 2007. The Park is striving to develop knowledge-based economy in biotechnology, assure benefits of biotechnology to all sections of the society, and promote entrepreneurship in biotechnology-based industry. The Park has been promoting growth of bio-pharma, agri-biotechnology and bio-service sectors by inviting biotech industry to the State; works in collaboration with state agencies and central institutes of R&D and learning; and transform the society through higher crop productivity, better human health, greater employment opportunities and improved quality of life. It organizes programs for farmers and other sections of the society to make them aware of latest advances & applications and provide latest biotechnology products accessible to farmers to improve their agriculture and horticulture output. 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. The Park has incubated a large number of entrepreneurs. Currently Biotech Park is hand-holding 12 incubatees out of which, 5 are new entrepreneurs. Presently Park is actively expanding its Analytical and Quality Assurance and Extraction Unit facilities along-with strengthening of HRD programs. 129 samples were tested by the Analytical Laboratory, which has helped many entrepreneurs, industry and research scholars. The Park is also providing the extraction facility to new venture business for agribusiness, pharmaceutical, biochemical, nutraceuticals, healthcare and other micro-manufacturing companies. During the current year, 8 companies have utilized services of extraction unit of Biotech Park, Lucknow. A total of 236 biotech/ bioscience students were trained in different areas

of Biotechnology for a period ranging from 1-6 months. The focus is on low investment high impact innovative product model. The Park has signed an MOU with Institute of Pharmaceutical Sciences (Lucknow University), Lucknow on 3rd February, 2022 for collaborative Human Resource Development, Entrepreneurship Development and Research & Development.

Technology Incubation Centre, Guwahati Biotech Park, Assam

Guwahati Biotech Park is the first Biotech Park in the North East India and is a joint initiative of Government of Assam and Department of Biotechnology (DBT), Government of India, where Science & Business forms a platform to promote entrepreneurship in the North East India. The new building of Technology Incubation Centre (TIC) of Guwahati Biotech Park was inaugurated by Shri Dharmendra Pradhan, Hon'ble Minister, Ministry of Education, Government of India, in presence of Hon'ble Chief Minister of Assam and Hon'ble Minister Science & Technology and Climate Change Department, Government of Assam on 20th May 2022 (Fig. 6.1). The TIC is equipped with fully furnished dedicated lab spaces and facilities which houses sophisticated equipment, best-in-class conference room, auditorium and meeting rooms. The Park has played a pivotal role in shaping Entrepreneurs/Startups through consistent training, mentoring and guidance and creating a positive societal impact by providing incubation support to technology oriented start-ups. The Business Enterprise Zone of Guwahati Biotech Park is expected to have a direct impact on the economy of the State. To accelerate the R & D activities and ignite the young minds to cultivate entrepreneurial ideas in biotechnology and allied fields, Guwahati Biotech Park organizes a 'Talent Search Contest on Innovative Research Ideas Leading to Entrepreneurial Venture in Biotechnology and Allied Areas' every year. The 6th edition of Talent Search Contest was organized in February 2022 in association with North East Agri Technology

Entrepreneurs Hub, Assam Agribusiness Growth Lab and Numaligarh Refinery Limited. The winners of the contest were offered co-working space free of cost for 3 months, free mentorship and guidance from experts of Guwahati Biotech Park. Guwahati Biotech Park in association with Indian Institute of Technology Guwahati hosted the two day Assam Biotech Conclave 2022 from May 21 to May 22, 2022.



Fig. 6.1 New building of Technology Incubation Centre (TIC) of Guwahati Biotech Park, inaugurated by Shri Dharmendra Pradhan, Hon'ble Minister, Ministry of Education, Government of India.

KRIBS BioNest, Kochi, Kerala

KSUM-RGCB Innovation and Bioincubation Society (KRIBS)-BioNest – Biotech Park – Kochi, supported by Department of Biotechnology, Government of India, is the 3rd off site Centre of Rajiv Gandhi Centre for Biotechnology (RGCB), functioning jointly with Kerala Start-up Mission (KSUM) within the Kerala Technology Innovation Zone, Kochi. The facility provides infrastructure and scientific support to enable researchers, investors and entrepreneurs looking to translate biological research, innovations and medical technologies into mature business ventures. Spanning over 44,000 sq.ft, it provides bio incubation space of over 17,000 sq. ft, and a common 1000 sq. ft laboratory to the start-ups housed within the facility. Presently, the facility has 29 physical incubatees and 9 virtual incubatees. The broad business verticals/laboratories include Analytical Biochemistry, Phyto-Technology, Cell and Molecular Biology and Bioprocess Engineering and it

conducts industry relevant research, supports upstream, downstream and testing facility to incubatees and contract research operations. BioNest has been able to collaborate with a number of industries to set up Corporate Research Operations. The Centre also attracts students for curriculum based project training and pre-employment training. The facility over the last 4 years has witnessed growth in terms of number of incubatees, creating employment opportunities, training students, and conducting industry based contract research projects. Incubatees have also made progress in terms of patents, products launched and technology transfers. Some of the products developed by the incubatees include: CoviKwik – a rapid immunochromatographic test for COVID-19 by Sushruta Innovations and Wellness Pvt. Ltd.; Smartlyse hand sanitizer and wet wipes by Omics Ggen Life Sciences Pvt. Ltd.; mobile phone sanitizer by Biophoton Technologies Pvt. Ltd.; Coliform detection it by Klonex Life Sciences Pvt. Ltd.; Spice extracts by Spiceor Bionutralites Private Limited.

Industrial Biotechnology Parks (IBTPs) At Jammu & Kashmir

The two Industrial Biotechnology Parks (IBTPs) in the UT of Jammu & Kashmir (one IBTP at Kathua, Jammu and another at Kupwara, Kashmir Valley) were sanctioned by the DBT at a total cost of Rs 8466.00 lakhs 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 has executed through CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM), Jammu for setting up IBTPs and on completion, will be handed over the facility to J&K Industrial Biotech Parks Society. The facilities like herbal extraction, fermentation, analytical lab, distillation, micro-propagation, plant tissue culture would be available in Biotech Park, Ghatti Kathua besides the provision of technology incubation, training & skill

development. This Biotech Park would be a robust platform which would support the agri-entrepreneurs, startups, progressive farmers, young entrepreneurs, scientists, scholars and students not only from Jammu & Kashmir and Ladakh but also from nearby States of Punjab, Haryana and Himachal Pradesh. The Biotech Park would act as hub for incubation of new ideas the startups have and would also facilitate to connect with the industry. Hon'ble Minister of State (IC) of the Ministry of Science & Technology and Earth Sciences inaugurated the Industrial Biotechnology Park at Kathua, Jammu on 28th May, 2022.



Fig. 6.2 Industrial Biotech Park, Ghatti, Kathua

Chhattisgarh Biotech Park

The Chhattisgarh Biotech Park provides interface to research institutes with industry for bioresource based product commercialization. This park was supported by the Department of Biotechnology in July 2018. The project has two phases- first phase involves setting of “Biotech Incubation Centre” and then “Business Enterprise Zone” in the second phase. Biotechnology Incubation Centre under Chhattisgarh Biotechnology Park is named as Subhash Chandra Bose Biotechnology Incubation Centre (SCBinc) and is located in Raipur Chhattisgarh. SCBinc is the institutional partner of Clean tech Innovation Challenge 2022 organized by NCL- IIT (BHU). SCBinc invited call for proposals from individuals, start-ups and companies to work at incubation centre. Applications were shortlisted and

pitching of shortlisted candidates will be done soon. Best problem solving idea/proposal will be selected & may get funding support for their work.

Biopharma Growth Phase Park (B-Hub) at Genome Valley, Hyderabad

This park was supported by the Department of Biotechnology in February 2022. B-Hub will facilitate the growth and expansion of early-stage companies by offering R&D Lab Suites, Collaborative Spaces and Support Infrastructure. B-Hub is envisaged as a state-of-the-art scale-up manufacturing facility offering provision for modular R&D laboratory space. The Design and Massing of the building is envisioned as a 'Showcase Project' for Government of Telangana State. Setting an end-to-end Facility coupled with scale up manufacturing infrastructure with provision for Biopharma training in Hyderabad will support the Government of India's vision for biopharma innovation in the country. Companies that are in early-stage development but lack the requisite expertise and resources to navigate the complexities associated with business planning, cell line development, process development, technology, and/or regulatory and risk assessment, would leverage this facility to help break down roadblocks and improve the likelihood of commercial success. Furthermore, the development and operationalization of B-Hub will create potential employment generation of 300+ skilled and semi-skilled positions in the Life sciences sector.

6.2 Make-in-India & Start-up India Programs in Biotechnology

Department of Biotechnology (DBT) under Make in India 1.0 had established a Make in India Facilitation cell at its public sector enterprise, Biotechnology Industry Research Assistance Council (BIRAC) in 2015-16 for 3 years. Subsequently, the MII cell was extended by another 3 Years i.e. 2018-2021 and then for another 5 years i.e. up to 2026.



Fig. 6.3 Activities of Make-in-India Cell

Key Achievements of Make in India Cell are as follows:

Startup India Action Plan 2016 deliverables

	Aug 2016	Sep 2022
Number of startups	1022	5365+
Number of Bio-Incubators	20	75
Number of Regional Centers	2	4
Number of Bio-Connect offices	0	5
Number of startup products in market	07	800+
Number of TTOs	0	7

Supporting Startups for progression to commercialization

Startups Product/ Technologies were provided recognition and attention of relevant stakeholders to promote their scale up and commercialization through following successful efforts:

- **International Showcasing of Products/ Technology:** 15 Startups supported for national and international showcasing.
- **Product Launch platform for recognition created:** 75+ startup products launched in 75th year of independence
- **Biotech Showcase e-portal** <https://www.biotechinnovations.com>: A dedicated portal has been launched that features 750+

products & technologies from BIRAC supported biotech startups. The e-portal was launched by Hon'ble Prime Minister during Biotech Startup Expo 2022 on 9th June 2022.

- Covid-19 Solutions: Special Publication and 2 edition of Compendium published
- Startups raising follow on funding – 32 Startups raised INR 1000+ Cr as follow on funding. Cumulatively INR 4000+ Cr has been raised by 130+ startups.
- 75 Roadshows – Aligned with Azadi Ka Amrit Mahotsava, 75 roadshows were conducted across the country through 75 Bioincubation Centres.

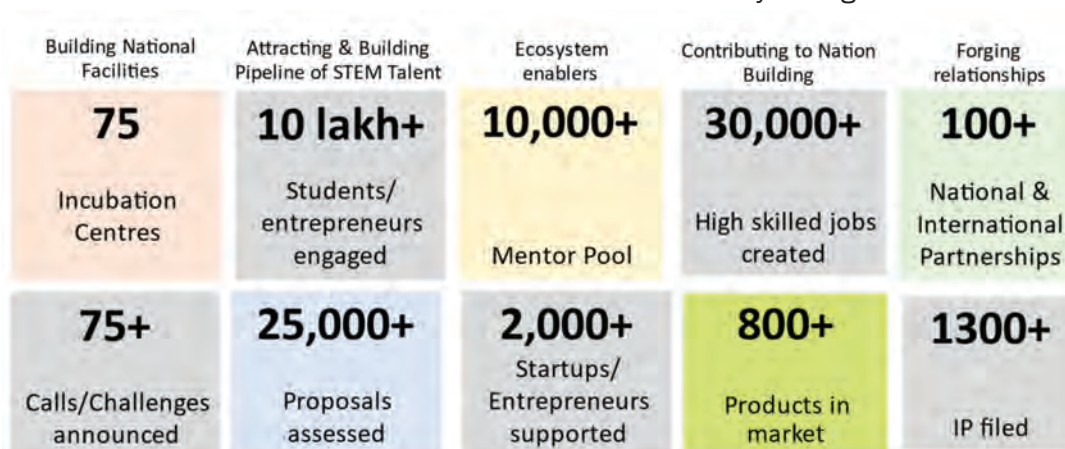


Fig. 6.4 Nurturing and Strengthening Innovation and Enterprise

Sector Mapping, Bio economy Assessment

Indian Bioeconomy Report (IBER) – No consistent official referral source was available in the country except for some sporadic secondary reports. Such publications referred to disparate observations. Now, a formal annual report mapping Indian Bioeconomy is being published regularly through MII facilitation cell. This has become a referral document at central, national and international levels.

- [IBER 2019 | IBER 2020 | IBER 2021 | IBER 2022](https://birac.nic.in/mii/mii_all_repots.php)
<https://birac.nic.in/mii/mii_all_repots.php>
- India's Bioeconomy grew to \$80.1 Bn USD in 2021 at 14.1% growth rate from \$70.2 Bn in 2020. The BioEconomy is expected to grow to \$300 Bn by 2030.

Policy Support/ Strategic Push

- Inter-ministerial contribution: The recently launched DPIIT's Startup SEED fund scheme is inspired by BIRAC's BIG scheme guided by

BIRAC's MII cell interface.

- BIRAC received first CSR grant from Stryker India Private Limited and Stryker Global Technology Center Private Limited to promote digital healthtech innovations.
- Annual Inputs for Budget Recommendations for Startup/ SMEs
- Inputs to GST Council through DPIIT for Startup & SMEs

Key Strategy inputs through Stakeholders consultation:

- Make in India 2.0 plan: Policy, Fiscal & Regulatory Recommendations for Biotech Subsectors collated & submitted to DPIIT-CII National Consultation Action Plan Committee
- Recommendations on India as a \$100 Bn Bio-Manufacturing Hub
- Recommendations on Covid-19 fall out for Startup sustenance: INR 100 Cr sanctioned from Finance Ministry

- **Establishing Technology Clusters** is in progress
- **Research Linked Incentives proposal:** To promote biotech innovations in the moon-shot areas, based on stakeholders inputs (Industry, Startups, CROs, Bio-services, Industry Associations like ABLE, CII) a draft proposal was prepared and shared with DBT.
- **Digital Healthtech Innovations:** Based on Niche area stakeholder's consultation, Amrit Grand Innovation challenge – JanCARE was launched to identify, support 75 innovations for Digital Healthtech, Telemedicine, mHealth using AI, ML and blockchain.

Regulatory Facilitation:

- **FIRST HUB:** Regulatory Facilitation is being extended to Startups through FIRST HUB wherein experts from CDSCO, ICMR, DBT, BIS, GeM and others resolve queries of Innovators and Startups. 750 + Queries have been resolved so far
- **Regulatory Facilitation Information Cell (RFIC):** Biotech Startups seek regulatory guidance from RFIC throughout year.

Established at BIRAC's Regional Centre – BRBC, Pune. 250+ startups facilitated; 11 ISO certifications assisted with 10 Product Approvals for Startups.

Biotech Startup Expo; Global Bio-India:

Mega Biotech Events representing Ecosystem initiated and steered through MII cell: Marquee events bringing together Biotech Industry, Startup Ecosystem, Academia, Investors, Regulators, Industry bodies, International Partners, Enablers, Public and Private Stakeholders.

Biotech Startup Expo 2022 in June 2022 was inaugurated by Hon'ble Prime Minister. About 5000+ delegates participated, 300 Startups, Incubators and enablers exhibited.

Fund of Funds - AcE:

Fund of Funds - AcE initiative steered through Make In India Cell has been able to attract SEBI registered Alternate Investment Funds (Category I and II). There are now 10 Daughter Funds with BIRAC investment commitment of INR 114.5 Cr. This has already supported 65 biotech companies, Startups with funding support of INR 733 Cr so far. Next call for application to identify new partners has also been launched.



Fig. 6.5 Highlights of AcE Fund

Make In India Facilitation Cell as a base to support Next Level Initiatives

- **Project Development Cell (PDC)** to boost FDI and manufacturing in Biotech sector
- **National Investment Clearance Cell (ICC)** for Biotech to promote Ease of doing business
- **Scale up support to mature Startups and medium scale companies** for piloting & manufacturing of startup products set up sectoral Technology Clusters

6.3 Biodesign Programme

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.

A. Phase I of the Biodesign Program

Under the Phase I of the programme, four biodesign centres have been established. School of International Biodesign (SiB) centred at AIIMS and IIT Delhi; Centre for Biodesign and in-vitro Diagnostics (CBD) at Translational Health Science & Technology (THSTI), Faridabad; Biodesign and Bioengineering Initiative (BBI) program at IISc., Bengaluru; and Healthcare Technology Innovation Centre (HTIC) at IIT Madras, Chennai.

A.1. School of International Biodesign

In 2022, a team of SiB Fellows has initiated their clinical immersion to find out the unmet need. While the fellows of 2021 batch are working on the prototyping refinement. SiB fellows have initiated the process to establish a start-up in India for “Device to Control Catheter associated Urinary Tract Infection” (CAUTI) and “Vascular Perfusion Monitoring Device” (VP) developed by them.

“A non-invasive, continuous way of monitoring vascular perfusion in transplanted tissues / flaps, in order to prevent tissue / flap loss”



Fig. 6.6 Vascular Perfusion Monitoring Device



Fig. 6.7 Device to Control Catheter associated Urinary Tract Infection

Also, an article on the SiB Project - Stoma Cap developed by SiB Spin-out Startup - “Crimson Health” has been published in “The Times of India” newspaper on 29th Nov, 2022. The device is classified under Class A category of medical device as per Medical Device Rules 2017 and has been granted a manufacturing license for sale in India. The device is a stoma cover that provides colostomates full control over evacuation of their bowel contents, reducing dependence on stoma bags.

A.2. Bioengineering and Biodesign Initiative at IISc Bangalore:

The project was an initiative to bring together biology and engineering faculty in IISc to work in bioengineering research. The focus of the centre was in areas of Biomaterials, biomechanics, computational bioengineering & neural engineering. The programme has resulted in significant research output in terms of patents, publications, incubated companies, and collaborations between IISc researchers and clinicians. During the Phase 1 of the project, a new academic department was founded and now the department is well established due to the activities in Phase 2. An undergraduate minor, a new MTech programme, and a pilot MD-PhD programme in bioengineering along with CMC, Vellore has been started in IISc. Furthermore, the interdisciplinary research in bioengineering in IISc had played a

significant role in initiating a hospital and post-graduate medical school in IISc. 9 training programs/workshops/summits have been organized, 15 new facilities established and 6 industry – academia collaborative projects are ongoing. In addition to capacity-building, 38 papers are published, 7 patents filed and 3 technologies are developed along with the setting up of 2 start-ups.

A.3. Healthcare Technology Innovation Centre (HTIC)

The Centre has successfully attracted domestic

industry players to partner in developing products using in-house technologies for both domestic and global markets. Technology like invasive imaging, non-invasive vascular imaging, robotic surgery, which is currently fully imported by the country, has been developed. Collaborator ecosystem was expanded to more institutions nationally and internationally to over 40 collaborators. HTIC trained around 200 highly driven young engineers, researchers, students, interns, entrepreneurs, thus acted as an integrated med-tech R&D + translation + incubation platform for developing affordable healthcare technologies.



Fig. 6.8 ARTSENS® Plus

B. Phase II of the Biodesign Program

Based on the success and importance of this program in nurturing technopreneurship, DBT expanded the program and 5 new biodesign centers—King George's Medical University (KGMU), Lucknow with IIT-Kanpur; IIT Guwahati with North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS), Shillong and

Guwahati Medical College; IIT Bombay with Hinduja Hospital, Mumbai; IIT-Jodhpur with AIIMS, Jodhpur and THSTI, Faridabad with IIT Madras, CMC Vellore; PGIMER, Chandigarh and Venture Center, Pune – twinning around 18 medical and engineering institutes have been identified.

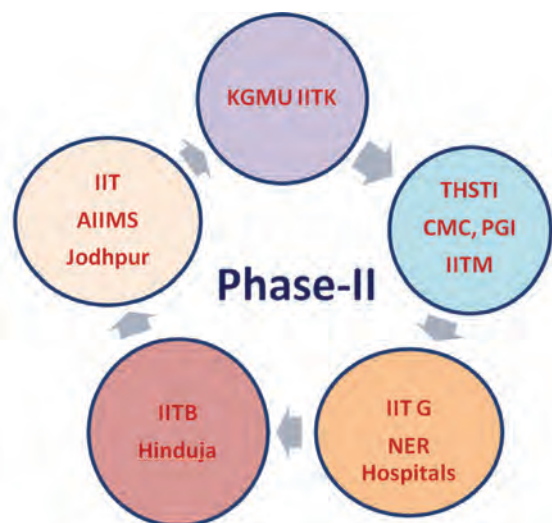


Fig. 6.9 – Phase II of the Biodesign Program

Department is taking many initiatives to promote and strengthen biodesign program across the country. Recently, the World Intellectual Property Organization (WIPO) has shown their interest to sponsor few fellows in this program. Also, to provide mentoring and guidance for the program involving med-tech innovation and entrepreneurship development, Steering Committee of National Biodesign Consortium has been constituted. Two National Biodesign Steering Committee Meetings has been held till November, 2022. Drafting of DBT Biodesign guidelines on IP protection, licensing, tech transfer, revenue sharing etc is under process.

B.1. School of International Biodesign (SiB)-Synergizing Healthcare, Innovation and Entrepreneurship (SHInE) at KGMU Lucknow & IIT Kanpur

The vision of the SiB-SHInE program at KGMU Lucknow and IIT Kanpur is to build most dynamic ecosystem by identifying, nurturing and maturing next generation of biodesign innovators developing disruptive and accessible technologies worldwide.

In 2022, the first batch of 9 fellows has been selected out of 131 applications after several rounds of interviews. The Orientation session for the selected fellows was held on 3rd September, 2022 in KGMU, Lucknow. The selected fellows have visited

approx. 33 medical departments for clinical immersion. Brainstorming sessions are being held regularly with panel of doctors including online lectures by IITK and external faculty members to guide the fellows on biodesign, biosensors, need identification, molecular basis of disease diagnosis and electrical engineering principles. Also, curriculum-based learning program like DISHa (Devices and Innovative Solutions for Her) has been implemented.

B.2. Deep-Tech Biodesign Centre: A Multi-disciplinary centre to train, nurture and transform clinicians and engineers into the Deep-Tech innovators in the field of Medical/Health Technology at IIT Jodhpur & AIIMS Jodhpur

The vision of the program is to create an ecosystem for nurturing multidisciplinary deep-tech entrepreneurship in the area of healthcare and to train biodesign fellows to identify problems of significance in healthcare domain, ideating research plan to deliver a solution and setting up of prototype production/manufacturing facility for commercialization. The key areas of the program are diagnostics, therapeutics, AI & Data Analysis and Medical Devices & implants. The objectives of the program include training, clinical immersion, establishment of research ecosystem and provisioning for technological and financial support for translational transformation of innovation to product. Many joint programs of IIT Jodhpur and AIIMS Jodhpur are being held regularly.

No. of research publication during 2022-23	10
No. of patent filed	2
No. of patent granted	2 (international) and 1 (national)
Process/product/Technology developed	3
Process/product/Technology licensed/commercialised	4

07

SOCIETAL PROGRAM

7

SOCIETAL PROGRAM

The benefits of biotechnological knowledge, processes and technologies should reach the masses and help them to improve their life and livelihood, with this objective the Department has been supporting projects in Aspirational districts and rural areas through Biotech Based Programmes for Societal Development. DBT also has Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) program that empowers farmers, especially women farmers. It aims to understand the problems of water, soil, seed and market faced by the farmers and provide simple solutions to them.

7.1 Biotechnology Based Program for Societal Development

Biotechnology Based Program for Societal Development was initiated by DBT in 1990 to benefit the vulnerable section of the society particularly farmers, women and SC/ST population. From 2018-19, the focus of the program has shifted to socio-economic upliftment of the underprivileged section of the society in Aspirational Districts.

During the reporting period, the Department has supported 32 projects in aspirational districts benefitting more than 5000 persons. 65% of the total beneficiaries are women whereas 56% belong to SC/ST communities. The projects have resulted in approximately 30% increase (on an average) in income of target beneficiaries and generated self-employment opportunities.

Major achievements during the year 2022-23 are:

In Ri-Bhoi district, Meghalaya, 110 farmers within Nalapara village cluster and in Barpeta district,

Assam, 55 farmers within Anandapur and Kharadhora villages, were motivated for organic cultivation of crops under rice-vegetable rotation. Farmers were trained on organic crop cultivation practices, use of biofertilizers and biopesticides, organic management of pest and disease, organic manuring practices, etc. The farmers were also motivated for creation of a Farmers Producing Organization and to sell their products from organic fields for enhancing income. Adoption of organic cultivation practices by farmers brought an additional higher income of Rs. 18,000/- to Rs. 28,000/- for sticky rice and Rs.25000/- to Rs. 40,000/- for Joha (Scented) rice per hectare area during *Kharif* season, 2022. Likewise, organic ginger growers could earn an additional income of Rs.1,00,000/- to Rs.1,20,000/- per hectare during 8-9 months' period by selling organic ginger.

Ramanathapuram is one of the driest districts in Tamil Nadu. This district is home to a growing movement of organic farming. In organic farming, usage of AM fungal biofertilizers not only increase the yield but also helps the plants to get rid of stress, drought, toxicity, higher temperature, tolerance to alkalinity, to minimize pest and diseases occurrence etc. Farmers, especially women are highly interested towards adapting and doing the mass production of AM fungi in this district. It gives an additional source of income and monetary benefits, which could even change their lifestyle through upliftment of livelihood. By the application of AM fungal biofertilizer to barren lands, polluted lands can be reclaimed and food crops can be grown in that areas which not only improves and enhance the fertility of soil but also greening the unusable land. Further application of

AM fungal biofertilizer biofortify the grains or vegetables or fruits with macro and micronutrients that improves the health and nutritional status of the farm families, which induce and inculcate the spirit of rural women towards bio entrepreneurship.

In Ri-Bhoi district, Meghalaya, awareness cum animal health camps and training programmes on scientific pig and poultry farming, deworming and vaccination, livestock based integrated cluster farming was organized in nine villages. A total of 128 nos. of beneficiaries are being benefited. Pig farmers trained to establish pig breeding unit in the village for availability of improved breeds of piglets throughout the year. Three low cost rain water harvesting structures i.e. jalkund constructed (120m², 132m², 99m²) in Umsawkhwan village to use it for activities such as irrigation of crops, cleaning poultry and pig sheds, drinking water for livestock, etc. Drip irrigation system (1 no.) set up at Umsawkhwan village for growing vegetables throughout the year. Inputs in the form of pig feed, poultry feed, veterinary medicines, vegetable seeds such as broccoli, cabbage, cauliflower, pea, cucumber, radish, carrot, capsicum, coriander etc were distributed to the beneficiaries. This year on an average farmers have obtained a benefit: cost ratio of 1.63.

Sericulture is a cultural heritage in the north-eastern region and one of the most promising income sources in the region. A project has been implemented in the aspirational districts Dhalai and Chandel from Tripura and Manipur states respectively. The project is combination of two major components, to organize Entrepreneurship Development Programme (EDP) and handholding support with improved sericulture technologies for uplifting/converting the traditional sericulture farming into commercial sericulture farming. 25,000 cuttings and 19,000 saplings of high yielding mulberry variety C-2038 have been distributed among the beneficiaries. Total four EDPs have been organized in both the selected aspirational districts through which 100 beneficiaries

have been trained on entrepreneurial traits and improved sericulture farming practices.

A multi-component collaborative project implemented in five villages of Nadia District in West Bengal, surrounding Khalsibeel lake aims to empower the women of the fisherfolk community by introducing cost effective technologies. Under the project, 77 women beneficiaries are being trained through Fisher's Field School. In addition, during the year 346 persons were sensitized in various agricultural components viz. fish seed raising in pens, backyard poultry farming, kitchen gardening and mushroom cultivation. Among 80 selected farm families, the employment was generated for 62 mandays/family/annum and 42.5% of the beneficiaries have produced marketable surplus that will help them to upscale their socio-economic status. During monitoring of fish health in the pen culture, different infectious diseases in both the pen and wetland were investigated as and when required and 11 bacteria were identified as etiological agent for fish disease from the pen culture and wetland using 16S rRNA sequencing and have submitted to the gene bank for accession number.

A project being implemented in the North-West Himalayan Region aims at pursuing the interventions such as value addition, product development, and entrepreneurial skill development-based innovations for rural and societal development in traditional Medicinal and Aromatic Plants (MAPs) based products. The beneficiaries were provided with the quality germplasm of the identified MAPs for cultivation. A processing facility housing the interventions for post-harvest management, and processing of MAPs was established for the beneficiaries. ICT-based interventions are being implemented for strengthening the connection, providing marketing and selling platform and developing the brand for the products developed through scientifically validated traditional practices. The farmers have adopted on-farm conservation of

the MAPs using the germplasm provided under the project, thus reducing the stress on the forests. Organic cultivation of the MAPs is being encouraged to maintain the sanctity of the Himalayan soil.

In Yadgir district of Karnataka, nine self-help groups have been created in several villages of Gurmitkal taluka of Yadagir District. The beneficiaries are being trained for scientific breeding practices, housing, feeding, and maintenance of goats to achieve higher reproductive efficiency and maintenance of disease free herd. Progressive farmers have built sheds for goats after gaining knowledge from the awareness program. A fodder block machine has been established in the local area and training is being provided to make fodder blocks from the locally available raw materials.

In Kupwara District of Jammu & Kashmir, two model walnut processing units have been constructed at Lolab and Zirhama Villages. Using in-house designed equipments, eight (08) training programmes of five days duration were organized demonstrating “in-shelled walnut processing” covering heaping, dehulling, washing, bleaching, drying of whole walnuts, size based grading, shrink wrapping, bagging and labeling. A total of 240 walnut farmers have been trained.

In a project implemented at Udalguri district, Assam, awareness, training, demonstration and motivation programs were organized benefiting 370 rural people. Farmers are being trained for Banana fibre extraction, thread twisting, Banana fibre mat weaving

and Banana sheath cup/plate making.

In a project implemented at Nuh, Haryana, 1532 dairy farmers were benefitted through training program, technology demonstrations, awareness program and artificial insemination of buffalo using superior germplasm. A total of 1250 artificial inseminations were performed using cloned buffalo bull semen.

In one of the projects implemented in Virudhnagar district of Tamil Nadu, biodegradable polymer production process has been developed, standardized and validated. The developed nanocomposite was coated on the brown paper sheets and bags were prepared in different sizes. Eco-friendly nanocomposite made of cellulose from maize cobs is an eco-friendly way of plastic production and synthetic plastics can be removed from the ecosystem. On an average a rural farm family could generate an income of Rs.1000-2000 per day if they could process 500-750 kg of cellulosic material.

A Rural Bioresource Complex has been established in Nuapada district of Odisha for primary processing and value addition of horticultural and non-timber forest produce such a mahua, harida, bahada, karanja, kusum, chironji and sal, to create local livelihood options for the tribal communities at their doorsteps. Hands-on training programs/workshops have been organised to develop skill and expertise among the local people for primary processing (cleaning, grading, decortication) and value addition of mahua flowers, chironji nuts, sal seeds and groundnuts.



7.2 Biotech-Krishi Innovation Science Application Network (Biotech-KISAN)

Department of Biotechnology (DBT) has an ongoing farmer-centric Mission Programme known as Biotech-Krishi Innovation Science Application Network (Biotech-KISAN). The programme provides funding to establish Biotech-KISAN Hubs in each of 15 agro-climatic zones of the country. Programme is aimed to work with small and marginal farmers especially the woman farmers for better agriculture productivity through scientific intervention and evolving best farming practices by linking available science and technology to the farm by first understanding the problem of the local farmer and providing solutions to those problems.

Some of the major interventions and success stories carried out by Biotech-KISAN Hubs are:

- Revival of grass pea cultivation in the state of Bihar (Biotech-KISAN Hub at Bihar Agriculture University, Sabour)
- Utilization of Rice Fallows for Enhancing Pulse Production in North Coastal Andhra Pradesh (Biotech-KISAN Hub at Acharya NG Ranga Agricultural University, Guntur, Andhra Pradesh)
- Empowerment of Women Farmers in Sundarban by adopting scientific goat and sheep rearing (Biotech-KISAN Hub at West Bengal University of Animal & Fishery Sciences, Kolkata)
- Development of rural women entrepreneurship on biofertilizers and biopesticides in the state of Telangana (Biotech-KISAN Hub at Agri Biotech Foundation, Hyderabad)
- Livelihood Improvement of Tribal Farmers of Ri Bhoi by adopting Scientific Pig Rearing and value-addition (Biotech-KISAN Hub at ICAR Research Complex for NEH Region, Umiam, Meghalaya)
- Income and livelihood improvement of farmers in Western Rajasthan by adopting good agriculture practices (GAP) and integrated pest

management (IPM) in Cumin (Biotech-KISAN Hub at South Asia Biotechnology Centre, Jodhpur, Rajasthan)

Biotech-KISAN hub at MANTHAN, Bhopal has continued activities in eight Aspirational districts of MP. Hub has demonstrated innovative agriculture technologies in the farmers' fields. Field demonstrations and interface meetings have benefited 8200 farmers. It has resulted in increase in yield around 70 to 80% over the control/baseline data. 84,542 farmers have been benefited, either directly or indirectly. Thirty rural entrepreneurship have also been developed in food processing, packaging and marketing of value-added products from the crops in these Aspirational districts.

Under the Biotech-KISAN Hub at ICAR-CIARI, Port Blair, the community-based mini-incubator for rural poultry production has been demonstrated to 925 woman farmers from 30 villages from A&N Islands and Minicoy, Lakshdweep. Five successful rural women have initiated micro business on mini-incubator for hatching and 2000 farmers availed incubation facility for hatching desi eggs. The multiplier flock concept in goat to establish breeding farm through sale of superior breeding bucks has been established in villages such as New Wandoor, shoalbay, Manjery, Hasmatabad, Garacharma and Rangat.

Under the Biotech KISAN Hub at Indira Gandhi Krishi Vishwavidyalaya, Raipur, 250 farmers were trained in backyard as well as protected vegetable cultivation. Biotech KISAN Hub organized 15 training programmes for technological and entrepreneurship development for low-cost vegetable production, seed treatment through bio-agents and scientific Goat farming in tribal areas and has benefitted 506 farmers. Total 18 Biotech KISAN fellows were selected and trained to become master trainer from the seven Aspirational Districts in Chhattisgarh.

Under the Biotech-KISAN Hub at FAARD Foundation, Varanasi, a number of demonstrations benefiting 63 farmers were conducted on paddy varieties namely

COH-54, DRR-50, DRR-53, HUR-1309, PUSA-1850 in Chandauli and Sonbhadra (Aspirational Districts) and Varanasi and Ghazipur (Non-aspirational districts). In vegetables, seeds of latest varieties of Okra (Kashi Chaman), Brinjal (Kashi Sandesh), Lobia (Kashi Nidhi), Chilli (Kashi Anmol) were provided to 172 farmers in selected villages which proved better than local varieties and, therefore, preferred by the farmers. A total number of 455 farmers have been benefitted during this year. In selected villages, 36 entrepreneurship in goat farming, mushroom production, honeybee rearing for honey production, seed production and fisheries have enhanced the income of the farmers.

Under Biotech-KISAN Hub at Bihar Agricultural University, Sabour, the activities have been continued in six Aspirational Districts (Araria, Aurangabad, Banka, Katihar, Khagaria and Purnea) of Bihar. A total of seventy (70) training programmes were conducted for the farmers and 34 self help groups created. Demonstration of tissue culture banana (G-9) was conducted in 50 acres farmers land and Sabour Makhana 1 in 75 hectares farmers' field. The scientific Goat farming, beekeeping and mushroom cultivation was demonstrated in 30, 300 and 125 households respectively. Market linkage with Private companies like Mithila Makhana & Organic Satwa were established for better marketing of makhana. Goat Farmers adopted the use of UMMB block, Green fodder and practicing vaccination and deworming regularly. Scientific Mushroom is getting popularity among the farm women and market linkage is created with local hotel and markets. Different value added products viz. like mushroom biscuit, mushroom powder, mushroom pickle, mushroom dry soup, and mushroom pizza are produced by the farmers. Honey produced by the farmers are processed in university honey processing unit and sold in the market with the branding of the project. For better marketing of produces, sixty five interfaces were conducted among scientist, industry and farmers.

Under the Biotech-KISAN Hub at PRADAN, Ranchi, the activities have been continued on demonstration

of innovative technologies in Tasar culture and of 2,100 families have been covered. In year 2022, a total of 740.13 ha of Tasar host tree plantations raised last year were maintained, which has benefitted 746 families. Intercropping of Black gram, Green gram and Dhancha followed by Mustard were demonstrated in 200 ha newly raised plantations, which supported 100 families. Total 89 entrepreneurships have been developed, out of which 68 entrepreneurs are engaged in tasar seed production. Eight community-based bio entrepreneurs/groups are engaged in quality seedling production.

At ICAR-NIBSM, Raipur Biotech-KISAN Main Hub and sub hubs KVKs demonstrated improved rice varieties like Indira Aerobic-1, biofortified Zinco riceMS and covered 42 hectares of land from three Aspirational Districts. Scientific support was provided in goat farming with improved breeds such as Sirohi, Jamunapari, Black Bengal and Barbari distributed to farm families. In addition, improved crop varieties developed through MABB (Indira Maheshwari, DRR Dhan 42, MTU-1010, Zinco Rice MS, IISS- Pragati, PKM- 1 and RVG 202) and eco-friendly biofertilizer were also promoted in the Aspirational Districts.

Under Biotech-KISAN Hub in Tripura, activities have been initiated on seed production and management practices of Pabda and minor carps involving 243 fish farmers from 10 villages. Fish seed of minor carps and fish feed were distributed to the beneficiary farmers in West Tripura for field demonstration.

Under the Biotech-KISAN Hub in Assam, a total of 10 demonstration units have been established in eight villages in Dima hasao district for fish-cum-duck farming and fish-cum-poultry-farming. A total of three in-house training programs, four awareness campaign and 10 fields-based training programmes have been conducted. Fish seeds of Indian major carps were distributed to the entire demonstration unit with a stocking density of semi-intensive fish culture. Conventional duckery and poultry house

were also constructed. Twenty chick of Kamrupa strain and 20 duckling of Campbell @ 0.21 hectare of pond have also been distributed to the entire demonstration unit. Supplementary Feed for fish and Feed for chick & Ducklings has also been provided to the demonstration unit. Health checkup & vaccination of the ducks & poultry are being done. Egg laying of Poultry and Duck has also been initiated.

Under the Biotech-KISAN Hub at North Eastern Hill University, Meghalaya, demonstration units have been established on low-cost polyhouse growing of vegetables (tomato, nagachilli, capsicum) and production of compost in university field as well as in farmer's field. The hub released its first product, vermicompost which is produced from farmer's field and farmers have taken as a small-scale business. At present, total number of direct and indirect farmers' beneficiaries is around 570. The Hub has organized eleven training programmes/events for the farmers including "Kisan Mela" in September 2022.

Activities have been initiated on demonstration of biocontrol agents in farmers' fields under the Biotech-KISAN Hub at CAU-Pasighat centre, Arunachal Pradesh. The Hub has conducted six off-campus awareness-cum-biocontrol inputs distribution programme to NEH farmers at different villages under two aspirational blocks viz. Monigong-Didu, ShiYomi/West Siang and Hunli-Desali, Lower Dibnag Valley districts. The total number of 197 ST farmers were benefitted from six different villages. Demonstrations were carried out on usage of knapsack sprayers for organic pest management by using recommended bio-pesticides in high value vegetable crops. Farmers were benefitted with the critical inputs like truthful label vegetable seeds (Chilli, Tomato, Okra, Cow pea and French bean) and quality bio-pesticides.

Under the Biotech-KISAN Hub Assam Agriculture University, Assam, Base line survey has been completed for three different districts. Farmers group has been formed from the selected locations for executing bee keeping from different districts.

Awareness programme at different locations has been organized successfully to sensitize the farmers on scientific bee keeping. Survey and selection for demonstration of bees in the field has been completed which was initiated during the peak season. Whatsapp group has been created with 10 farmers from each location for group discussion regarding bee problems and their solution. Tribal farmers of Karbi Anglong, Dima Hasao and Karimganj have benefitted from the scientific information that created awareness regarding modern beekeeping in sustainable manner.

Establishment of organic hub for promotion of organic and alike farming in farmer's field of North east, three aspirational villages i.e., Langdongdai (District: West Khasi Hills) and Jetra (District: South Garo Hills) of Meghalaya and Mabong (District: West Sikkim) of Sikkim were reached out through the project. Farmers in these respective remote locations were made aware on the organic agricultural practices through use of bio-input technologies (Biopesticides, Biofertilizer, and hands-on trainings were imparted to them on application of these proven technologies of biopesticides, biofertilizers, Pheromone traps, Sticky traps and microbial). Four organic packages and practices on turmeric, maize, potato and tomato were developed for the targeted villages. Critical inputs such as seed materials (2.01 q maize, 5 q potato, 4.2 kg tomato, 1 q turmeric), biopesticides (150 lt.), biofertilizers (20 lt.), spray machines (05), yellow sticky traps (350 Nos.), blue sticky traps (200 Nos.), enriched compost (30 kg), microbial (150 cards, 5000 Nos.) were provided to the selected farmers of SHGs. Besides, extension components like banner/posters (04), extension bulletins (05), and audio/video aids (03) etc. were prepared in farmer-friendly local languages and distributed as a ready reckoner for the technology adopters. Technologies were demonstrated in farmer's field covering an area of 8.18 ha in Langdongdai, 8.19 ha in Jetra and 2.50 ha in Mabong village.

08

**PROMOTING
BIOTECHNOLOGY IN THE
NORTH EAST REGION OF
INDIA**

8

PROMOTING BIOTECHNOLOGY IN THE NORTH EAST REGION OF INDIA

The North East Region (NER) of India has been identified as one of the biodiversity hotspots of the world. The region faces several challenges in terms of poor agriculture output, high disease burden in the homogeneous ethnic communities, degradation of the fragile ecosystem etc. Rich bioresources spread across NER's diverse ecosystems provide opportunity for furthering economic development of the region through scientific and technological interventions.

In order to give focused attention for the region, the Department has been allocating 10% of its annual budget every year for implementing special programmes for NER since 2010. The special programme for NER aims at promoting and strengthening biotechnology related activities for addressing local challenges and harnessing endemic bioresources for economic development of the region. DBT has set up NER Biotechnology Programme Management Cell (NER-BPMC) to effectively manage the programme for NER, which is being managed by DBT-Institute of Life Sciences (DBT-ILS), Bhubaneswar.

Quantitative outcomes during 2022-23:

Number of completed projects	68
Number of Process/Product/Technology Developed	06
Number of Process/Product/Technology Transferred	01
Number of research publications	55
Number of patents granted	01
Number of human resources trained	3100

Major Initiatives during the Year 2022-23

A. Twinning R&D Programme for NER

The programme has continued during the year towards developing core competence and capacity in various areas of biotechnology through collaboration of institutes from Northeast India with other leading institutes across the country. The programme has made huge impact in terms of capacity building and creation of trained work force by catalyzing vibrant collaborations between 65+ institutions from NER and those from the rest of India in various spheres of biotechnology. In the current year, 125 projects are in progress and about 200+ NE researchers and 500+ NE students have benefitted under the programme.

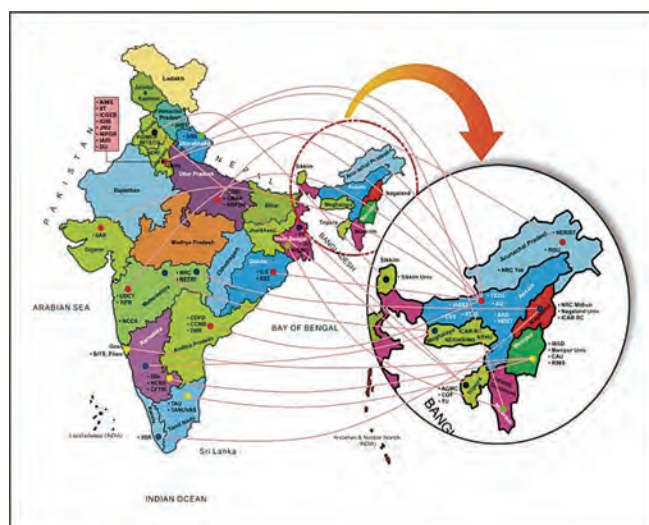


Fig. 8.1. Collaborations under the DBT- Twinning R&D Programme

B. Establishment of Biotech Hubs across NER

Biotech Hubs were established across NER for providing necessary infrastructure in universities/ colleges/ institutions and the required trainings in sophisticated technologies to support and promote biological sciences / biotechnology education and research. Out of total 126 Hubs established since 2011, 76 Biotech Hubs have been selected for further support under Phase-II in four categories: (i) Advanced-level State Biotech Hubs with Leadership role (ii) Advanced-level State Biotech Hubs (iii) Advanced-level Institutional Biotech Hubs, and (iv) Institutional Biotech Hubs.

Advanced-level State Biotech Hubs with Leadership role (ALSBH-LR) and Advanced-level State Biotech Hubs focuses on research addressing local issues, conduct advanced and specialized training for students, researchers and local entrepreneurs, provide mentoring to Advanced-level Institutional Biotech Hubs, work on micro-grants with young researchers in other NE Institutes, conduct awareness programmes and Popular Lecture series. The ALSBH-LR at North Eastern Hill University (NEHU), Shillong is undertaking lead role in research areas such as plant-microbe-environment interactions, metabolic pathways engineering and conservation biotechnology research areas whereas, the ALSBH-LR at College of Veterinary Sciences, Assam Agricultural University, Khanapara is focusing on viral pathogens associated with porcine reproductive disorders with special reference to Porcine Circovirus 2 (PCV2). The State Biotech Hub at Mizoram University is focusing on discovery genomics and mitigation of disease burden through the integrated approach of epidemiology, genomics and public health. Till date 44 Biotech Hubs across NE states have been sanctioned under these categories.

C. Centers of Excellence in NER

Centre for Bioresources and Sustainable Development at Kimin, Papum Pare, Arunachal Pradesh

State-of-the-art Orchidarium with modern technologies have developed for conservation and cultivation of important orchids at Kimin. Seventy-five species of the endemic orchids have been collected and maintained in the conservatory. Database of around 50 species of orchids was created and important information documented. Five satellite units have been established at Pasighat, Ziro, Deed, Namsai and Kimin for promotion of orchid cultivation and orchid based entrepreneurship avenues.

Different batches of high fibre quality banana (about 1000 each) have been distributed to the farmer association groups for cultivation purpose in the selected satellites units in Papum Pare, East Siang and Namsai. Five workshop/awareness programmes and two exhibitions have been conducted for the utilization of banana fibre and value-added products. Value-added and fibre products such as candy, banana flour, rope, muffler, compost, liquid biofertilizer are being prepared through SHGs by the Centre in collaboration with the College of Horticulture and Forestry, CAU, Pasighat.

The centre has organized 11 extensive training programmes / workshops on aromatic plants cultivation and processing, micropropagation and cultivation of orchids, banana fibre extraction and value-added products, essential oil, fragrance and flavor industry that has benefitted more than 500 farmers and prospective young entrepreneurs of Arunachal Pradesh.



Fig. 8.2. State of the art Orchidarium and facility for utilization of banana fibre for value-added products established at DBT APSCS&T CoE for BRSD, Kimin, Arunachal Pradesh

North East Centre for Agriculture Biotechnology (NECAB), AAU, Jorhat

Activities have been continued on stress tolerance in rice, gene-based improvement of chickpea, bioprospecting of soil microbes, novel biofertilisers and biopesticides. A core set of 300 ahu rice accessions was created and phenotyping of 300 ahu rice accessions for drought tolerance was completed while genotyping through sequencing is in progress. Further, phenotyping of 290 Sali rice accessions have been carried out resulting into identification of submergence tolerant lines. Efforts are in progress to identify the gene(s)/QTL(s) responsible for submergence tolerance. Lines 89 and 135 were found to be more tolerant to submergence than FR13A (the source of Sub 1). A total of 7 QTLs for yield and yield attributing traits identified from Banglami x Ranjit, F6 generations were phenotyped and fine mapping of these 7 identified QTLs is being carried out. BLB resistance gene has been incorporated into Luit and Dishang varieties.

Introgression of drought, submergence and blast-resistance genes into elite rice varieties of Assam is in progress.



Fig. 8.3. North East Centre for Agriculture Biotechnology (NECAB) at AAU, Jorhat

Translational Programme for Developing Diagnostics and Nano-based Sensors

Taking forward the significant research leads from DBT Programme Support on Fundamental Molecular Investigations in Biotechnology (Phase-II), a Translational Programme on Developing Diagnostics and Nano-based Sensors has been initiated at IIT, Guwahati. The programme aimed at (i) Development of Nano-ensemble Kit for early detection of Breast Cancer Markers; (ii) Development of a low cost and field deployable sensor for detection of formaldehyde both in liquid and gaseous forms; and (iii) Development of low cost and portable field deployable methanol and malaria sensing kits. Some significant achievements so far include: development of a channel embedded chemiresistor biosensor device for *in-vitro* detection and quantification of GSH which detects real-time antigen-antibody

interaction between GSH and GSH antibody, development of a new strategy for the detection of formaldehyde in the gas phase, a novel approach for detection of methanol using silk fibroin film as stabilizing matrix for alcohol oxidase and chromogenic dye, and a smartphone-based application for detecting malarial biomarkers using an optical signal transduction approach.

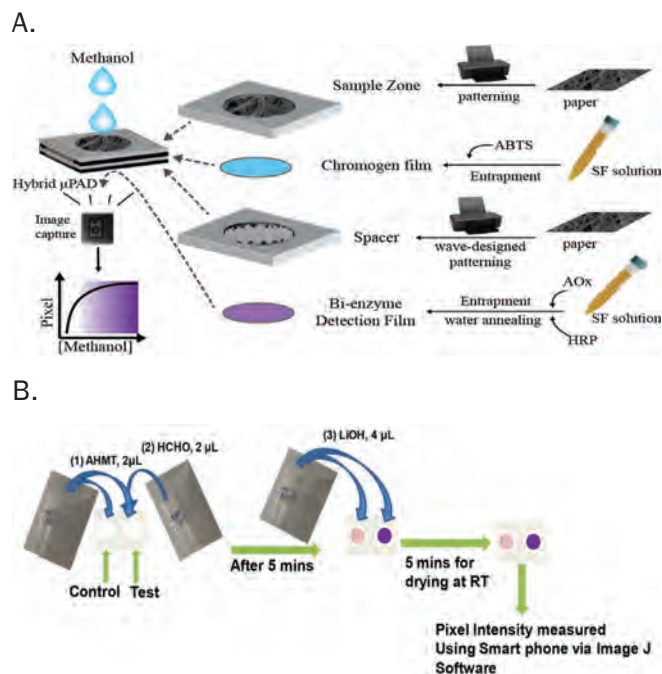


Fig. 8.4. Schematic representation of different sections of the hybrid iPAD and their usage for methanol sensing (A), and illustration showing purple color formation and the calculation of pixel intensity of developed color using a smart phone for the detection of formaldehyde in liquid samples.

D. Major Infrastructure Facilities

Animal House Facility at RMRC, Dibrugarh

Work is in progress for establishment of the state-of-the-art animal facility for housing / holding small laboratory animals in different levels of biosafety environment (excluding BSL-3 and above) to make the facility accessible to biomedical / biotechnology researchers from all the eight states of Northeast Region. The construction work of around 3,111 sqm. (Animal house area: 2152 sqm. + Utility / Electrical service area: 959 sqm.) of Ground floor and 1st floor

building is in progress. Seventy percent of the construction work for the main Animal house area and 10% for the Utility / Electrical service area has been completed.



Fig. 8.5. DBT Animal House Facility being established at RMRC, Dibrugarh, Assam

E. Major Network Projects:

Biotechnological interventions for the improvement and management of Tea (*Camellia sinensis*)

A major programme has been initiated during the year on biotechnological interventions for the improvement and management of tea involving multidisciplinary research collaborations of 26 institutions under five networking projects has been launched in the area of basic biology to advanced

genetic research for the improvement of plant quality, processing aids, biochemical properties, stress resistance, to develop sustainable agriculture practices for biotic/ abiotic stress management in conventional and organic tea plantations, and nutrient management. Biological evaluation of the tea polyphenolic compounds for development of value-added nutraceuticals for health benefits has also been taken up. The programme also envisages the sustainable management of tea waste and transform tea industry into reduced or no-carbon emissions.

Biotech Interventions in Citrus of Northeast Region

NE Region is blessed with abundant Citrus genetic diversity, represents several natural wild species and commercially cultivated species. Following the multi-institutional and multidisciplinary research collaborations, 11 major network projects have been initiated to strengthen the citrus research in NE Region. The notable research areas include conservation of citrus germplasm, phytochemical characterization, and nutritional profiling of citrus germplasm of Northeast Region, developing diagnostic kits for *Citrus tristeza virus* (CTV), *Phytophthora gummosis* and Citrus canker diseases. A spoke centre for conservation and morphophenological studies of Citrus species in Nagaland has been established at Medziphema campus of Nagaland University. Sixty-four unique germplasms of Citrus species have been collected so far with high variability within the species. Facilities have been established at IHT, Mandira, Assam for generation of certified scion material of Khasi mandarin (*Citrus reticulata*) and sweet orange. Rootstocks free from Citrus Greening Bacteria (CGB) and *Citrus tristeza virus* have been developed. Under a collaborative project between IIT, Guwahati and Mizoram University, Aizawl, an effective nature-derived moisture barrier, antifungal coating for the citrus fruits has been developed for improving the shelf-life.



Fig. 8.6. Representative images showing the Collected Germplasms of different citrus groups at SASRD, Nagaland University, Medziphema.

Exploration of native legumes and characterization of associated nitrogen fixing microsymbionts in NER

The programme has been recently initiated for exploration and conservation of wild and under-utilized nodulating legumes of NE Region. Efforts are in progress for development of consortia of effective and broad host range Rhizobia and development of native NER-RNB plant growth promoting (PGP) formulations. Molecular mechanism of cross infectivity would be investigated to understand the mechanisms of specificity of broad-range symbiont system by unraveling signal transduction through NGS, metabolomics, transcriptomics, and small RNAs/peptides approaches.

Consortium programme on MDR-TB

Activities have been carried out for mapping hot-spots of TB and MDR/XDR-TB in NER, population genetic studies to delineate predisposing factors, repurposing studies of drugs, development and validation of new tools for diagnosis of TB & MDR-TB and non-tuberculosis Mycobacterium (NTM) in NER and awareness programme on NTMs and Paragonimiasis. About 2000+ *M. tuberculosis* isolates have been collected from diverse population of NER with patient's basic and clinical datasets from all the eight NER states covering a total of 72 districts and genome sequencing of around 400 isolates has been completed. A BSL-3 facility with BACTECTM MGIT-960 fully automated TB culture and Cryo Preservation Tank (3000 Vials capacity) has been established at Tomo Riba Institute of Health & Medical Sciences (TRIHMS), Naharlagun, Arunachal Pradesh for carrying out further research following the standard operating protocols.



Fig.8.7. BSL-3 facility established at TRIHMS, Naharlagun, Arunachal Pradesh

Advanced Animal Diagnostic and Management Consortium (ADMaC) programme

The programme aims at validation and translation of the vaccines and diagnostic technologies developed during Phase-I of ADMaC. Bulk production of DPV antigen and raising polyclonal antibodies has

been achieved. For screening of anti-brucella antibodies, serum samples of 304 cattle, 230 goats and 59 pigs collected from 12 different districts of Assam have been tested. ICT-based, farmer centric, syndromic analytics enabled Knowledge Based System (KBS) for early detection, forecasting and disease alert system by calibrating machine learning algorithms for pig diseases in NE Region has been developed. A total of 243 numbers of cattle samples and 18 numbers of goat samples were screened for Q fever by Indirect ELISA Multi- species kit. One Hands-on-Training and two online lecture programmes were organized in Assam for demonstration of cELISA kits and lateral flow assay developed under ADMaC Phase-I.



	Livestock Species	LFA Interpretation
1.	Bovine positive 	Bovine negative
2.	Small ruminant positive 	Small ruminant negative
3.	Pig positive 	Pig negative
4.	Vaccinated positive 	Vaccinated negative

Fig. 8.8. Representative images showing disease surveillance and diagnosis under DBT-NER ADMaC programme

Chemical Ecology Programme for the NE

Under the Chemical Ecology programme for the NE Region of India, six multi-institutional collaborative projects with the participation of 17 institutions from NE Region and non-NE Regions are in progress to decipher the inter and intra species interactions, communications and synergies mediated by small molecules and their macromolecular counterparts. Pheromones-based studies are in progress for the pest management of black looper pest (*Hyposidra talaca*) in tea plantation in NE Region with an aim to identify and synthesize the molecule that can be utilized as a pheromone trap. Besides, exploration of the chemical ecology of L-DOPA, in understanding how a precursor compound released by *Mucuna pruriens* (velvet bean) is able to inhibit the growth of other plants will give more insight about plants and their interactions with herbivores.



Fig 8.9. The chemical ecology of high L-DOPA. Representative images showing the tagging of plants for spatiotemporal analysis of defense traits in different NE regions (left panel) and evidence of herbivory on different tissues of *M. pruriens* (right panel).

Demonstration and Scale-up programmes for Societal Upliftment in NE

Field Demonstration of FUSICONT technology to control wilt disease of banana in NE Region

The project aims at management of *Fusarium wilt* in NE Banana using FUSICONT technology as well as production and successful demonstration of 1.5 lakh disease-free bio-immunized tissue culture Malbhog and Sabri banana plantlets in 10 selected districts of Assam and Tripura. During the year, a total of 18 training programs and 26 demonstrations were conducted at different localities of Gossaigaon, Barpeta, Goalpara and Chirang districts of Assam covering 758 farmers. 20,000 bio-immunized tissue cultured Malbhog plantlets were developed at ICAR-CSSRI, Lucknow in collaboration with the startup incubatee M/s Barsana Farms, Assam and is hardened at Horticultural Research Station, AAU, Kahikuchi, Assam for distribution to the farmers in the district of Goalpara, Assam. Further, 6000 bio-immunized tissue culture Malbhog plantlets and 2000 Sabri plantlets were developed at ICAR-CSSRI, Lucknow in collaboration with the startup incubatee M/s Atharv Biotech, Lucknow and is hardened at Agriculture College, Tripura. A total of 185 farmers and prospective entrepreneurs have benefitted from capacity building training programmes comprising of interactive lectures and hands on training in Tripura.





Fig. 8.10. Images showing training activities and field demonstration of FUSICONT technology

Development and Utilization of Bioresources of NER for Generating Livelihood Security and Entrepreneurship

An improved and hygienic process for mass production of fermented foods of Meghalaya – Chubitchi (fermented rice beverage) and Tungrymbai (fermented soybean) has been standardized. Training programmes were organized on the same package of practice including starter culture involving 250 beneficiaries. Two *Lactobacillus* cultures i.e., *Lactobacillus fermentum* and *Lactobacillus rhamnosus* have been deposited in the MTCC-IDA patent under the Budapest Treaty. A novel hybrid

biogas (with PRB) operated by solar dryer was designed and fabricated for drying of large quantity (50 kg) of high-value nutraceutical, medicinal and agricultural products. A 500kg solar-biomass hybrid distillation plant with the mobile type distillation vessel design has been developed. Training and demonstration of hybrid distillation plant is provided to more than 150 farmers.

To promote the seed production and culture of Pabda – a commercial important local fish of NE Region, three awareness camps at Sepahijala, Tripura and one awareness camp at Imphal (East), Manipur were conducted benefiting 126 fish farmers. Several OFTs were conducted in the farmers' field on monoculture, polyculture and seed production technology at Manipur and Tripura. A technology for the commercial cultivation of Shiitake mushroom using different substrates (enriched paddy straw, perilla stovers) has been developed, validated and demonstrated in farmers' field. To optimize and scale up the PGPR strain(s), a bioreactor of 600L capacity has been designed and fabricated in a way that it is able to address improved productivity, validation of desired parameters for obtaining compatible and higher quality products in a cost-effective manner. Various training, demonstration and awareness programmes were organized on the use of OP-12 biofertilizer and its beneficial impact on normal to water stress conditions.





Fig. 8.11. Training and sensitization programmes on Mushroom cultivation for sustainable livelihood

Production of Quality Planting Material of Elite Walnut Cultivars and Demonstration of Improved Agro Technology for Walnut Orchards

The project aims at establishment of commercial walnut orchards with high density plantation of elite walnut varieties which are dominant in world trade as well as the mass multiplication of indigenous varieties with desired traits in Kashmir and Arunachal Pradesh. The project is expected to generate 30,000 quality plants every year from second year onwards covering a total of 300 acres of high-density plantation during the period besides attaining high rate of success in grafting by overcoming the seasonal barrier which is a limiting factor for mass multiplication of grafted walnut plants.

F. Mission Programmes

Himalayan Bioresource Mission programme

The programme, launched in 2021 and anchored through DBT-ILS-IBSD Partnership Centre, primarily aims at bioresource-based development and sustainable utilization through biotechnological interventions for socio-economic upliftment of the entire Himalayan region. During the year, 27 projects were initiated connecting eastern and western Himalayas. Most significant achievements during the year are summarized below:

Plant Bioresources (including Agri and Horticulture resources):

Evaluation of genetic diversity of underutilized crops of Himalayan region such as *Amaranthus* spp., *Nigella sativa* (Kalaunji), *Bunium persicum* (Kala Zera), wild edible fruits and vegetables (*Rubus* spp., *Crataegus* spp., *Viburnum* spp., *Taraxacum* spp.) based on molecular and genomic characterization was initiated. Agro-technology is being developed for cultivation of low chilling varieties of apple (Anna, Dorsett Golden, M111, M7) in non-traditional areas such as Manipur along with virus indexing. Program has been initiated for generating high-depth genomic information on the NER and J&K rice cultivars (black and red rice) towards improving their nutritional quality and stress tolerance. Available pre-breeding material and QTL will be characterized, validated for micro-nutrient content (iron, zinc, and anthocyanin compounds) along with improving in yield by manipulating grain numbers, lodging and drought tolerance through genomics-based breeding strategy.

Animal Bioresources (including Fisheries, Wildlife etc.):

Prevalence, characterization and molecular epidemiology of Mycobacterial infections in free-ranging Kashmir stag (hungul) and captive Double-humped camel, Mithun and Yak of Eastern and Western Himalayas has been initiated. Sero-surveillance and molecular epidemiology studies of selected infectious diseases of the livestock in Himalayan Region has been taken up. Work has been initiated on exploring the Himalayan medicinal plants with immunomodulators and galactagogue properties towards improving the animal health to optimize cattle productivity. Efforts have been initiated for isolation and identification of potential bioactives from selected edible insects of NER with specific reference to anti-diabetic and anti-inflammatory

activities. Breeding protocol has been developed for three indigenous, commercially important, ornamental species of snow trout (*Schizothorax richardsonii*, *S. progustus* and *S. plagiostomus*).

Microbial Resources:

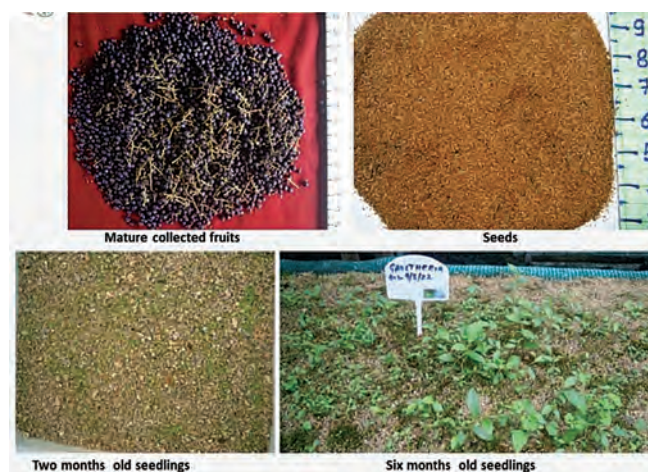
Work has been initiated on process optimization and scale-up production of lignocellulosic extremozymes from Western Himalayan microbes for biomass valorization / depolymerisation and xylanase / cellulose enzymes microbes of Sikkim Himalayas. Work on development of mycovirus-based biological control strategy for the control of *Rosellinia necatrix* infecting fruit crops and *Sclerotinia sclerotiorum* infecting vegetable crops in Indian Himalayan region has been initiated. Program has been initiated on microbial resources for enhancing the crop productivity and soil health under jhum and terrace / valley agro-ecosystems of Eastern and North-Western Himalayas.

Medicinal and Aromatic Plants (including Nutraceuticals, Phyto-Pharmaceuticals, etc.):

Documentation and validation of traditional medicine resources of Eastern Himalayan region along with developing new generation alternative therapeutics has been initiated. Ethnobotanical survey of seven districts of Manipur has been completed covering 102 traditional healers. About 180 medicinal plants and 308 formulations were documented for their traditional uses. Eight formulations have been tested scientifically for their bioactivity and one formulation for traditional remedy of wound healing has been finally selected for further development.

Multiplication, cultivation, standardization of post-harvest processing of high-altitude aromatic plants of Western and Eastern Himalayas have been taken up. Four nurseries have been established for production of quality planting material of target

aroma crops in different locations of Uttarakhand and Manipur. About 5.65 acres area has been covered involving 95 farmers during the current year with *Allium stracheyi*, *Allium humile*, *Angelica glauca*, *Carum carvi*, *Rosemarinus officinalis*, *Origanum vulgare* in Uttarakhand and *Ocimum basilicum*, *Cinnamomum zeylamicum* and *Elsholtzia griffithii* in Manipur. A total area of 6.22 acres has been covered following GAPs so far, with cultivation of *S. chirayita*, *N. jatamansi* and *A. heterophyllum* in Uttarakhand and *S. chirayita* and *G. fragrantissima* in Meghalaya involving 354 farmers. On-farm training programmes have also been organized for farmers and potential entrepreneurs in the region. Work on standardization of agrotechnology for captive cultivation of *Mentha piperita* in Manipur has been initiated. Distillation unit (2500 L capacity) is being set up to facilitate the extraction of essential oil by beneficiary farmers in the state. A total of 22 medicinal plants extract from Manipur were screened for anti-bacterial activities against 18 strains of Sepsis causing multi-drug resistant bacteria (*E. coli*, *Klebsiella pneumoniae* and *Acinetobacter baumannii*), and three plant extracts have shown promising results.



A



B



C.

Fig. 8.12. Outcome from plants based bio resources. (A). *Gaultheria fragrantissima* (winter green) seed germination and seedling raising (DBT-IBSD Node, Shillong). (B). Nursery plot of *Mentha piperita* at Hararao campus of DBT-IBSD, Imphal. (C). Library of plant extracts and phytomarkers of Medicinal Plants of NE Region (DBT-IBSD, Imphal)

Bioresources for livelihood security, training and entrepreneurial opportunities:

Programme has been initiated on creating and promoting bioresource-based livelihood security and entrepreneurial opportunities in North-East and Western Himalayan region. Demonstration of complete agro-technology packages for *Picrorhiza kurroa* (a medicinal plant) and Shitake mushroom has been taken up involving farming communities of high-altitude areas of Himachal Pradesh and NER. Efforts have been initiated on creating social innovations and entrepreneurial opportunities for Himalayan bioresources at GIAN, Sikkim. Eighteen value-added products from local bioresources in Himalayan region have been identified for promoting entrepreneurships.

09

**DATA MONITORING AND
ANALYSIS**

9

DATA MONITORING AND ANALYSIS

Implementation of Output-Outcome Monitoring Framework (OOMF)

Department of Biotechnology (DBT) implements Output-Outcome Monitoring Framework (OOMF) which has been formulated by NITI Aayog for each Department/Ministry to strengthen the monitoring & evaluation of various schemes/programmes. Presently, DBT has two Central Sector Schemes, i.e., (i) Research and Development (R&D) and (ii) Industrial and Entrepreneurship Development (IED).

The core focus areas of R&D Scheme is to promote and encourage collaborative research to address needs for developing technological and clinical solutions in the field of Agriculture, Medicine, Environment, Marine, Animal and other areas such as societal related challenges. However, IED Scheme focuses to develop high quality basic infrastructure and high-end equipment facilities with research and development, product development, piloting and validation by SMEs and Biotech industries. There are well defined Scientific Decision Units headed by Departmental Scientists to manage, monitor and supervise various thematic areas pertaining to the various fields of Bio-Technology.

The DBT has set annual targets against each output and outcome indicators to monitor the progress of each of its programmes and schemes through OOMF. All the output (i.e., the direct and measurable product of programme activities) indicators and outcome (i.e., the collective results or qualitative improvements brought about in the delivery of the activities) indicators are measurable, bringing-in greater accountability in execution of schemes and programmes of the Department. The progress is updated both quarterly & annually by DBT on OOMF dashboard developed and maintained by NITI Aayog.

Some of the selected scientific outputs and outcomes of R&D Scheme and IED Scheme have been given in the Table-9.1 - Table-9.3.

Table-9.1: Selected Outcomes of R&D Scheme

Sl. No.	Outcome indicators (R&D)	2020-21	2021-22
1	Manpower trained	9763	36028
2	Publications	2393	342
3	Patents Filed	80	54
4	Technology Developed/ transferred/ commercialized	112	6

Table-9.2: Selected Outputs of IED Scheme

Sl. No.	Output Indicators (IED)	2020-21		2021-22	
		Targets	Achievements	Targets	Achievements
1	No. of incubators supported & facilities developed (instrumentation, fermentation, etc.)	60	61	70	240
2	No. of new facilities developed to promote linkages between research institutions & industries	NA	NA	9	20
3	No. of small business innovation research Initiative (SIBRI) supported in the current year.	NA	NA	54	47
4	No. of biotechnology ignition grant (BIG) grantees supported in the current year.	NA	NA	300	1008
5	No. of Biotechnology industry partnership program (BIPP) projects supported in the current year.	NA	NA	45	44

Table-9.3: Scientific Outcomes pertaining to IED Scheme

Sl. No.	Output Indicators (IED)	2020-21		2021-22	
		Targets	Achievements	Targets	Achievements
1	Technologies/Products commercialized	13	13	91	80
2	Patents filed/ Granted	40	43	62	13
3	Start-up generating follow-on funding (<10 Lakhs)	29	29	32	37
4	No. of users using facilities in clusters	150	450	800	2064
5	No. of manpower supported/trained	NA	NA	260	5726
6	No. of Entrepreneurs, Startups/SMEs/Industry supported	NA	NA	850	1113

eProMIS

To bring transparency and saving the delay in the cycle of research proposals, the Department of Biotechnology, Ministry of Science & Technology, Government of India has introduced a web enabled Project Management Information System, namely, eProMIS. eProMIS facilitates for the online submission, evaluation, management, monitoring and closure of research proposals in various area of Biotechnology. It is hosted at the NIC sever at <http://www.dbtepromis.nic.in>. It is a gateway that unifies access to departmental information of research proposals/projects on the internet. eProMIS helps the Department in managing its data and large volume of information with more accuracy and transparency. It has helped DBT in reducing the time lag and use of paper in the department.

The thematic area wise distribution of selected research proposals that DBT has received in the past few years has been depicted in Table-9.4. Out of 3946 completed research proposals, DBT has been able to achieve 7472 publications, 565 patents and 281 technologies.

Table-9.4: Research Grants and its Scientific Outcomes of selected thematic areas (From FY 2014-15 to 2021-22)

Sl. No.	Thematic Areas	No. of Proposal	Amount Released (Rs. In Lakhs)	Publications	Patents	Technology
1	Agricultural Biotechnology	304	46,791.69	431	36	37
2	Animal Biotechnology	132	15,876.05	196	17	18
3	Biofertilizers & Biopesticides	67	2,438.31	123	16	2
4	Cancer Research Biology	332	36,319.54	524	24	8
5	Computational Biology	180	21,141.99	547	11	11
6	Environmental Biotechnology	386	37,481.46	1063	71	34
7	Industrial Biotechnology	53	2,372.38	65	5	3
8	Infectious Disease Biology	342	30,465.19	614	23	22
9	International Collaboration & Cooperation	107	30,209.39	53	2	0
10	Marine biotechnology	136	7,688.10	308	15	15
11	Medical Biotechnology	468	1,51,123.72	658	34	20
12	Miscellaneous*	63	52,796.77	641	74	20
13	Modern Biology	808	51,535.97	1691	202	34
14	NER	281	29,422.05	26	0	0
15	Plant Biotechnology	126	8,399.84	176	19	21
16	Public Health & Nutrition	161	8,511.87	356	16	36
17	Grand Total	3946	5,32,574.33	7472	565	281

* Misc. includes projects related to Centre of Excellence and Infrastructure Facilities.

Table-9.5, below, shows the trend analysis of research project completed in selected thematic areas of R&D from FY 2014-15 to FY 2021-22. Further, Table-9.5 also indicated that highest number of research projects have been completed under the Modern Biology Thematic Area.

Table-9.5: Research Project Completed in selected thematic areas of R&D

Sl. No	Thematic Area	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	Grand Total
1	Agricultural Biotechnology	35	40	38	43	24	30	47	47	304
2	Animal Biotechnology	27	16	13	23	11	13	14	15	132
3	Biofertilizers & Biopesticides	19	24	18	3	3	0	0	0	67
4	Cancer Research Biology	87	43	50	29	17	35	46	25	332
5	Computational Biology	15	14	7	13	26	31	53	21	180

6	Environmental Biotechnology	74	37	45	47	37	31	57	58	386
7	Industrial Biotechnology	14	19	15	5	0	0	0	0	53
8	Infectious Disease Biology	24	70	56	33	24	19	62	54	342
9	International Collaboration & Cooperation	13	9	11	9	5	5	23	32	107
10	Marine biotechnology	13	12	12	14	23	17	26	19	136
11	Medical Biotechnology	48	62	44	56	17	68	91	82	468
12	Miscellaneous	4	6	14	10	8	8	8	5	63
13	Modern Biology	149	110	165	114	69	50	66	85	808
14	NER					1	126	25	129	281
15	Plant Biotechnology	11	19	21	23	14	2	6	30	126
16	Public Health & Nutrition	29	30	18	31	15	10	10	18	161
17	Grand Total	562	511	527	453	294	445	534	620	3946

Table-9.6: Year-wise Publications in selected thematic areas of R&D

Sl. Thematic Area No	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	Grand Total
1 Agricultural Biotechnology	26	60	119	73	28	61	60	4	431
2 Animal Biotechnology	30	29	12	83	11	4	24	3	196
3 Biofertilizers & Biopesticides	33	42	37	0	11	0	0	0	123
4 Cancer Research Biology	125	112	86	81	35	56	23	6	524
5 Computational Biology	39	56	14	12	128	143	153	2	547
6 Environmental Biotechnology	170	100	164	87	85	106	298	53	1063
7 Industrial Biotechnology	24	26	12	3	0	0	0	0	65
8 Infectious Disease Biology	18	168	127	63	129	1	77	31	614
9 International Collaboration & Cooperation	18	1	8	12	0	0	7	7	53
10 Marine biotechnology	13	43	57	10	74	77	15	19	308
11 Medical Biotechnology	99	65	81	85	27	112	134	55	658
12 Miscellaneous	0	0	68	415	15	51	92	0	641
13 Modern Biology	307	251	562	272	132	62	62	43	1691
14 NER	0	0	0	0	0	7	0	19	26

15 Plant Biotechnology	20	37	71	27	13	0	2	6	176
16 Public Health & Nutrition	36	130	49	49	7	42	7	36	356
17 Grand Total	958	1120	1467	1272	695	722	954	257	7472

The Table-9.6 above portrays the year wise trend of publications out of completed research projects. It can be inferred from the Table-9.6 that maximum number of publications came out in the year 2016-17. Out of total 7372 publications the highest numbers of publications are from the field of Modern biology that is 1691 publications.

Table-9.7: Comparative Statement on Research Proposals and Outcomes (FY 2014-15 to FY 2021-22)

Sl. No.	Thematic Areas	No. of Proposal	Average Project Cost (Rs. In Lakhs)	Average Patent /Technology Cost (Rs. In Lakhs)
1	Agricultural Biotechnology	304	153.92	640.98
2	Animal Biotechnology	132	120.27	453.60
3	Biofertilizers & Biopesticides	67	36.39	135.46
4	Cancer Research Biology	332	109.40	1,134.99
5	Computational Biology	180	117.46	961.00
6	Environmental Biotechnology	386	97.10	356.97
7	Industrial Biotechnology	53	44.76	296.55
8	Infectious Disease Biology	342	89.08	677.00
9	International Collaboration & Cooperation	107	282.33	15,104.69
10	Marine biotechnology	136	56.53	256.27
11	Medical Biotechnology	468	322.91	2,798.59
12	Miscellaneous	63	838.04	561.67
13	Modern Biology	808	63.78	218.37
14	NER	281	104.70	0.00
15	Plant Biotechnology	126	66.67	210.00
16	Public Health & Nutrition	161	52.87	163.69

The Table-9.7 represents the average project costs and the average patents/technology cost of selected completed Research Projects from the FY 2014-15 to FY 2021-22. It can be observed from Table-9.7 that the Societal Program as a Biotechnology area has the lowest average project cost of completed projects which further indicates that in low amount maximum number of research projects has been completed. Moreover, the Public Health & Nutrition is that Biotechnology area wherein the average cost of patents/technology is the lowest.

10

AUTONOMOUS INSTITUTIONS AND PUBLIC SECTOR UNDERTAKINGS

10

AUTONOMOUS INSTITUTIONS AND PUBLIC SECTOR UNDERTAKINGS

The Department has set up 14 theme based Autonomous Institutions, one statutory organization (RCB) and supporting one International Centre (ICGEB). These institutions facilitate flow of knowledge from Basic Science to Translational Research in Health, Agriculture, Bioresources 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 resulted in more than 900 Publications and 90 patents (applied & obtained). More than 30 technologies / products/ processes have been developed, and Over 1600 human resource have been trained. Apart from Autonomous Institutions, the DBT also has three Public Sector Undertakings (PSUs) under its administrative control. Various activities carried out during the year by these institutions are given in subsequent part of this chapter. Apart from the R&D activities in various areas of Biotechnology and Modern Biology, the autonomous institutions and PSUs have also taken initiatives to address the challenges due to COVID-19 pandemic including efforts related to understanding the pathophysiology and epidemiology of the disease, and development of diagnostics, vaccine and therapeutics. These initiatives pertaining to the COVID-19 pandemic have been mentioned in a special chapter of this report. Detailed of the R&D and other activities carried out by all these institutions during the year are as follows:

NATIONAL INSTITUTE OF IMMUNOLOGY (NII), NEW DELHI

The National Institute of Immunology perpetually strives to expand its intellectual and academic horizons in the area of life sciences. The research programs of NII are focused on unravelling immune pathways that help preserve organismal homeostasis, deciphering mechanisms of pathophysiology that operate in infectious and non-infectious diseases, elucidation of the structure and function of biomolecules and development of novel diagnostics, therapeutics and vaccines. Special attention is given to research work on diseases of particular concern to the country. The thrust areas of NII are organized under three broad umbrella programs, namely: Immunity and Infection; Genetics, Cell Signalling and Cancer Biology; Chemical Biology, Biochemistry and Structural Biology.

Major Initiatives Taken:

- A study from NII has demonstrated that BBV152/Covaxin elicits robust memory CD4 T cells to SARS-CoV-2 and variants of concern.
- Biosynthetic mechanism of a novel class of compound that sequesters zinc from the host and contributes to pathogenesis of *Mycobacterium tuberculosis* (*Mtb*) have been dissected. Also, a novel class of non-toxic inhibitors targeting Histidine biosynthetic pathway of *Mtb* has been identified using structural biology and macrophage infection models.
- A novel pathway involving protein kinase PfCDPK7 was dissected, leading to clues about new drug targets. Studies towards vaccine

development for malaria have delineated the minimal protective antigenic regions of several newly identified antigens.

- Research at NII has demonstrated that progesterone slows the growth of beta-hCG responsive tumor cells *in vivo*, an observation that has implications for treatment with progesterone upon detection of intra-tumoral/extra-tumoral beta-hCG in post-menopausal women.
- Studies on the molecular basis of aging using *Caenorhabditis elegans* as a model system have revealed how specific dietary interventions can influence the aging process, and have demonstrated the potential of employing repurposed drugs as therapeutics in diabetes-related illnesses.
- NII has filed a trademark (ASPAGNII) for a SPAG9 recombinant protein cell-based immunotherapeutic vaccine component for the treatment of various types of cancer.
- Technology developed at NII for using a collagen-based formulation for treatment and management of osteoarthritis has been transferred for commercialization.

Notable Outcomes and Achievements

<i>Major Achievements</i>	<i>Number</i>
Projects completed	34
Process/Product/ Technology Developed	2
Research Publications	54
Patents Applied	4
Patents Obtained	4
Human Resources Trained	80
<i>Major Honours & Awards received by scientists</i>	3

Major Achievements

- **Inactivated whole-virion vaccine BBV152/ Covaxin elicits robust memory CD4 T cells to SARS-CoV-2 and variants of concern:** BBV152/Covaxin is a whole-virion inactivated vaccine based on an Asp614Gly variant and formulated with a toll-like receptor (TLR) 7/8 agonist molecule (imidazoquinolin) adsorbed to alum. BBV152 was the first alum-imidazoquinolin adjuvanted vaccine produced in India and received emergency use authorization from the World Health Organization for use in a large population. Although the clinical trial data were available for the vaccine efficacy, there were several questions remained unanswered, particularly, (i) whether the vaccine induces immune memory (ii) how long the vaccine-induced memory persists and (iii) whether these memory responses are able to sustain against the SARS-CoV-2 variants. In a multicentric collaboration, the team at NII provide the first evidence on the traits of immune memory generated in response to inactivated virus vaccine. Team further confirmed that vaccine was capable of inducing Tfh cells that exhibited B cell help potential and thus, it seems to have the ability to induce a good quality humoral immunity. These findings show that inactivated vaccine Covaxin induces robust immune memory to SARS-CoV-2 and variants of concern that persists for at least 6 months after vaccination. This work has been published in *Nature Microbiology* (<https://doi.org/10.1038/s41564-022-01161-5>).

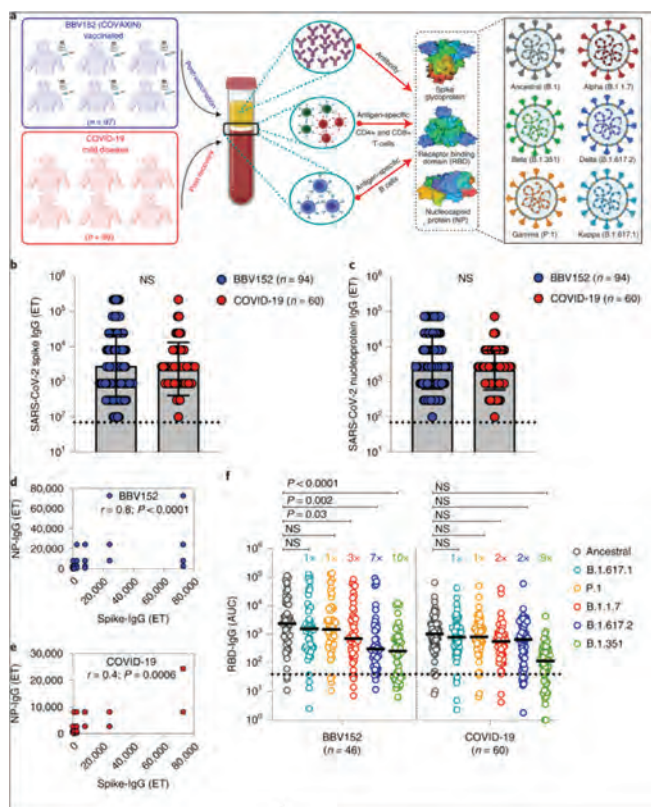


Fig.10.1 Inactivated whole-virion vaccine BBV152/Covaxin elicits robust cellular immune memory to SARS-CoV-2 and variants of concern

- Mycobacterium tuberculosis* (Mtb)** produces zinc homeostatic metallophores, Kupyaphores, required for colonization: Mtb endures a combination of metal scarcity and toxicity throughout the human infection cycle, contributing to complex clinical manifestations. Pathogens counteract this paradoxical dysmetallostasis by producing specialized metal trafficking systems. While Mtb iron-chelating siderophores, mycobactin, have been known since 1965, it is not known whether Mtb produces zinc scavenging molecules. This study characterizes low-molecular-weight zinc-binding compounds secreted and imported by Mtb for zinc acquisition. These molecules, termed kupyaphores, are produced by a 10.8 kbp biosynthetic cluster and consists of a dipeptide

core of ornithine and phenylalaninol, where amino groups are acylated with isonitrile-containing fatty acyl chains. Kupyaphores are stringently regulated and support Mtb survival under both nutritional deprivation and intoxication conditions. A kupyaphore-deficient Mtb strain is unable to mobilize sufficient zinc and shows reduced fitness upon infection. Early induction of kupyaphores was observed in Mtb-infected mice lungs after infection, and these metabolites disappeared after 2 wk. Furthermore, the team identified disonitrile hydratase, which can possibly mediate intracellular zinc release through covalent modification of the isonitrile group of kupyaphores. Mtb clinical strains also produce kupyaphores during early passages. This study uncovers a previously unknown zinc acquisition strategy of Mtb that could modulate host-pathogen interactions and disease outcome. This work has been published in PNAS (doi: 10.1073/pnas.2110293119.)

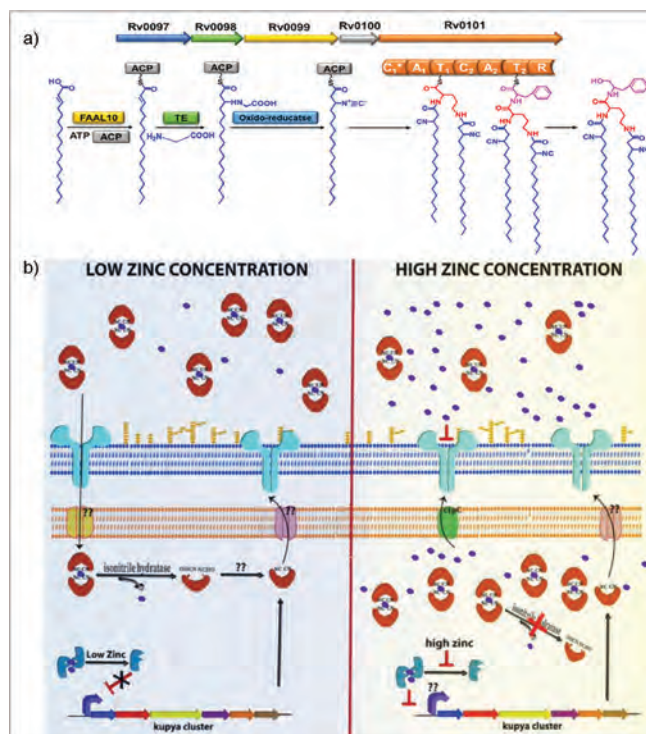


Fig.10.2 a) Biosynthetic gene cluster for Kupyaphore b) Secretion of kupyaphores under limiting zinc conditions would

allow *Mtb* to scavenge zinc from environment Conversely, under toxic zinc conditions, kupyaphores would chelate intracellular accumulated zinc levels thus contributing to metal detoxification.

- Peptide complex with immunomodulatory and anti-inflammatory function (Granted US Patent No. 11, 447, 534)

In the last several years, peptide therapeutics have gained wide attention. Peptides represent a unique class of pharmaceutical compounds, molecularly positioned between small molecules and proteins, yet biochemically and therapeutically unique from both. The present invention relates to a peptide complex and the use of the peptide complex for immunomodulation and treatment of inflammatory diseases. Studies by NII scientists had revealed that certain immunomodulatory complexes were formed in the brain of 5xFAD mice treated with undercarboxylated osteocalcin (Glu-OC), because of co-localization of “Abeta4” (A) with “osteocalcin” (O). They found that the A-O complex was a non-toxic peptide complex, acting as a potent immunomodulator and anti-inflammatory agent. It is envisaged this complex, with its immunomodulatory and anti-inflammatory potentials, will have commercial application for the treatment of immune and inflammatory disorders. After due process of patent application very recently US patent was granted to the investigators at NII for this invention. In brief, the present invention relates to the compositions that are effective in the management of inflammatory diseases. The disclosure provides a non-toxic peptide complex comprising Abeta 1-42 and undercarboxylated osteocalcin, which displays anti-inflammatory and immunomodulatory functions. The disclosure further provides processes for preparing the compositions.

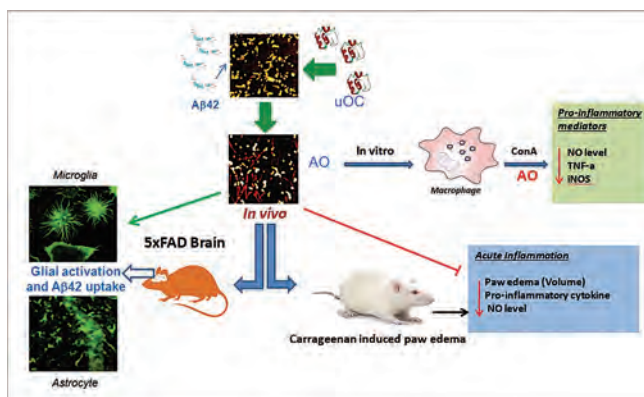


Fig.10.3 Peptide complex (AO) with immunomodulatory and anti-inflammatory function

Societal Impact: By providing cutting-edge training in biotechnology, NII continues to contribute towards the strengthening of the scientific aptitude of the county's undergraduate students. The Institute's outreach programmes continued during the pandemic, with lectures held online. Under the “Science Setu” programme, NII scientists delivered five scientific lectures to undergraduate and postgraduate students across India (January 2022 till date). Four lab visits were conducted for students from the Lions Public School, Vidyarthi Vigyan Manthan (VVM), Gargi College (University of Delhi), and from Guwahati University.

CENTRE FOR DNA FINGERPRINTING AND DIAGNOSTICS (CDFD), HYDERABAD, TELANGANA

CDFD an autonomous Institute of Department of Biotechnology, is the first and only institute in the country that works on ‘hybrid model’ including services and research both components, complementing and enriching each other. The unique features of the CDFD is providing service and training in human DNA fingerprinting, plant DNA fingerprinting, genetic disorder diagnosis as well as basic research in various fields of modern biology.

Major activities during 2022-23:

Human DNA fingerprinting services: CDFD provides DNA fingerprinting services to different civil and criminal cases and also in various national security and public safety cases referred by the National Investigative Agency (NIA).

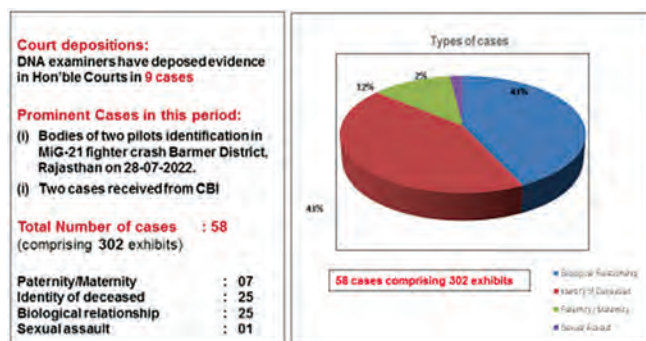


Fig. 10.4 Human DNA fingerprinting services

Plant DNA fingerprinting services: CDFD tests the Basmati rice samples for its purity received from Export Inspection Council (EIC), Ministry of commerce, Govt. of India which has contributed to the increase in Basmati exports, and acted as a major deterrent to adulteration in Basmati export consignments.

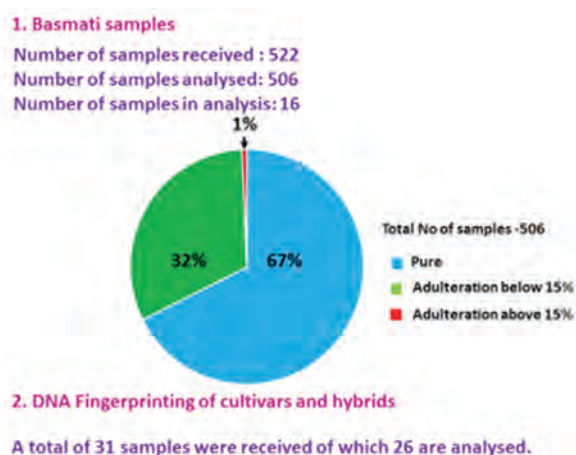


Fig. 10.5 Plant DNA fingerprinting services

Diagnostic services: The Diagnostics services division of CDFD offers comprehensive diagnosis of genetic diseases (cytogenetic, biochemical and

molecular). CDFD is one of only two centres in India offering DNB in Medical Genetics program. In addition, CDFD has established a DBT Nidan Kendra at Yadgir and Raichur District hospitals, Karnataka. CDFD has established National Genomics Centre for NGS based diagnosis for rare diseases.

COVID Diagnostics and Genome Sequencing: CDFD initiated RT-PCR based diagnostics of SARS-CoV-2 causing COVID-19 infection from 17th April 2020 by establishing a state-of-the-art laboratory with a maximum testing capacity of 450 samples per day. Around 60,761 suspected patient samples obtained from various districts of Telangana have been analyzed so far. Identification of positive samples has helped the State Govt. in contact tracing and containment measures. CDFD also performed the first comprehensive study from the state of Telangana on the dynamics of SARS-CoV-2 genomic evolution. As part of the Indian SARS-CoV-2 genomics consortium (INSACOG) initiative, CDFD has sequenced SARS-CoV-2 genomes with the overarching objective of identifying unique mutations. A total of 8407 samples have been sequenced in 2022.

Research: Basic research activities at CDFD are geared towards a better understanding of different biological processes. There are 19 different research groups involved in a wide range of research areas in modern biology. CDFD has published a total of 52 research articles in the year 2022, some of which are in highly reputed journals including British Journal of Cancer, Journal of Immunology, Plant Communications, Autophagy, Trends in Microbiology, Nucleic Acids Research, EMBO Molecular Medicine, EMBO Journal, Fertility & Sterility Science, Aging Cell, etc. A few significant research findings are given below:

High level accumulation of stress-induced misfolded protein aggregates are cytotoxic. Selective degradation of such aggregates by macroautophagy

protects cells from proteotoxicity. In the recent work, scientists at CDFD have shown a novel functional role of HYPK protein in coordinating degradation of stress-induced polyneddylated misfolded protein aggregates by autophagy. In this process, HYPK function as an autophagy receptor in a polyneddylated dependent macroautophagy of misfolded protein aggregate (*Autophagy*, 2022).

In another study, CDFD discovered a new histone modification - H2B Y121 phosphorylation – that acts as a molecular switch during DNA transcription. In addition, it was found SHP-1 as a phosphatase that regulates this modification (*EMBO Journal*, 2022)

Human Resource Development: Another important mandate of CDFD is to train manpower through its PhD and various other training programmes. This year 15 students were enrolled for PhD and 13 students have been conferred with the degree. CDFD scientists and students have been recognized with many prestigious award including Shanti Swarup Bhatnagar, J C Bose Fellowships and Fellowships of National Academies.

Key Initiatives & Achievement:

Mission program on Pediatric Rare Genetic Disorders (PRaGeD): PRaGeDis a PAN-India initiative aims to; create awareness, achieve genetic diagnosis, discover & characterize novel genes, provide counselling, and to develop novel therapies for pediatric rare genetic diseases in India. CDFD is collaborating with pediatric departments of various medical colleges, DBT-UMMID centres, and 15 collaborating centers across India to collect blood samples from children with rare genetic disorders, and their parents. Furthermore, the PRaGeD aims to develop novel and cost-effective diagnostic and screening approaches for rare genetic diseases aligning with the Ministry of Health and Family Welfare's National Policy for Rare Diseases 2021, which intends to lower India's high treatment costs

for rare diseases. Through this program, the investigators are aiming to minimize the burden of rare diseases in India.

Establishment of CDFD- High Performances Genomic Data Supercomputing Facility: This facility has an ultra-high-capacity data storage facility (2Petabyte) connected with a lighting fast CPU and GPU-based high performances genomic data supercomputing facility. The facility provides high-volume next-generation sequencing (NGS) data analysis, storage, and exchange via high-speed internet. A BSL-3 facility also being established for studies on infectious diseases.

Societal Impact:

CDFD has established a DBT Nidan Kendra at Yadgir District hospital and Raichur Institute of Medical Sciences, Raichur Karnataka under a DBT-UMMID initiative for management and treatment of inherited disorders. Establishment of a science museum at an aspirational district in Raichur, Karnataka is in final stage. CDFD organized various seminars/conferences/workshops during the reporting period and also organized many open days and institutional visits of the students from various schools and colleges for the benefit of the students under various outreach activities of the institute

CENTER OF INNOVATIVE AND APPLIED BIOPROCESSING (CIAB), MOHALI, PUNJAB

Center of Innovative and Applied Bioprocessing (CIAB), an autonomous institute of the Department of Biotechnology, Govt. of India, is the only institute in the country which works mainly on Secondary Agriculture and development of value added products from different types of bio resources. Its mandate fits well with the of Govt. of India's programme on "Doubling the Farmer's Income" with the same inputs. It also become more relevant in present context when Indian Agriculture is going on complete transformation with limited land resources

and increasing input costs. We all are aware that the agricultural wastes are being burnt by many farmers. If this Agri-waste is used to isolate bioactive compounds with high market value, it can directly benefit the farming community by increasing their farm income. It will not only provide new avenues to establish industrial units on utilization of Agri-waste but will also provide new employment opportunities to the rural masses.

Major Initiatives & Achievements:

Within ten years of establishment, CIAB has made substantial contributions in developing various processes to derive products from the agricultural waste. The Scientists of the institute have been able to transfer two technologies, i) D-psicose-a nearly zero calorie sugar production from the biomass and ii) a liquid whey beverage product named CIAB-NAVITA to the industries. Also, CIAB has signed non-disclosure agreement (NDA) for three technologies with the industries who have expressed their interests. In addition, institute has developed several other technologies which are at different stages of scale up and commercialization. The institute is working in the well-designed four R & D programmes; (i) Value addition to primary processing residue/wastes for edible products, (ii) Valorization of crop wastes for specialty products and chemicals, (iii) Nutritionals, nutraceuticals, and upgradation of value or of use of primary processing bioproducts and (iv) Biosynthetic technology/synthetic biology for low volume-high value products and industrial enzymes.

CIAB has recently licensed a technology on production of Food grade dye from *Butea Monosperma Kuntze* via Indian Patent <http://Appl.No.202211005755> to Vexcel Upkram Pvt. Ltd., Ranchi via Biotech Consortium India Limited. Inventors: Bhuwan B. Mishra, Pooja, Nishant, Jyoti, Umesh Singh.

Photodynamic lignin hydrogels were prepared as a versatile self-healing platform for sustained release

of photosensitizer nanoconjugates. These developed biodegradable lignin-based nanocomposite hydrogels can be efficiently used for the development of wound dressings and nanocoatings over various surfaces for stimuli responsive antimicrobial effect. Bhaumik and coworkers, *ACS Appl. Polym. Mater.* 2022, <https://doi.org/10.1021/acsapm.2c01319>

A research article on Enhanced Basicity of MnOx Supported Ru for the Selective Oxidation of HMF to FDCA has been published. A stable, basic MnOx-supported Ru catalyst realizes highly efficient and selective oxidation of 5-hydroxymethylfurfural to 2,5-furandicarboxylic acid (FDCA) in a green solvent (water) in the absence of external base, achieving an excellent yield of FDCA (87 %) with a turnover number of 88 (turnover frequency: 22 h⁻¹), exhibiting higher catalytic efficiency than previously reported Ru-based catalytic systems. *ChemSusChem*, 15, e202200902.

Potential cocoa butter substitute derived from mango seed kernel. This recently developed cocoa substitute has the potential to address the global problem of cocoa butter scarcity, which is being exacerbated by rising population and improving economies. *Food Chemistry* 372, 131244

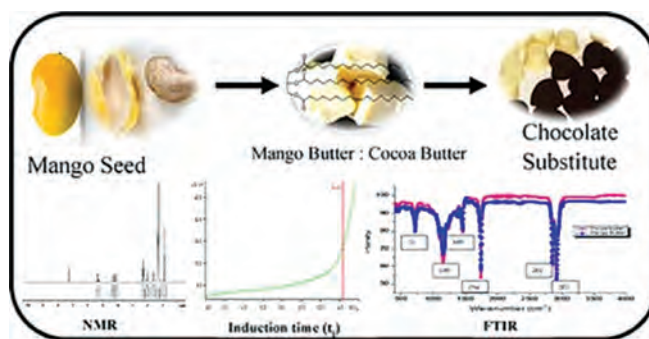


Fig. 10.6 Mango seed kernel butter as potential substitute of cocoa butter

The underutilised agro residue, such as rice straw, cannot be used as fodder and is formidable to valorise to produce value-added chemicals due to its high silica content and intricate nature. This project

focused on concurrently removing non-digestible components, such as lignin and silica, to enrich carbohydrate contents under mild conditions. The carbohydrate-enriched component can also be utilised as feedstock for producing high-value chemicals, such as furfural and levulinic acid – the precursor for biofuels, bioplastics and foundry resin.

Societal Impact: Economy of our country largely depends on agriculture. However, we lack in systematic approach of handling large agro-biomass produced through agriculture. Lot of primary and secondary agriculture produce is wasted. Recently, attention has been paid towards handling such biomass for value addition. In this effort, Center of Innovative and Applied Bioprocessing (CIAB) is continuously working for value addition to primary and secondary agriculture produce by innovative technologies. CIAB's focus is to identify gaps in the research areas of biomass utilization, bioprocessing, food processing and synthetic biology as well as to provide technological solutions. Institute is working on four major R & D programmes; (i) Value addition to primary processing residue/wastes for edible products, (ii) Valorization of crop wastes for specialty products and chemicals, (iii) Nutritionals, nutraceuticals, and upgradation of value or use of primary processing bioproducts and (iv) Biosynthetic technology/synthetic biology for low volume-high value products and industrial enzymes. Overall, CIAB's agri-waste based cutting edge translational research will help developing startups which can directly benefit entrepreneurs, create employment and directly contribute to Government of India's 'Make in India' initiative.

INSTITUTE OF BIORESOURCES AND SUSTAINABLE DEVELOPMENT (IBSD), IMPHAL, MANIPUR

Institute of Bioresources and Sustainable Development (IBSD) is working with the mission for "Bioresources development and their sustainable

use through biotechnological interventions for the socio-economic growth of the North Eastern Region". For the development of bioresources and other outreach activities, IBSD has established three other entities in NER including its Regional Centre at Gangtok in Sikkim and Research Nodes at Shillong in Meghalaya and at Aizawl in Mizoram.

Major Initiatives:

During the year, IBSD has taken many new initiatives including programme on Bioeconomy from Bioresources, programme on Anti-Microbial Resistance (AMR) for the evaluation of antimicrobial activity of the medicinal plants/microbial resources of NER, exploring wild mushroom from NER for nutraceutical and therapeutic potential, development of different formulations with the natural resources including phytosomes of potent phytomolecules and extracts, quality evaluation and therapeutic validation of Cucurbitaceae plants of NER, establishment of translational research facility in IBSD for the development of products/processes/ technologies, capacity building, training and outreach activities for encouraging Start-ups programme under 'AatmaNirbhar Bharat Abhiyaan', Industry-Connect programmes to link industries with local entrepreneurs of Manipur, Meghalaya, Mizoram and Sikkim, collaborative research for linking Eastern and Western Himalaya under Himalayan Bioresource Mission etc. In this context, IBSD has signed MoU with Centre for DNA Fingerprinting and Diagnostics, Hyderabad, Regional Centre for Biotechnology, DBT, New Delhi, NII, New Delhi, CSIR-IHBT, Palampur, Assam Biotech Park, NIT, Manipur, NEHU, Shillong, Department of Science & Technology, Govt of Manipur, PHED, Govt of Manipur.

Key Achievements:

- During 2022, IBSD has published 32 research papers, 02 International patents and filed 01 patent application (Annexure-I).

- IBSD has established the Indian SARS-CoV-2 Genomics Consortium (INSACOG) facility, which is the first time such an effort has been made in NER of India. IBSD has launched Mobile Diagnostic Laboratory (I-LAB) for COVID testing for the State of Mizoram.
- IBSD has organized Industry-Connect (I-Connect) programme under the theme “Exploring Traditional Medicines-Drugs from Nature & drugs from our Ancestors” as a part to celebrate “Azadi Ka Amrit Mahotsav” and forge partnership(s) with industries. The programme was attended by experts from industries, local entrepreneurs, traditional healers from Manipur and experts from different institutes of NER.
- IBSD has been working for Water Quality Management through Testing, Surveillance and Technological Intervention for Socio-Economic Development of Manipur. In this context, IBSD has developed a Bacteriological field test kit for drinking water.
- For the promotion of Start-ups in NER, IBSD has setup Bioincubators Nurturing Entrepreneurship for Scaling Technologies (BioNEST) incubator at IBSD, Node Meghalaya to develop women entrepreneurship through orchid floriculture in Meghalaya. Major focus of the programme is capacity building and training of women bio-entrepreneurs and farmers from different parts of Ri-Bhoi District of Meghalaya. More than 30 progressive women bio entrepreneurs from different villages have been enrolled under IBSD’s BioNEST incubator for providing hands on training on horticulture practices, up keeping, harvesting, packaging, marketing and industry linkage for the selected orchids.



Mobile Diagnostic Laboratory (I-LAB) for COVID Testing for the State of Mizoram



INSACOG facility at IBSD for SARS-CoV-2 genome sequencing

Total Samples sequenced: >1500

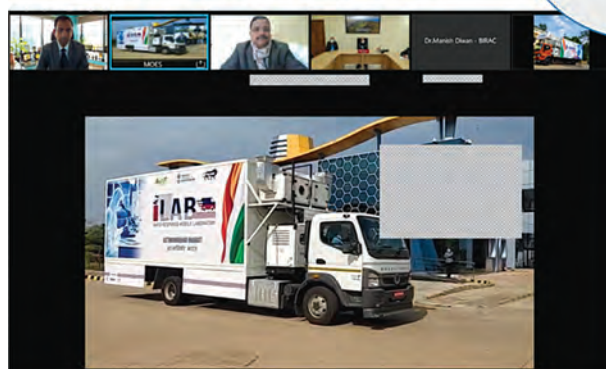


Fig. 10.7 COVID-activities at IBSD

Societal Impact:

To commemorate the 75 years of Independence and to celebrate “Azadi Ka Amrit Mahotsav”, Institute of Bioresources and Sustainable Development (IBSD), Imphal has organised 177 outreach activities including outreach activities, capacity building & training programmes, workshops, webinars for researchers, scientists, school students, traditional healers, farmers, local entrepreneurs of NER besides scientific activities as per the mandate of IBSD. In this context, IBSD has organized 75 International Webinars on “Re-imagine ethnopharmacology”, 25 programmes on “Bioeconomy from Bioresources” with special reference to NER, 41 seminars under “Science Museum” established in Aspiration district for the students from different schools and colleges across the whole state of Manipur, 12 webinars under “Science Setu” programme of Department of Biotechnology, Govt. of India for the DBT STAR colleges of Assam, 15 traditional healers programmes, 04 programmes on capacity building & training on instrumental Techniques under IBSD-JU collaborative research programme for researchers, scientists, students from NER, 05 Industry-Connect (i-Connect) events under the theme “Exploring Traditional Medicines-Drugs from Nature & drugs from our Ancestors” in Manipur, Meghalaya, Mizoram and Sikkim states of NER. All these outreach activities of IBSD have been compiled in the form of book which may serve a reference material for the scientific awareness about local bioresources among the students, researchers, scientists, entrepreneurs, farmers of this region.

INSTITUTE FOR STEM CELL SCIENCE AND REGENERATIVE MEDICINE (DBT-inStem), BANGALORE, KARNATAKA

The scientific programmes at DBT-inStem are organized in the following interdisciplinary themes:

- (i) Cardiovascular development and disease

mechanisms, (ii) Chemical Biology Approaches for Stem Cells and Therapeutics, (iii) Mechanisms Regulating Barrier Tissue Homeostasis, (iv) Modelling neurodevelopment and disease, and, (v) Metabolic Regulation of Cell Fate. The scientific programme at Centre for Stem Cell Research (CSCR), a translational unit of DBT-inStem at Christian Medical College, Vellore is focused on gene therapy of Hemophilia A & B as well as applications of Induced Pluripotent Stem Cell (iPSC) Technology.

Major initiatives taken:

The clinical arm of inStem, the Centre for Stem Cell Research has undertaken two major initiatives:

(a) **Musculoskeletal regeneration-** A cell-based therapy phase I/II clinical trial using foetal liver derived mesenchymal stem cells for the treatment of osteogenesis imperfecta is currently ongoing in collaboration with the Karolinska Institute in Sweden. Another phase I/II trial where the culture expanded muscle derived stem cells is developed for the treatment of urinary sphincter incontinence.

(b) **Novel vectors and gene editing approach for thalassemia and sickle cell disease and haemophilia:** First in human phase 1 clinical trial of Lentiviral vector-based gene therapy of hemophilia A initiated at CMC, Vellore with first subject recruited in May, 2022. Novel AAV vectors developed for haemophilia B. Novel lentiviral vectors for gene addition (beta or gamma globin genes), gene modulation (BCL11A gene) technologies as well gene editing approaches using CRISPR-Cas9 and base editing technologies developed for thalassemia and sickle cell disease and proof of concept studies completed. The first comprehensive program for control and prevention of thalassemia and sickle cell disease in India established in Odisha.

(c) **DBT-inStem: Initiation of stem cell training and workshops through the stem cell facility.**

Major Achievements:

A novel self-skin permeable nano-lithocholic-lipidoid was developed as potential therapeutics for psoriasis, a skin autoimmune disease. A collaborative study at DBT- inStem has identified the mechanism Cancer Stem Cells use to maintain their behaviour in a population of differentiating cells within the tumor. They found that the transcriptional factor, Snail is connected to stemness in both cancer and embryogenesis and that it is involved in the maintenance of the stemness of a specific type of skin cell called epidermal keratinocytes during non-epithelial mesenchymal transition. Establishment of translational platforms that facilitate drug discovery and vaccine efficacy against COVID-19 in vitro and in vivo by grants from the DBT and BIRAC; using this we have identified novel therapies and have patented new diagnostic sensors. DBT-inStem's Recognition in Nature Index 2022 based on Research Publications has been praise-worthy. DBT-inStem is ranked 15th in Life Sciences in India.

Outreach Initiative: The institute has celebrated Stem Cell Awareness weeks by hosting research webinars, and podcasts from experts (English and Kannada) on stem cell research. It has also launched a Science Setu programme under the aegis of the Azadi ka Amrit Mahotsav and hosted 19 online webinars on stem cell science and regenerative medicine for undergraduate students during the reporting period. Additionally, DBT-inStem has also hosted video outreach series "Meet Our Faculty", celebrated various occasions (e.g., National Science Day, Rare Disease Day, Brain Awareness Week) and hosted visiting undergraduate and postgraduate students. DBT inStem in Collaboration with DBT Wellcome Trust India Alliance released documentary film "Out of History: Stories of Forgotten Indian Scientists".

Societal Impact: The research at CSCR has led to the development of novel cell and gene therapies to

meet unmet needs in health care in India and in the world related to hereditary blood disorders such as haemophilia, thalassemia and sickle cell disease as well as bone and muscle regeneration.

INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY (ICGEB), NEW DELHI, DELHI

The ICGEB New Delhi component has made significant progress in research during the year 2022. The component has published around 76 publications and filed 02 national Patent applications. During the year, 01 National and 01 US Patent have been granted. 18 students have been graduated. The New Delhi component has conducted 08 workshops with support of Department of Biotechnology. Recently, an Italo-India one-day joint symposium was also organized on Pandemic and Post Pandemic responses.

A brief description of the progress highlights in three research domains are as follows:

Major Achievements	Number
Projects completed	34
Process/Product/ Technology Developed	6
Research Publications	76
Patents Applied & Obtained	4
Human Resources Trained	369
Major Honours & Awards received by scientists	2

In a study, ICGEB, New Delhi has characterized several human monoclonal antibodies (mAbs) isolated from single B cells of the COVID-19-recovered individuals in India who experienced ancestral Wuhan strain (WA.1) of SARS-CoV-2 during early stages of the pandemic. A receptor binding domain (RBD)-specific mAb 002-S21F2 was identified that has rare gene usage and potentially

neutralized live viral isolates of SARS-CoV-2 variants. The study was conducted in collaboration with Emory University.(Sci Adv. 2022 Oct 7;8(40))

Arboviruses cause several diseases in humans and livestock. Vector control is the main strategy for controlling diseases transmitted by mosquitoes. Efforts are being made to understand the process of viruses replication in the vector for designing better transmission blocking strategies. The global transcriptome signature of *A. aegypti* cells during CHIKV infection was obtained, and further the well-characterized *Drosophila* system was utilized to identify a set of transcripts and their pathways that affect *A. aegypti* cells during CHIKV infection. These analyses and further validations reveal that important pathways related to protein degradation are actively involved during CHIKV infection in *A. aegypti* and are mainly proviral. Targeting these molecules may provide novel approaches for blocking CHIKV replication in *A. aegypti*.(Microbiol Spectr. 2022 Apr 18;e0059522)

A study on *Plasmodium falciparum* HtrA2 (PfHtrA2) protein was conducted that established its specific role in maintaining mitochondrial homeostasis as well as in regulating the stress induced cell death. Under this study, a *Plasmodium falciparum* HtrA2 (PfHtrA2) protein was functionally characterized, which harbours trypsin like protease activity. Genetic ablation of PfHtrA2 caused significant parasite growth inhibition, decreased replication of mtDNA, increased mitochondrial ROS production, caused mitochondrial fission/fragmentation, and hindered parasite development. (PloS Pathogens 18(10):e1010932)

ICGEB through one of its recent studies illustrated importance of an oleaginous yeast *Rhodotorula pacifica* INDKK in an integrated bio-refinery field by utilizing renewable sugars generated from

lignocellulosic biomass. The maximum 11.8 g/L lipid titer, 210.4 mg/L β -carotene and 7.1 g animal feed were produced by *R. pacifica* INDKK in bioreactor containing 5% (v/v) molasses supplemented with enzymatically hydrolyzed and alkali-pretreated sugarcane bagasse hydrolysate (35% v/v). Furthermore, xylooligosaccharides (20.6 g/L), a beneficial prebiotics were also produced from the hemicellulosic fraction separated after alkali pretreatment of bagasse. This novel concept will leads to a sustainable and profitable process of production of biofuels (Bioresour Technol. 2022. 351:127067)

Under another study, it is focused to employ carbon supplementation with varying nitrate concentrations to enhance the total tocopherol, a highly active form of the antioxidant molecules yields in the native isolate *Monoraphidium* sp. CABer41. The best tocopherol productivities were obtained in the NLHC (Nitrate limited + 3% CO₂) supplemented cells (734.38 μ g/L-1 d-1) accompanied by a significant increase in cell biomass (2.65-fold) and total lipids (6.25-fold). In conclusion, the study depicts valorization of carbon dioxide as a cost-effective alternative for the enhancement of biomass along with tocopherols and other concomitant products like lipids and carotenoids in the indigenous strain *Monoraphidium* sp., as an industrial potential strain with relevance in nutraceuticals and pharmaceuticals.(Cells, 11: 1315, 2022)

Salmonella pathogenicity islands (SPI) encodes proteins that are essential virulence determinants for pathogen colonization and virulence. SPI-1, SPI-2 and SPI-6 (formerly known as *Salmonella enterica* centisome 7 island [SCI]) encoding proteins are known to play pivotal role in *Salmonella* pathogenesis. In one of the important studies, a SPI-6 *Salmonella typhimurium* VirG-like protein (STV) is characterized using interdisciplinary experimental approaches

including X-ray crystallography, nuclear magnetic resonance (NMR) spectroscopy and infection assays. Altogether, the findings suggest that STV, a member of the LTxxQ stress protein family, modulates bacterial survival mechanism in macrophages through SPI-1 and SPI-2 genes, respectively (Protein Sci. 2022.doi: 10.1002/pro.4272.).

There is an urgent need to generate rice plants which have improved capacity to tolerate stresses to feed the rising world population. In this aspect, ICGEB explored the genetic conservation of CBS domain-containing protein family in *Oryza* species and their association with abiotic stress responses. This study provides novel insights into the classification, evolutionary conservations, and functional divergence of the members of the CDCP family across different *Oryza* species, which in the future can help researchers in pursuing functional characterization of these proteins. The stress-responsiveness of some members of CDCP genes noted in this study encourages their further study for improving stress tolerance in domesticated *Oryza* species (International Journal of Molecular Science, 23(3):1687)

Root hairs (RH) are a single-cell extension of root epidermal cells. In low phosphorus (LP) availability, RH length and density increase thus expanding the total root surface area for phosphate (Pi) acquisition. To explore genes involved in Root hairs (RH) development and response to low phosphorus (LP) in chickpea, tissue-specific RNA-sequencing was performed and analyzed the transcriptome modulation for RH and root without RH (Root-RH) under LP. It is found that RH shows a multi-faceted response that starts with molecular changes for epidermal cell differentiation and RH initiation in Root-RH and later induction of tip growth and various LP responses in elongated RH. (Front Plant Sci. 13:983969).

INSTITUTE OF LIFE SCIENCES (ILS), BHUBANESHWAR, ODISHA

Significant contribution has been made during the year by the research activities focusing on cancer biology, where the scientists have undertaken studies following multi-disciplinary approaches for deciphering the mechanism of onset, progression, and possible therapies for different types of cancer such as oral, pancreatic, prostate, and breast cancer and leukemia. These findings have the potential for contributing to the control and management of the diseases. Similarly, the focus of the infectious disease biology group is on understanding pathogen biology, host response and disease progression at cellular and molecular level, as well as identifying potential drug targets for combating various types of infectious diseases. The focus of the plant and environmental biotechnology group has been primarily towards developing climate-resilient crop varieties for enhancing productivity and adaptation. These were achieved by generating genomic resources for pulses and millets, as well as by following advanced molecular breeding strategies.

Major Initiatives:

During the year, ILS has also focused on developing an institutional mechanism for translation of its research progress, as well as for promoting entrepreneurship in biotechnology and life sciences. The DBT-ILS bioincubator has been established with the support of The Department of Biotechnology, Govt. of India and the Bionest Program of the BIRAC and The Department of Science and Technology, Govt. of Odisha. During the year, 23 start-ups representing agriculture, healthcare, diagnostics and devices, and wellness products incubated in the ILS Bioincubator. During the year, ILS has strengthened its research infrastructure and facilities. The ABSL-3 facility has been made completely operational with all necessary equipment, facilities, and trained technical human resources. These facilities have

been extensively used by the ILS scientists, academic institutions, and private sectors for testing and validating drugs and vaccine candidates using animal models such as Syrian hamsters and transgenic mice. ILS has also established a drug screening platform for development and validation of potential antiviral drug molecules. With the support from BIRAC under COVID- SURAKHYA MISSION, a comprehensive immunogenicity platform is being created for future product development for viral diseases.

Major Achievements

Major Achievements	Number
Projects completed	16
Process/Product/ Technology Developed	01
Research Publications	76
Patents Applied	02
Patents Obtained	02
Human Resources Trained	106
Major Honours & Awards received by scientists	05

Understanding the Microbiome Diversity in COVID 19 patients: The research findings at DBT-ILS contribute to the novel insights regarding the emergence of opportunistic pathogens in COVID-19 patients and their relationship with symptoms, suggesting their potential role in co-infections, which may result in COVID-19-associated complications. (DOI: 10.1039/d2mo00044j).

Development of Animal Challenge Platform: Realising the importance of preclinical animal models for SARS-CoV-2 related studies, under the mission COVID Suraksha, DBT-BIRAC has supported DBT-ILS to establish an ABSL-3 platform to provide services on a fee-for-service mode for screening of antivirals. Our animal model is standardised with two well

characterised isolates of SARS-CoV-2 which reproduce the lung pathology similar to human COVID-19 patients. Our findings on SARS-CoV-2 infection in Syrian Golden Hamsters provided strong molecular evidence that supports the clinical relevance of this model in COVID-19 research.

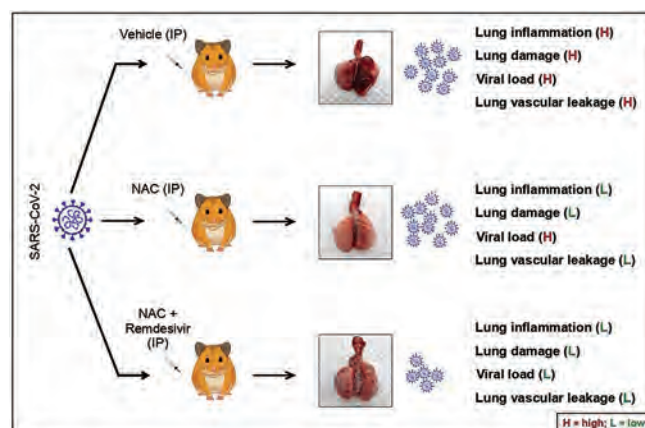


Fig. 10.8 Aniaml Challenge Platform for COVID-19 at ILS, Bhubaneswar

Societal Impact: ILS also emphasizes the importance of appropriately using science and technology for societal development. Its high priority research focus employing omics approach has contributed significantly toward tribal health and nutrition, which has been described in another section in this report. At the same time, considerable efforts have been made for improving the lives and livelihood of tribal farm families of Nabarangapur. Improvement of agriculture productivity, sustainable utilization of natural resources, promotion of integrated farming practices, skill and capacity development of the communities for value-added product development, and promotion of nutri-gardens are some of the important initiatives undertaken, which have benefited more than 1,000 farm families in the region.

NATIONAL AGRI-FOOD BIOTECHNOLOGY INSTITUTE (NABI), MOHALI, PUNJAB

National Agri-Food Biotechnology Institute (NABI) was established with the objectives to promote and

coordinate research of high calibre in basic and translational aspects at the interface of Agriculture, Food and Nutrition. The major areas of the institute include five core areas that deals with, improving cereals for nutrition and processing quality; improving fruits for post-harvest quality and nutrition; basic Biology for crop improvement; diet and health, and computational biology approaches for marker and gene discovery.

Major initiatives:

During the year, several significant achievements have been made. The scientists at NABI, Mohali are actively engaged in applying molecular breeding and biotechnological tools for improving micronutrients, antioxidants, resistant starch, dietary fibers and reducing the anti-nutrient properties in the various identified crop plants. An extensive collection of wheat germplasm is being maintained at NABI. It comprises about 500 indigenous and exotic wheat genotypes including landraces; 1,200 ethyl methyl sulphonate (EMS)-treated M10 populations; ~250 aneuploid stocks; and several bi-parental segregating populations (F1s, F2s, F6s, F7s).

The ambitious banana biofortification project has now been extended further with support from BIRAC for the multi-location event selection trials. The most promising banana (cultivar Grand Naine) events have shown near to 50-fold higher accumulation of pro-vitamin A in fruit-pulp of ratoon crops (2nd generation) and has been considered for the regulatory approvals for event selection trials.

Research has been initiated on the use of plant-derived extracellular vesicles (P-EVs) as a therapeutic reagent in mitigating obesity. NABI has used genomic deletion strategy to generate low rancidity rice lines. Employing nanotechnology-based approaches, two types of bacterial-specific antibody conjugated gold nanoparticles were synthesized with simple steps for rapid visible detection of food-borne bacteria within 5 minutes.

Major Achievements:

Major Achievements	Number
Research Publications	56
Patents Applied	10
Human Resources Trained	190

Wheat lines containing high amylose that have shown low glycemic index (GI) and improved agronomic traits have been developed. Candidate quantitative trait locus gene (QTGs) for high amylose biosynthesis were identified using saturation mapping. Further, two low glycemic wheat lines were evaluated in a large field.

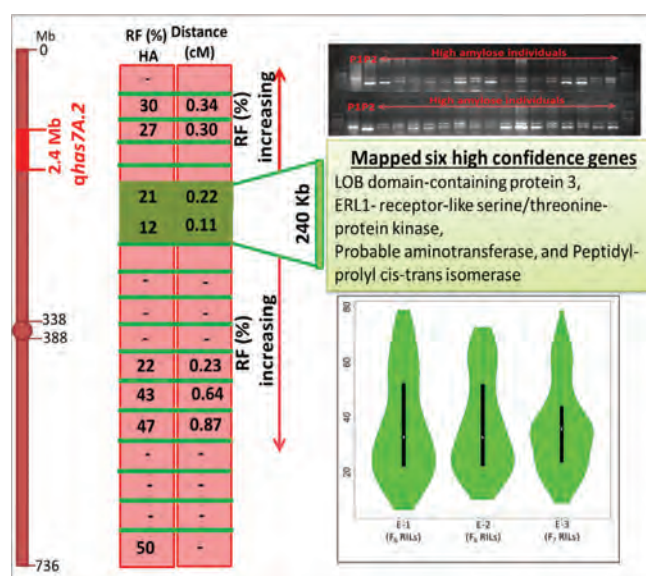


Fig. 10.9 Flow diagram representation of the process for QTL saturation and QTG identification for high amylose biosynthesis.

Biofortified colored wheat with high anthocyanin content has been developed by the breeding approach and would be exploited for different nutraceutical applications. At least one isoform of MYC and MYB transcription factors was found to sufficient to regulate the anthocyanin synthesis in pericarp or aleurone layers of colored wheat seed. Further, the study revealed that nutritional profile and sensory score of black wheat vermicelli was better than white.



Fig. 10.10 Vermicelli prepared from white, purple and black wheat grains (ascending order of color variation was white<purple<black based on anthocyanin content).

Under the ambitious banana biofortification project, promising ten Pro-Vitamin A (PVA) enriched events, as well as control Grand Naine plants were multiplied under *in-vitro* conditions for distribution to partner institutes in NRCB, Tamil Nadu, TNAU Tamil Nadu, NAU Gujarat and AAU Assam and also plantation in the NABI research field for event selection trails by following DBT biosafety guidelines.

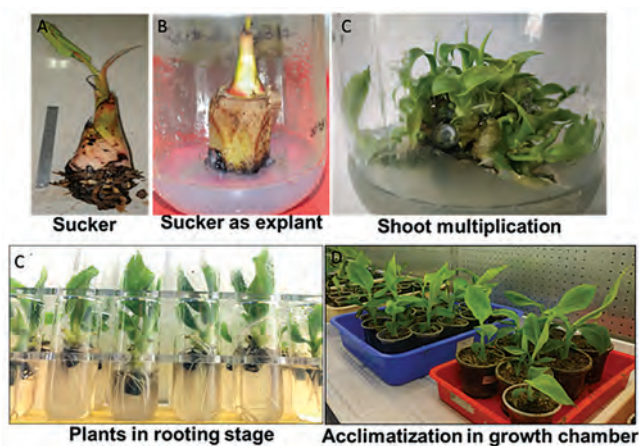


Fig. 10.11 *In-vitro* multiplication and maintenance of tissue raised promising GE banana lines. (A) Sucker, (B) Sucker used as explant, (C) Shoot multiplication, (D) Plants at rooting stage, (E) Acclimatized plants in soil-pots.

NABI has used genomic deletion strategy to generate low rancidity rice lines. In this direction, CRISPR/Cas9 DNA constructs were designed and assembled for knocking out lipase and lipoxygenase genes identified by transcriptomics and bioinformatics analysis. Chronic low grade inflammation, a hallmark of obesity, mainly contributes for multiple comorbidities

such as insulin resistance, type 2 diabetes and hepatosteatorosis. Bio-actives from finger millet and kodo millet were identified to counteract obesity and hepatosteatorosis development. Under the area of food and GM crops biosafety, NABI has developed microfluidic-chip based detection from a mixture of bacterial strains (*S. typhimurium*, *E. coli* and *P. aeruginosa*)

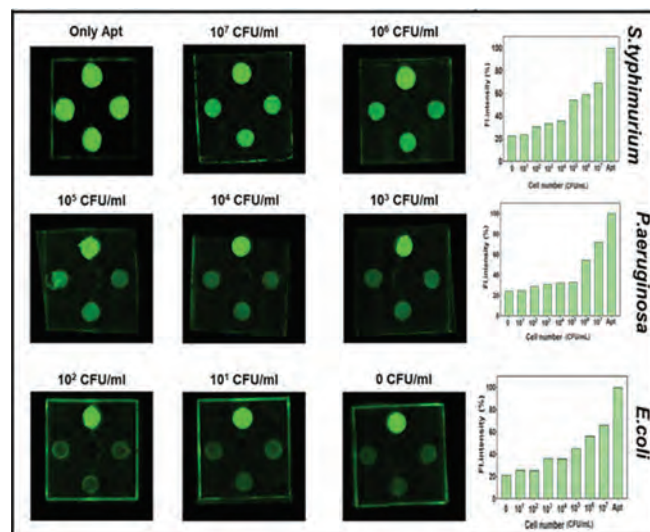


Fig. 10.12 Multiplexed detection in microfluidic chips. (a) Microfluidic chip design and the fluorescence signal in the presence and absence of GO; (b) Increase in fluorescence with the increase in bacterial concentration.

Societal Impact:

During the year, NABI has been able to publish the research outcomes in 56 peer reviewed scientific journals and applied for 10 patents. A total of 190 students were trained as short-term trainees and JRF, SRF and Research Associate. NABI has developed antioxidants rich bio-fortified coloured wheat (Black and Purple) showing health benefits. For its wide dissemination, initiatives have been made to gather the attention of farmers, consumers and industry and it is expected to increase to significant levels in the coming years. NABI has developed low-glycemic wheat lines through EMS mutagenesis (non-transgenic approach) in the background Indian bread wheat variety (var. C 306).

The developed low-glycemic wheat will be highly beneficial for diabetic and obese individuals in India. Using biotechnology approaches, NABI has generated high provitamin A (PVA) enriched genetically engineered transgenic banana lines. This study will help to develop nutritionally enriched varieties of bananas, providing β -carotene, essential for human health. NABI has developed an edible carbohydrate based coating material from agricultural crop residues and food processing by-products to maintain post-harvest qualities of various fruit crops to minimize losses during transportation and storage. Through pharmaco-nutritional studies, NABI has developed novel class of functional foods (cobotics) to prevent double nutritional burden (under nutrition and over nutrition) in India. In line with its social obligations, NABI scientists are developing nano-technology-based approaches, such as developing micro-chip array-based detection systems for detecting multiple foodborne pathogens.

NATIONAL BRAIN RESEARCH CENTRE (NBRC), MANESAR, HARYANA

National Brain Research Centre (NBRC) is a premier research and education Institute dedicated to conducting advanced research in Neuroscience. The mandate of NBRC is to pursue research to understand brain function in health and disease, generate trained human resources to carry out interdisciplinary research in neuroscience, and promote neuroscience in India through networking among institutions across the country. NBRC is a NAAC accredited Deemed to be University and awards M.Sc. and PhD degrees. NBRC has also been recognized as an Institution of Excellence by the Government of India.

Major Initiatives

NBRC is coordinating a DBT-funded comprehensive and multi-centric Dementia Science Programme aimed at collecting data regarding incidence, prevalence, biomarkers, and risk and protective

factors. This programme involves basic scientists as well as clinicians from rural as well as hospital sites across the country. All the participating sites use robust and uniform criteria for the diagnosis of dementia and its classification.

Magnetoencephalography (MEG) Resource Facility in NBRC, is a collaborative project between NBRC and All India Institute of Medical Sciences (AIIMS) under the aegis of the Department of Biotechnology. This is one of the few facilities in India which brings together a premier medical science institute and a dedicated neuroscience research centre to study difficult-to-treat epilepsy.

Major Achievements

No. of Projects completed:	07
No. of Research Publications :	41
No. of Patents obtained:	01
No. of Human Resources Trained:	74

NBRC found in a study that neither initiation of regrowth nor branching is affected by the axon injury pathways. Surprisingly, they have found that a small GTPase CED-10 (RAC) and upstream GEF TIAM-1 are essential for dendrite regeneration. Their work provides a framework for understanding the cellular mechanism of dendrite regeneration using PVD neurons. Another group of scientists have demonstrated that host innate antiviral response might play a critical role in the deterioration of motor functioning and pathogenesis of flaccid paralysis upon neurotropic virus infections.

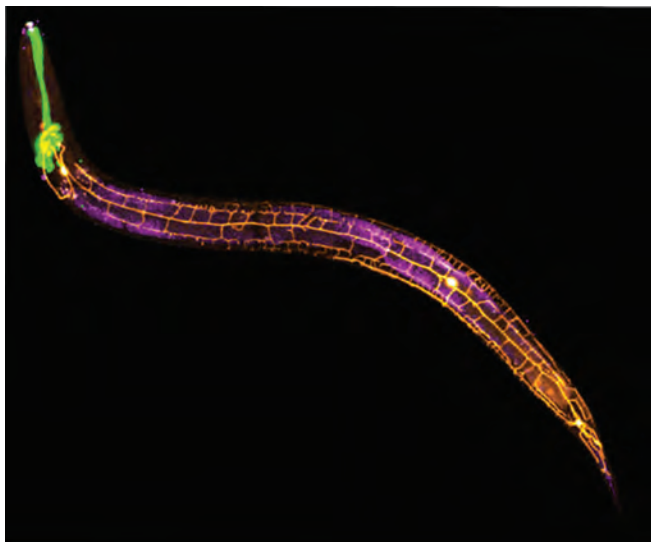
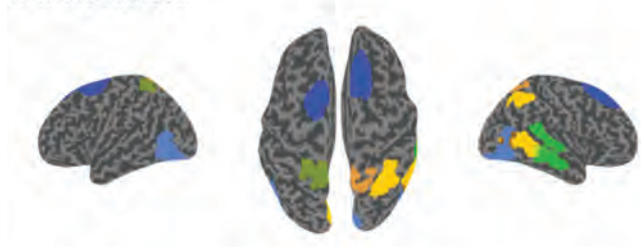


Fig. 10.13: NBRC uses the nematode *C. elegans* as a model system to understand the principles of neural circuit development and repair. In this picture, the mechanosensory neuron is labeled in orange color, and the olfactory neurons are labeled in green color.

NBRC has shown that advancing an earlier understanding that multisensory contexts speed up early sensory processing, and their study reveals that this temporal facilitation extends to even the later components of prediction error processing, using custom-designed experiments that allow comparisons across different modality combinations. Such knowledge can be of immense value in clinical research for determining the stages of various treatments in ageing, schizophrenia and depression and their efficacy on cognitive function. Another group of scientists showed a novel role of YAP1 in regulating mitochondrial dynamics, and their study suggests that the altered mitochondrial function and redox status in IDH1 mutant gliomas have clinical relevance pertaining to their sensitivity to oxidative stress inducers.

A. MMN sources



B. P300 sources

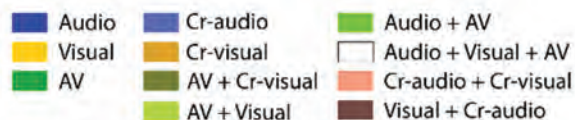
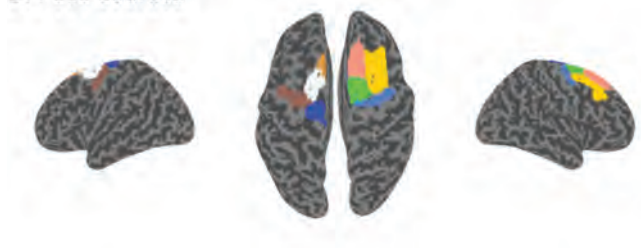


Fig. 10.14: eLORETA source localization results using time-locked analysis (at threshold level 95%) representing the underlying (a) MMN and (b) P300 sources for Audio, Visual, Audio-Visual, Cross-Visual and Cross-Audio modalities

Group of scientists working with Blood Brain Barrier (BBB) and virus has provided novel findings that suggest that the Zika Virus E protein is affecting the expression of tight junction proteins such as ZO-1, Claudin and Occludin, and hence altering the BBB integrity. The NeuroImaging and NeuroSpectroscopy Laboratory (NINS) have discovered early diagnostic biomarkers for Alzheimer's disease.

NBRC shown that on knocking down AP3D1 (on doxycycline + cells), there is a significant decrease in the number of responding puncta and an overall increase in the number of nonresponding puncta. Furthermore, they have also shown a delayed response in the +DOX cells compared to the control cells, which may result from the failure of the regulated secretory machinery to deplete the AP3D1 subunit.

Societal Impact

NBRC offers medical services to citizens and those from surrounding districts, from the neurological outpatient department services at Civil Hospital, Gurgaon. Patients with epilepsy visit the campus for medical checkups using the magnetoencephalography facility in collaboration with AIIMS, New Delhi. NBRC conducts awareness programs for senior citizens residing at old age homes regarding mental health and neurodegenerative diseases in collaboration with HelpAge India. Recently, Director NBRC inaugurated Science Museum at Government Model Sanskriti Senior Secondary School, at Nuh district, Haryana. This is an initiative of the Dept. of Biotechnology and National Brain Research Centre in celebration of Azadi Ka Amrit Mahotsav.

NATIONAL CENTRE FOR CELL SCIENCE (NCCS), PUNE, MAHARASHTRA

NCCS is involved in cutting-edge research in several areas of cell biology relevant to human health, including the biology of diseases like cancer, malaria, tuberculosis, metabolic disorders like diabetes and obesity, as also neurobiology, stem cell biology, immunology and microbiology. It contributes immensely to the capacity building of the nation through high-quality human resource development in cell biology research and serves to support cell biology research across India.

Major Initiatives:

A. Initiatives to facilitate the national efforts against COVID-19

NCCS has been making invaluable contributions to the national efforts against COVID-19 through various initiatives as listed below:

a) Research projects.

b) Serving as a COVID bio-repository and a CDL for testing COVID vaccines.

c) COVID-related outreach.

B. Other initiatives

a) Contributions of the National Cell Repository:

NCCS has facilitated cell biology research across India, including COVID-related research, by providing 4311 cell cultures to 511 organizations.

b) Research Achievements: The valuable outcomes of research at NCCS, which have relevance to biomedical research include, for example:

* COVID-related research: Studies led by NCCS, published in Microbiological Research have thrown light on the association between the oral microbiome and the severity of COVID infection, revealing an elevated abundance of certain opportunistic pathogens in COVID-19 patients. Their findings further suggest that microbiome alteration in elderly patients and patients with comorbidities might make them more vulnerable and may promote secondary infections. These findings are a valuable addition to this field, especially given the relevance to the Indian scenario, and could guide future longitudinal investigations. Another study led by NCCS, published in Microbes and Infection, assessed the effect of SARS-CoV-2 infection on the composition of the nasopharyngeal microbiome in COVID-19 patients, towards understanding the association of these changes with host conditions.

c) Capacity Building:

Over five hundred fifty beneficiaries received research training through various initiatives of NCCS, including the academic programmes (including 111 PhD students currently enrolled, 43 Project Trainees and Indian Science Academies' Summer Research Trainees, 65 participants from various institutes in the PhD coursework conducted by NCCS on behalf of the S. P. Pune University, and eight postdoctoral scientists), training workshops and participation in

extramurally-funded research projects (project staff).The PhD students are registered with the S.P. Pune University and RCB, Faridabad. It is expected that at around a hundred and fifty people will be trained during January through March 2023.

d) Azadi ka Amrit Mahotsav

Various seminars were organized to celebrate contemporary science in India. These talks were delivered by invited external researchers as well as NCCS faculty, postdoctoral Fellows, other early-career scientists, and PhD students. Twenty-seven seminars in the Speak Your Science (SyS) series and eight seminars in the Cell Biology Lecture Series were organized. Around eleven seminars in these series are estimated to be organized in the first quarter of 2023.

Key Achievements:

Human Microbiome Initiative of Select Endogamous Populations of India: Exhaustive dietary information on ~750 dietary variables was collected across the country for 3451 samples. Each community follows a peculiar diet.

Ayurvedic Prakriti phenotypes were found to show a strong association with the gut microbiome. All three prakriti phenotypes, vata, pitta and kapha, were found to have different gut microbiomes, with vata showing the highest microbial diversity, followed by pitta and kapha, respectively. Investigations on the diet features that influence gut bacterial diversity revealed individuals with a high intake of a non-vegetarian diet have a different microbial diversity than individuals who consume a vegetarian diet.

V γ 2+ $\gamma\delta$ T cells in the presence of anti-CD40L control surgical inflammation and promote skin allograft survival: Blood consists of various immune cells and soluble components. Among the different types of blood cells, T cells are white blood cells, which play an important role in providing help

to other cells and fighting foreign components. They do this by detecting new peptides (short protein molecules) present in other cells. A category of T cells called gamma-delta ($\gamma\delta$) T cells have effector and regulatory functions, which play an important role in infections, autoimmunity, and cancers. In this study, led by NCCS, the researchers investigated the mechanistic role of $\gamma\delta$ T cells in transplantation tolerance. Their data revealed that a subset of these cells called the V α 2+ subset, has an immunoregulatory function and promotes the survival of skin tissues transplanted from one strain of mice to another. These scientists developed a method to help increase the numbers and distribution of V α 2+ T cells in the body. Further, they defined these new tolerogenic V α 2+ T cells and provided pre-clinical evidence that these cells could potentially be used as adoptive cellular therapy to promote the survival of transplanted organs and tissues. This study was published in the Journal of Investigative Dermatology.

Feedback-regulated transcriptional repression of FBXO31 by c-Myc triggers ovarian cancer tumorigenesis: A protein called FBXO31, which is a member of the F-box protein family, plays an important role in preventing tumor formation. Inactivation of this protein is associated with various cancers, including ovarian cancer, one of the deadliest forms of gynecological cancers. However, the exact role of this molecule and how it is regulated in ovarian cancer was earlier not clear. Studies led by an NCCS scientist demonstrated that an oncogene, called c-Myc, can impair the tumor-suppressive functions of the FBXO31 protein, which can promote the progression of ovarian cancer. These findings thus suggest that the c-Myc-FBXO31 axis is a good target to be explored further towards developing better cancer therapy. This study, published in International Journal of Cancer, was led by NCCS and done in collaboration with SDM College of Medical Sciences & Hospital, Dharwad, and S.

Hegde Medical Academy, Mangalore, India.

Major Achievements	Number
Projects completed	17
Research Publications	92
Patents Applied	04
Patents Obtained	01
Human Resources Trained	>550
Awards & Honours of NCCS	24

Societal Impact:

The cell biology research at NCCS has biomedical relevance, and is aimed at serving the society in the long run by helping to address human health issues. Additionally, NCCS has played an important role in capacity building of the nation by providing high-quality research training and by providing services that benefit students, faculty and other researchers across India that have facilitated cell biology and microbiology research in India. The outreach activities of NCCS, including a public talk by Nobel laureate, Sir Richard Roberts organized in association with the S. P. Pune University, open days and students' visits, also served to take various aspect of science to over 1800 students, educators and the general public.



Fig. 10.15 A public talk by Nobel laureate, Sir Richard Roberts

NATIONAL INSTITUTE OF BIOMEDICAL GENOMICS (NIBMG), KALYANI, WEST BENGAL

NIBMG, is the first institution in India explicitly devoted to research, training, translation and service and capacity-building in Biomedical Genomics. The focus of the Institute is to understand the genetic underpinnings of all major human diseases, particularly those that are of public-health importance in India, translate the research findings to reduce the burden of disease, and build a formidable team of enablers through collaboration and training.

Key Initiatives:

NIBMG is coordinating Indian SARS-CoV-2 genome sequencing surveillance being conducted by the Indian SARS-CoV-2 Genomics Consortium (INSACOG). Till date, NIBMG has sequenced the viral whole genome from 33170 individuals, mostly from West Bengal and NER. We are also undertaking Waste water surveillance in collaboration with Universities and Research Institutes in West Bengal and North East region.

NIBMG examined the non-genetic intra-tumoral heterogeneity, responsible for the emergence of the hybrid state of cancer stem cells. As a part of the Systems Medicine Cluster project, we have performed single cell transcriptomics analysis of OSCC-GB to understand the major pathways in tumor cells and also undertaken a study to delineate the molecular events which may be predictive of progression from precancerous lesion to oral cancer.

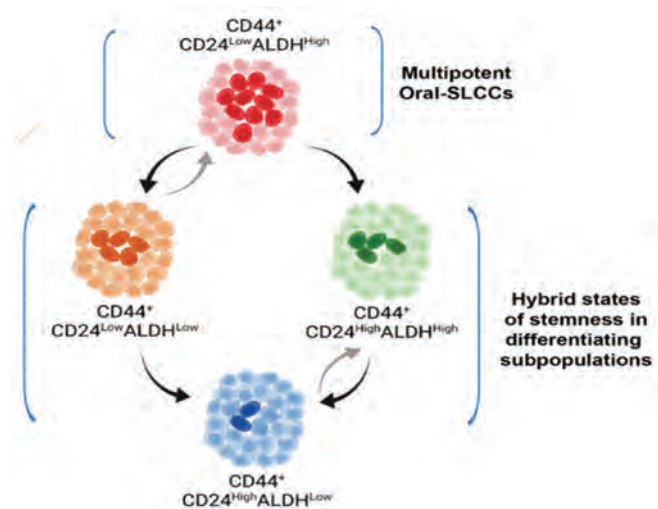


Fig. 10.16 Emergence of hybrid states of stem-like cancer cells which lead to poor patient prognosis

To understand genomic and epigenomic underpinning of Preterm birth, NIBMG performed the first GWAS in SouthEast Asia of 6,211 mothers using 700,604 SNPs and the first epigenome wide longitudinal analysis of 88 mothers at 850,000 CpGs. NIBMG also participating in MultiOmics for Mothers and Infants (MOMI)-India initiative which is funded by Bill and Melinda Gates Foundation. Additionally, NIBMG was also a part of the first study from India to describe a large cohort of genetically confirmed patients with sarcoglycanopathy and reported its disease progression.

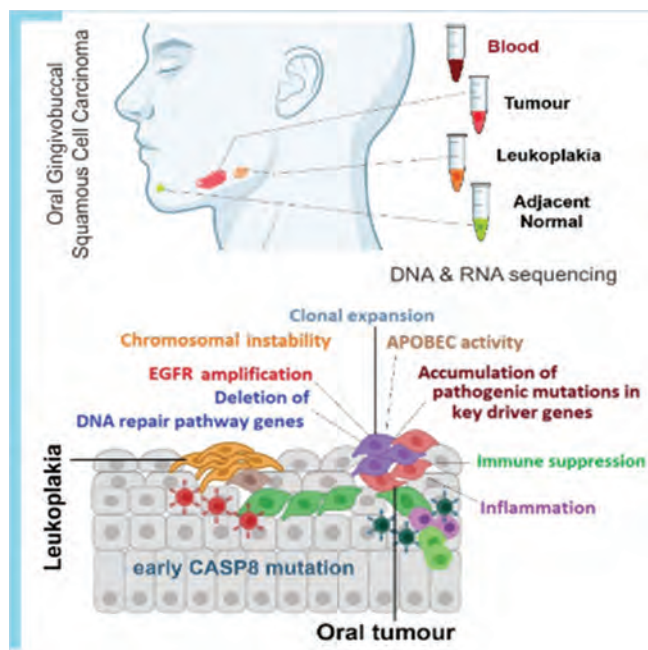


Fig. 10.17 Sampling strategy used to understand the progression leukoplakia to oral cancer (top) and the gene mutations and the pathways altered in the progression to oral cancer (below)

As a part of GenomeIndia Project (GIP) NIBMG generated WGS data and performed comprehensive anthropometric and dexa scan. We have also performed comprehensive quantitative analysis of biochemical variables and genotyped individuals using the GSA array and identified population specific variants. Further, we have undertaken a study to understand the linguistic transformation in NorthEast India and mainland Southeast Asia. In addition to this, NIBMG is also a part of International collaborative projects such as Immune Cell Atlas of Asian Populations and Global Paediatric Cell Atlas of Nasal and Oral Mucosa.

Key Achievements:

NIBMG described the phenotypic-composition of heterogeneous subpopulation of cells critical for global tumor behavior in oral cancer; which may provide prerequisite knowledge for treatment strategies. In another study, we have found mutational changes responsible for progression of

an oral tissue lesion into a malignant tumor. We have identified common and rare variants possibly interfering with miRNA mediated gene regulation in Pancreatic Ductal Adeno Carcinoma (PDAC). In another study, we identified novel differentially methylated genes and validated the previously identified differentially methylated CpG sites associated with PDAC cancer patient's survival. We also reported heterogeneity among HPV16 positive Cervical Cancer based on the analysis of viral factors. In our research on Breast Cancer, we reported that blocking Estrogen receptor (ER) alone in patients may not eradicate proliferation of Jumonji Domain Containing 6 (JMJD6) expressing ER⁺ cells and JMJD6 may predispose and sustain endocrine therapy resistance. Next, in our study set out to understand linguistic transformation, we have found evidence of two distinct migration events from East Asia, which have affected the ancestors of today's Tibeto-Burman speakers. In our research on Infectious diseases, we reported global gene expression changes induced by Interferon (IFN) lambda 3 (IFN- λ 3) and IFN- λ 4 in M1 and M2 monocyte-derived macrophages. In another study on drug re-purposing for SARS-CoV-2, we found that out of all the statins, Fluvastatin can bind to multiple target proteins of SARS-CoV-2 including the spike-mutant proteins. We also reported long-term oropharyngeal microbiome dysbiosis among SARS-CoV-2 patients which increases their susceptibility to lower respiratory tract infections. In another study tracking the viral variants in West Bengal compared to rest of the country, we found dynamic changes in different waves of pandemic with different pattern of distribution and contrasting amino acids in different variants.

Additionally, NIBMG developed protocols for maintaining oral cancer stem cell cultures in the lab and developed novel methodology to successfully identify the resident Placental microbiome.

Additionally, we have developed Tamoxifen resistant Breast cancer cell lines and established Long-term Estradiol Deprivation (LTED) model system to study Endocrine therapy resistance. In collaboration with IISER Kolkata, we have invented a novel photoactive molecule 'morphocumin coordinated RuII-pcymene complex' which can inhibit the growth of Oral Cancer like stem cells enriched 3D-spheroids of oral squamous cell carcinoma.

Major Achievements	Number
Projects completed	3
Process/Product/ Technology Developed	4
Research Publications	25
Human Resources Trained	59
Major Honours & Awards received by scientists	15

Societal Impact:

NIBMG Faculty members run several research programs in local communities in the areas of communicable, non-communicable and chronic diseases that are of National Interest. NIBMG leads INSACOG and has contributed heavily in utilizing their research expertise to track the pandemic, using sequencing technologies to understand the changing scenario of the viral mutations. NIBMG has established a Kalyani Cohort of more than 40,000 individuals and is following their life time trajectories to understand disease risk. Among other activities, we regularly run camps for cervical cancer awareness and testing for the individuals recruited in the cohort. In addition to this, NIBMG is one of the 20 Institutes participating in the GIP and is catering to the rural population in several areas. NIBMG conduct several outreach activities and have open days to invite students from local

schools and colleges to kindle their interest in scientific activities. Additionally, NIBMG runs several workshops and training programs catering to the need of scientists and researchers across India, particularly the North-East regions of India.

NATIONAL INSTITUTE OF ANIMAL BIOTECHNOLOGY (NIAB), HYDERABAD, TELANGANA

NIAB has shown scientific leadership in its mandated areas with a mandate of, “Animal Health for Human Welfare”. The institute is aimed to harness novel and emerging biotechnologies and create knowledge in the cutting-edge areas for improving animal health and productivity. Research focus of the institute is on animal genetics and genomics, transgenesis, stem cell & its applications, reproductive biotechnology, infectious diseases, nanotechnology, bioinformatics and Nutrigenomics. The Institute aims at translational research leading to genetic enhancement of Indian Livestock species and basic research towards development of novel vaccines, diagnostics and improved therapeutic molecules for farm animals.

Major Initiatives:

The Ongoing research projects in the area of infectious diseases include those on genotyping, host-pathogen interaction, vaccines and diagnostics for brucellosis, leptospirosis, mycobacteria, staphylococci, bovine ephemeral fever, porcine reproductive and respiratory syndrome, Newcastle disease, Theileria, Toxoplasma, and JEV. Other areas include antimicrobials and antimicrobial resistance, vectors for antigen delivery. The research in reproductive biology focuses to overcome infertility, enhance fecundity, early detection of estrus. NIAB has taken leads in transgenic technology, production of therapeutic molecules in animals. Bioinformatics research is focused on omics analysis, development

of programs and pipelines, target molecule identification for various purposes. The nanotechnology program involves development of delivery systems, biosensor and aptamer-based diagnostics.

NIAB is currently running three flagship programs, i) Livestock genomics, development of genomic chip for identification of pure breed of Indian cattle, ii) Genome-assisted pathobiology to identify novel targets for diagnosis and therapeutic interventions of JEV and Leptospirosis and iii) Zoonosis and One Health.

Nos. of Process/Product/ Technology transferred/developed:	02
No. of Research Publications:	50
No. of Patents Applied:	03

Major achievements:

A recombinant protein or peptide-based ELISA and Lateral Flow Assay (LFA) with DIVA capability has been developed for detection of brucellosis in animals and humans. NIAB has filed a patent application for the DIVA capable assays and the technology has been transferred to Engrave Bio Labs, Hyderabad for commercialization.

Mastitis is one of the problems which has immense economic significance for dairy industry. NIAB has developed an iron nanoparticle-based mastitis detection kit. It an affordable technology (Rs 20/test) which has been developed for naked-eye detection of subclinical and clinical mastitis using nano-adsorbed paper-kit comprising magnetic nanoparticles. NIAB has also devised a portable device for field level rapid antimicrobial sensitivity testing (Rs 50/test; time required: 2-6 hr) to treat mastitis. These technologies have already been transferred to the ACS Neoteric Technologies Hyderabad, a start-up company incubating at the NIAB incubation facility.

An Immuno-chromatic probe based lateral flow assay for point-of-care detection of Japanese Encephalitis Virus NS1 protein biomarker in clinical samples using a smartphone-based approach. It has been validated for detection of JEV in clinically infected pig serum samples for point-of-care testing.

Lumpy Skin Disease (LSD) is a trans-boundary viral disease of cattle causing significant morbidity and mortality. NIAB has designed a multi-epitope protein as a vaccine candidate against the LSDV to deal with its epidemic in current scenario.

NIAB performed the whole genome analysis and molecular characterization of chicken infectious anemia virus from an outbreak in a layer flock reveals circulation of genogroup IIIb in South India. Chicken infectious anemia virus (CAV) is an economically important poultry pathogen that makes them vulnerable to other infectious agents.

A novel DNA transfection agent for expression of therapeutic proteins in cultured cells have been designed and tested at NIAB. The transfection efficiency of hexanoylated-bPEI25 was more than native bPEI or lipofectamine 3000 (commonly used transfection agents). The rate of transfection of hexanoylated-bPEI25 was very high in primary mammary epithelial cells

Societal Impact:

The various technologies developed for detecting antibiotics, toxoplasmosis, brucellosis, mastitis, JEV etc. by the Institute will help in improving the animal health and productivity and of great significance to the farmers. The Generation of animal bioreactors for the easy and cost-effective production of therapeutic protein for human and animal uses will also be of great significance.

NATIONAL INSTITUTE OF PLANT GENOME RESEARCH (NIPGR), NEW DELHI, DELHI

NIPGR since inception has focused scientific program

both in basic science and translational work with a mission to undertake research of high caliber in plant molecular biology and to seek applications of the same. The Institute is actively engaged in research on topics ranging from genome analysis and molecular breeding, plant development and architecture, adaptation to abiotic stresses, molecular mechanisms of host-pathogen interactions, plant immunity, computational & structural biology, nutritional genomics and emerging areas covering cutting-edge research. Overall, the Institute has made significant progress in its research activities, which are reflected in high-quality publications and some promising technology leads. Now, it is poised to steadily march forward in contributing to plant science and thereby the nation building. Today NIPGR's vision is to be recognized as a centre of excellence not only in the Asia-Pacific region, but also among top plant science institute in the world. To fulfil the vision, the mission is to continue to call for research and innovation to have transformative impact on society.

Major Initiatives

Institute is continuously upgrading its research infrastructure in order to effectively pursue the twin goals of conducting high-quality basic research and seeking its application towards product development. Towards this, full utilization of the newly created platforms, strengthening of the existing facilities and functionalization the National Genomics and Genotyping Facility (NGGF) in PPP mode has been done.

The First NIPGR Translational Centre at Bulandshahr, UP was also launched by the Hon'ble Minister of State (IC) of the Ministry of S&T and Earth Sciences to mark the 75th year of Indian Independence, in celebration of Azadi Ka Amrit Mahotsav. Currently, the efforts are ongoing to develop the Speed Breeding and High Throughput Phenotyping platforms, which would be providing service to the

scientific community very soon.

Institute has initiated the development of “Plant Computational and Bioinformatics Facility”, and expansion of Central Instrumentation Facility to give fillip to the research work. The Institute has launched a Multi-institutional National Mission Mode Program on “Nutritional Improvement of Digestible Protein Content and Quality in Rice” in collaboration with ICAR and ICMR institutes.

Under the Mission mode program of “Characterization of chickpea germplasm resource”, 1600 Pan Genebank Core germplasm accessions have been resequenced and comprehensive phenotypic characterization of 2000 Pan Genebank Core germplasm accessions identified 171, 87 and 10 promising accessions resistant/tolerant to five biotic, four abiotic stresses and erect plant types amenable to mechanical harvesting. NIPGR during this period has run seventy seven national and international collaborative programs, besides participating in various national mission mode projects.

Major Achievements:

To translate the research findings towards developing products, large seeded, high yielding, high protein content improved JG11 and KAK2, desi and kabuli chickpea varieties (using ABC transporter gene marker), a semi-dwarf and optimum plant width chickpea variety (using bHLH 121 gene marker) and a drought tolerant high yielding improved JG 11 chickpea variety (using bHLH 10 gene marker) have reevaluated for the second year of testing (Advanced Varietal trial 2; AVT-2) in 2021-2022 at 16 locations in India. Further, an early flowering and high yielding (high flower number) chickpea variety developed using CaCLV3 (CLAVATA 3) gene marker using integrated genomics assisted breeding also have undergone ICAR coordinated field trial AVT-1 in 2021-2022 at 16 locations in India.



Fig. 10.18. The seeds and plant of high-yielding desi chickpea line (NC7) nominated by ICAR for variety release and notification for national use.

NIPGR has earlier developed transgenic *B. juncea* lines having seed glucosinolates as low as 11.26 $\mu\text{mol/g DW}$ through RNAi-based targeted suppression of BjMYB28, which had undergone event selection trial in collaboration with UDSC. Further, using gene editing technology T3 generation of low glucosinolate mustard lines have been developed.

Details of completed projects:	25
Details of Process/Product/ Technology Developed:	07
No. of Research Publications:	129
No. of Patents Applied:	08
No. of Patents Obtained:	04
No. of Human Resources Trained:	181

Societal Impact of the program

A high yielding chickpea line NC7 (ADVIKA) under drought condition has recently been approved by ICAR for cultivation in India. This is the first MAB based crop variety developed by not only NIPGR but such product from all DBT institutes. NIPGR startup-Fruvitec, developed several devices which can enhance shelf life of fruits and vegetables and keep nutritional status intact during the storage.

Maize germplasm screening technique against fall armyworm (FAW) FAW was optimised with a damage rating scale suited to Indian climatic conditions. A nitrogen sensitive rice (NS) genotype was identified by screening a set of rice genotypes under low

nitrogen condition.

During the Coronavirus Pandemic, NIPGR conducted a series of free online training programs in Data Science and Complex Networks, under the name “Protocols From Home”, in order to help students pick up vital skills in Computational Biology. NIPGR hosted several 9 Science Setu webinars to expose undergraduate students to high-end research b carried out at NIPGR. NIPGR had organized iConnect Events under ANB theme on “Nutriomics for better health and developed the SWATI portal.NIPGR has set up the PMU for the NCS-TCP to encourage the entrepreneurs and safeguard the farmers.As a part of “Azadi ka Amrit Mahotsav” to commemorate “75 years of India’s independence”, NIPGR has set up DBT-NIPGR Pandit Jaiwant Ram Upmanyu Science Museum in GBSSS in the aspiration district Chamba, HP as a part of the occasion on the basis of Jan-Bhagidari.

Several computational tools were developed for the benefit of plant science researchers, namely, PTPAMP (<http://www.nipgr.ac.in/PTPAMP/>), PtnCRNAdb (<https://nipgr.ac.in/PtnCRNAdb>), MedProDB (<http://www.nipgr.ac.in/MedProDB/>), AlnC (<http://www.nipgr.ac.in/AlnC>), tncRNA (<http://www.nipgr.ac.in/tncRNA>), PlantPepDB(<http://www.nipgr.ac.in/PlantPepDB/>), PtRNAdb (<http://www.nipgr.ac.in/PtRNAdb/>), AtFusionDB(<http://www.nipgr.ac.in/AtFusionDB/>), PVsiRNAdb (<http://www.nipgr.ac.in/PVsiRNAdb/>), PtRFdb (<http://www.nipgr.ac.in/PtRFdb/>)

RAJIV GANDHI CENTRE FOR BIOTECHNOLOGY (RGCB), THIRUVANANTHAPURAM, KERALA

The major focus of RGCB, is discovery and translation research programs in areas of Cancer Research, Pathogen Biology, Chemical Biology, Cardiovascular & Diabetes Biology, Neurobiology, Reproduction Biology and Plant Disease Biology. RGCB is known for its established Head Neck Cancer Bio-repository

and central cell and tissue repository with patient derived xenografts to enable drug discovery and genomics analysis of specific tumours. The pathogen biology group is working on host factors of broad-spectrum antivirals and disease pathogenesis modifiers associated with Chikungunya, dengue, identification and early-stage development of antimicrobial agents, antimicrobial drug resistance, population studies on distribution and transmission of infectious agents, infection biology and response to vaccines. RGCB is also working on identification of factors responsible for increased risk for vascular disease in patients with type II diabetes mellitus with the aim of discovering diagnostic biomarkers and possibly develop diagnostic tools as well as strategies to reduce the risk. The chemical biology division of RGCB has been working on specialized bacterial nanopore of sophisticated architecture and elucidates the molecular mechanism of carbohydrate polymer translocation and bioactive peptides.

Major Achievements

After the two years of COVID 19 crisis, RGCB has seen transformative changes in all aspects of its academic and educational activity in the year 2022. Responding to the call for Start-up initiative, RGCB have strengthened our start-ups effort in supporting more start- up incubates at our Biotech Incubator Facility BioNest, for the development of Covid 19 solutions and biotech process/ product development, with an aim of promoting industrial growth and creating job opportunities in Biotechnology.

The two major developments of the year worth mentioning are the establishment of BSL3 Plus and Next Generation Sequencing facility and completion of a fully equipped new campus at Akkulam. With this additions, RGCB has become the first R& D centre in Kerala to have a fully equipped BSL3 facility for supporting research involving high containment requiring pathogens including SARS CoV2. This year, RGCB has also strengthened our genomics facility

with the addition of a new NGS equipment, Illumina Novaseq 6000 through the special support from DBT. RGCB will be offering live virus neutralisation assays, vaccine efficacy testing services and drug screening services using live SARS CoV2 virus for the academia and industries soon with these new developments.

COVID-19 Initiatives:

In a quick response to the emergence of the COVID-19 pandemic, RGCB formed a core Corona virus Research & Intervention Group, consisting of scientists from infectious disease biology, cell biology, immunology, diagnostics services, public health epidemiology and technology development group, who are currently involved in all research & development / service activities on Covid-19. A brief description of these activities and outcomes in specific areas are highlighted below.

- i. RGCB has completed 14562 SARS CoV2 sequencing for the INSACOG
- ii. Completed 256447 RT-PCR diagnostic test and validated 110 diagnostic kits from different part of the country at our LMMD facility for regulatory approval
- iii. Developed a Bead Based SARS CoV2 neutralisation Assay
- iv. Developed SARS CoV2 permissive recombinant drug discovery cell lines, that will be commercially available from ABM Biotech, Canada starting from 2022.
- v. Established the first BSL3Plus facility at Kerala

Impact of RGCB's Research in Shaping Global Policy on Cervical Cancer Prevention: Several of RGCB academic research collaborations with many National and International Institutions yielded appreciation from public and academia. The key exciting examples are translational research work

on HPV vaccine trial, that received attentions and has helped in radical policy change in vaccine scheduling, with a great social and economic impact on vaccination drive. Similarly, RGCB has played a significant role in determining the efficacy of Cervavac, India's first indigenously developed vaccine developed for preventing the second most common cancer among women in the country. This is an illustrious example of our commitment to the Make in India concept and capability to support high end socially relevant research.

RGCB has been involved in two landmark studies in this specific area- (i) the WHO funded Indian multicentre study, and (ii) measurement of cervical infection rates in the Cervavac trial. In the first study, RGCB serves as the central repository for all biological samples collected from over 20,000 girls recruited from 9 centres across the country for over 10 years (still ongoing). RGCB serves as the central laboratory where bioassays for the measurement of vaccine efficacy are completed. Results from this study have impacted policy recommendations on HPV vaccination globally by demonstrating that-

- i. Single dose of the quadrivalent HPV vaccine is similar to the three- and two-dose vaccine schedules (Lancet Oncol 2016, PMID: 26652797)
- ii. Two doses of HPV vaccine can be extended to older girls aged 15-18 years (Papillomavirus Research 2018, PMID: 29578097, 30711698)
- iii. Vaccine efficacy of single dose quadrivalent HPV vaccination is similar to that of two or three doses in preventing persistent and incident HPV16/ 18 infections and cervical neoplasia (Lancet Oncology 2021, PMID: 34634254, 29551226)
- iv. Single dose of quadrivalent vaccination elicits durable immune response up to 10 years post vaccination. (Vaccine 2022, PMID: 36446654)

These findings from the IARC-India HPV multi-centre vaccine study played a pivotal role in the recommendation to implement single dose HPV vaccination by WHO Strategic Advisory Group of Experts on Immunization (SAGE) in April 2022 and the Joint Committee on Vaccination and Immunisation (JCVI), UK in December 2021.

Biotech Industrial Support : KRIBS-BioNest - Biotech Park - Kochi, the technology incubation centre of RGCB, operates in collaboration with Kerala Start-up Mission at Kerala Technology Innovation Zone, Kalamassery, This is a unique facility designed to provide infrastructure and scientific support to enable researchers and investors entrepreneurs looking to transform biology, medical based technologies and innovations into real and mature big business. With a total floor area of over 44,000 square feet, it offers over 17,000 square feet of bio incubation space and a common laboratory measuring 1000 square feet to the Start-ups housed within the facility. The facility currently has 23 physical incubators and 7 virtual incubators. The number of new inquiries and applications for incubation based on biotechnology has significantly increased in the last year. Four of the incubators in their fourth year of incubation were permitted to lease land in the KINFRA Hi-Tech Park for the next 33 years. These companies can continue to utilize the cutting-edge technological platforms offered by KRIBS-BioNest. The broad business verticals/laboratories include Analytical Chemistry, Molecular Biology, Phytochemistry and Bioprocess Engineering conducts industry relevant research, supports upstream, downstream and testing facility to incubates and contract research operations. BioNest has been able to collaborate with a number of industries to set up Corporate Research Operations.

Societal Impact

Through RGCB team driven activity for social empowerment of tribal community using scientific

interventions, RGCB have documented traditional knowledge of livestock, ethno-veterinary practices, traditional paddy varieties, and cultivation practices. This ongoing research done as part of 'Center for Excellence in Inclusive Technology Interventions for Tribal Heritage Resilience of Kerala', led to the development of many value added products based on tribal knowledge in ethno-veterinary medicine. We have also completed one of the best science museum in our country at Wyanad, the aspiration District identified by the Govt of India, with an aim of promoting science culture among school students and public in line with the azadi ka amrit mahotsav call.

REGIONAL CENTRE FOR BIOTECHNOLOGY (RCB), FARIDABAD, HARYANA

RCB is an Institution of National Importance established by the Department of Biotechnology (DBT), Govt. of India, under the aegis of UNESCO with a mandate to impart education and training, and conduct research in the frontier areas of biotechnology. The vision of RCB is to produce human resources tailored to drive innovation in biotechnology, particularly in areas of new opportunities and also to fill the talent gap in deficient areas. The mandate of the Centre is to provide a platform for biotechnology education, training, and research at the interface of multiple disciplines.

Major Initiatives and Achievements

Academic Programs:

RCB offers structured degree programs as well as short-term training programs in highly specialized areas of biotechnology and life sciences. Currently, 120 students are pursuing doctoral degree programs in Biotechnology, Bioinformatics, and Biostatistics in different RCB laboratories. So far, RCB has awarded 54 PhD degrees. RCB also has an integrated MS-PhD degree program where students with bachelor's degrees are admitted. A total of 49 students are

currently registered for this programme.

The RCB Act 2016 empowers the Centre to recognize higher learning institutions for their various academic programs. In this direction, after the due diligence, RCB has granted recognition to the MSc, MS-PhD (integrated), or PhD programs at 13 such centers. These include the Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad; National Institute of Animal Biotechnology (NIAB), Hyderabad; National Agri-Biotechnology Institute (NABI), Mohali; Centre for Innovative and Applied Biotechnology (CIAB), Mohali; Institute of Life Sciences (ILS), Bhubaneswar; Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram; Translational Health Science and Technology Institute (THSTI), Faridabad; National Institute of Biomedical Genomics (NIBMG), Kalyani; Christian Medical College (CMC), Vellore; National Centre for Cell Science (NCCS), Pune; Institute of Bioresources & Sustainable Development (IBSD), Imphal; ESIC Medical College and Hospital (ESIC), Faridabad and Institute for Stem Cell Science and Regenerative Medicine (InStem), Bengaluru. More than 400 students from these recognized centers are registered for their degrees with RCB.

Scientific Programs:

RCB's scientific achievements in terms of quality of publications and the ability of our faculty to attract extramural grants have shown consistent growth. RCB continued to conduct cutting-edge scientific research in the broad areas of Structural Biology, Infectious Disease Biology, Molecular Medicine, Cancer and Cell Biology, Agricultural Biotechnology, and Systems and Synthetic Biology.

The various scientific programs of RCB can be broadly grouped under the following heads: Infectious Disease Biology, Molecular Medicine, Cancer and Cell Biology, Agricultural Biotechnology, and Systems and Synthetic Biology. Several advances were made in the various research areas being pursued at the

Centre which are discussed in the scientific reports section of the annual report. Provided below are some of the research highlights of this year.

Pancreatic cancer (PC) is one of the most lethal forms of cancer with a 5-year mean survival rate of less than 10% wherein most of the deaths are associated with secondary metastasis. Cancer and Cell Biology group at RCB has shown that Orai3 expression is inversely associated with the mean survival time of PC patients. The *in vitro* functional assays showed that Orai3 regulated PC cell cycle progression, apoptosis, and migration. Most importantly, the *in vivo* xenograft studies demonstrated a critical role of Orai3 in PC tumor growth and secondary metastasis. Mechanistically, Orai3 was shown to control G₁ phase progression, matrix metalloproteinase expression, and epithelial-mesenchymal transition in PC cells. Taken together, this study for the first-time reports that Orai3 drives aggressive phenotypes of PC cells, i.e., migration *in vitro* and metastasis *in vivo*. Considering that Orai3 overexpression leads to poor prognosis in PC patients, it appears to be a highly attractive therapeutic target.

The high toxicity of most cancer drugs remains a major challenge. Another lab from Cancer and Cell Biology group at RCB engineered a supramolecular nanomicellar system (LCA-DTX-PEG) composed of self-assembled units of the PEGylated lithocholic acid (LCA)-docetaxel (DTX) conjugate, which were safer in comparison with their parent FDA-approved drug formulation (Taxotere® or DTX-TS). The LCA-DTX-PEG nanomicells effectively reduced the tumor volume and increased the survival of 4T1 tumor-bearing mice with improved blood circulation time of the drug and its higher accumulation in tumor tissues. This study highlights the potential of PEGylated bile acid-drug conjugate-based nanomicells for the development of next-generation cancer therapeutics.

RCB continues to participate in a multi-institutional research program aimed at understanding the biology

of preterm birth to identify possible biomarkers to predict birth outcomes. A large cohort of pregnant women has been established by THSTI and the scientists at RCB are conducting a comprehensive study on the proteome of the various tissue samples from these women. The RCB flagship program on antiviral development has also been progressing well. Screening of several small molecule libraries has identified a few drug-like molecules showing antiviral activity against the Chikungunya virus in the cell culture. Their antiviral activity is being further studied in the mouse model of virus infection.

Training activities:

RCB offers short-term innovative training programs for young scientists to fulfil its mandate on human resource development in the advanced areas of life sciences and biotech sciences. In this direction, UNESCO-sponsored training workshops were conducted in areas of Mass Spectroscopy, Electron Microscopy and Confocal Microscopy introducing to the participants the latest methodology and instrumentation in these important areas of modern bioscience research. Participants for these training workshops included research scholars, doctoral students, and postdoctoral fellows selected from various institutions across India and overseas countries like UAE, Sri Lanka, Nepal, Ghana, Nigeria, Mauritius and China. Besides, RCB continues to provide Indian researchers access to the ESRF synchrotron radiation facility. This program has provided tremendous support to Indian structural biologists and has benefited a large number of young research students.

The workshops were open to all with a chief focus on scientists and researchers from Asia and Africa. A total of around 150 people were benefitted from these workshops.

Vigyan Pradarshini

To commemorate India's 75th year of

independence, RCB successfully organized the (Virtual) Vigyan Pradarshini as a part of the 'Science Setu' program on the 10th December, 2021. The program featured a brief introduction of RCB followed by 10-minute presentations on various research verticals of RCB. The faculty presented PowerPoint presentations that highlighted the key questions being addressed by different laboratories and the approaches being utilized. The sole objective of the Vigyan Pradarshini was to encourage young minds to the sphere of science and technology.

Indian Biological Data Centre

The 'Indian Biological Data Centre (IBDC)' is the first national repository for life science data in India (ibdc.rcb.res.in). As per the Biotech-PRIDE (Promotion of Research and Innovation through Data Exchange) guidelines, IBDC is mandated to archive all life science data generated from publicly funded research in India.

The data center has started its operation by providing nucleotide data submission and analysis services. For this purpose, two data portals were developed within IBDC. The first one is the 'Indian Nucleotide Data Archive' (INDA) which is accepting all type of Nucleotide data submission as per international data formats. INDA actively collaborates with all major international nucleotide data archives such as GenBank, ENA and DDBJ. Any data set submitted to INDA automatically gets IBDC as well as INSDC accessions (GenBank, ENA and DDBJ). So far, over 48 billion bases of nucleotide data have been submitted to INDA. The other is the 'Indian Nucleotide Data Archive-Controlled Access' (INDA-CA), which does not share data with any other repository and provides only controlled access to the submitted datasets. Over 1.5 lakh Covid genome sequences have been submitted at INDA-CA. Further, a dedicated 'COVID data portal' has also been developed that archives and analyses the COVID 19 genome sequences being generated by the INSACOG

in India. Other sections of IBDC are also under development that will handle various kinds of life science data sets. Currently, the IBDC team consists of 11 personnel including data curators, programmers and system administrators.

Societal Impact

RCB has contributed significantly to the human resource development by training students and young researchers for their skill enhancement and academic degree programs. RCB has been catalyzing the entrepreneurial activities in the National Capital Region through its Bio-Incubator which is supporting several start-ups in the area of life sciences. RCB Flagship program aims to develop prophylactics and therapeutics against viral diseases highly prevalent in the Indian population. Under this DBT-funded program, a small number of drug-like molecules have been identified that show anti-Chikungunya virus activity in cell culture as well as in the animal model of disease. Anti-JEV compounds from the Spectrum library have been identified and being tested in the mouse model. We have also begun to screen potential antiviral compounds from commercial libraries.

TRANSLATIONAL HEALTH SCIENCE AND TECHNOLOGY INSTITUTE (THSTI), FARIDABAD, HARYANA

THSTI, India's one of the premier research institute, is engaged in cutting-edge research in many areas of public health importance which include mother & child health, tuberculosis, dengue, SARS-CoV-2, autoimmune diseases and non-alcoholic fatty liver diseases. THSTI made seminal contributions to COVID-19 research during the pandemic, which has helped in developing vaccines, evaluating therapeutic molecules and establishing diagnostic assays. THSTI has been recognized nationally and internationally as an excellent hub of basic, translational and clinical research.

Major Initiatives & Achievements:

Publications	Patents	
	Filed	Granted
70	5	6

Technologies Developed

S. No.	Name of the technology
1.	Novel cholic acid derivatives for the treatment and prevention of autoimmune diseases and uses thereof
2.	Monoclonal antibodies specific to receptor binding domain of SARS-CoV-2 and uses thereof
3.	Universal microbial sample transport medium for genomic and metagenomic studies
4.	Ha monomer based universal influenza vaccine candidate and its uses thereof
5.	A biomaterial and method of its preparation

Technologies Transferred to Industry:

Name of the technology	Transferred to
Multiepitope self-assembled nanoparticle vaccine platform (MSN-vaccine platform) and uses thereof	M/s Panacea Biotec
Monoclonal antibodies specific to receptor binding domain of SARS-CoV2 and uses thereof	M/s Panacea Biotec
Recombinant bacterial strains for antigens of and Hybridoma clones for producing monoclonal antibodies against Malaria (Plasmodium), Dengue virus, and SARS-COV2 and Mammalian expression constructs	M/s Advinogen Innovations Pvt. Ltd.

(plasmids) for the expression of SARS-CoV-2 RBDs and human ACE2 receptor.	
Universal microbial sample transport medium for genomic and metagenomic studies	M/s Ruhvenile Biomedical Pvt. Ltd.

COVID-19 clinical research: THSTI led cohort studies as a part of SARS-CoV-2 clinical research with an enrolment of more than 32,000 participants.

Vaccine effectiveness studies: At the height of the Delta led crisis, THSTI led multi-institutional group conducted a vaccine effectiveness study that helped inform the policymakers about the vaccine effectiveness of the most commonly used vaccine, Covishield, against the Delta variant. Later, when the Omicron variant emerged in December 2021, THSTI was the first institute in the country to culture it and showed that vaccine-induced antibodies were much less effective in neutralizing the omicron variant. The durability of immune response in terms of longevity of vaccine and infection-induced antibodies was also studied in the cohorts, and it was observed that antibody levels begin to wane after a median of 8 months after vaccination and therefore emphasized the need for the booster policy, which was announced by the Government of India.

Genomic sequence studies: As a part of INSACOG, THSTI sequenced more than 1200 COVID-19 clinical samples and contributed to the isolation of several new variants of SARS-CoV-2, including the Omicron variant. THSTI leads a Pan-India hospital network studies to evaluate the severity and outcomes of SARS-CoV-2 infection and correlation of clinical outcomes with virus variants.

Monoclonal antibodies (MABs): THSTI developed monoclonal antibodies using hybridoma technology which has shown excellent neutralization against VOCs of SARS-CoV-2. These antibodies are now being co-developed with an industry partner. Researchers

at THSTI isolated potently human monoclonal antibodies from an unvaccinated Indian convalescent donor, which has shown excellent neutralization capabilities against SARS-CoV-2 VOCs. THSTI is in the advanced stages of discussion with a commercial partner to co-develop these MABs.

Vaccine Development

- Multivalent Nanoparticle Platform:** THSTI's scientists have developed a novel vaccine platform which is being taken forward in collaboration with industry. The efforts have led to a large consortium grant by Coalition for Epidemic Preparedness Innovations (CEPI) to develop a pan-beta coronavirus vaccine. This multivalent nanoparticle platform could be used for developing vaccines against important diseases such as Dengue, Influenza, RSV, Nipah and emerging viruses and also for bacterial antigens or onco-antigens for cancer vaccines etc. *In collaboration with Panacea Biotech, THSTI received funding of \$12.5 million to develop a pan beta coronavirus vaccine from CEPI in March 2022.*
- Influenza soluble HA monomer as subunit vaccine candidate:** THSTI has developed Influenza soluble HA (Hemagglutinin) monomer expressing structurally occluded interface/epitopes as a subunit vaccine candidate. The patent application has been filed for this subunit vaccine candidate.
- Universal Influenza Vaccines as a part of Horizon 2020:** Under the ENDFLU project, researchers have tested and assessed the immunogenicity and protective efficacy of > 10 immunogens in pre-clinical animal model to down-select and well-advanced candidates for clinical trial. Under the INDIGO project, scientists at THSTI have found that indigenously developed hemagglutinin (HA) soluble antigen provides complete protection from intradermal

challenges.

- **Hepatitis E Vaccine:** Towards the development of a recombinant vaccine against the Hepatitis E virus, the researchers at THSTI have purified and characterized recombinant 112-608 HEVLP, and the technology has been transferred to Vaxfarm Lifesciences for product scale-up and formulation development
- **Dengue Vaccine:** Researchers at THSTI have prepared and purified DENV3 and DENV4 E protein dimers to apparent homogeneity as a part of developing vaccine candidates against Dengue Viruses (DENV).

Infection and Immunology

Tuberculosis: Researchers at THSTI have screened Med Chem Express library in target and host-based screens and identified small molecules that exert anti-inflammatory response. They have carried out intracellular activity studies of identified NCE and FDA approved drugs against MDR-, XDR- strains.

Microbiome: In collaborative research, scientists at THSTI have sequenced (n=32) and analyzed the whole genome sequences of 143 *H. pylori* strains of which 74 were isolated from Eastern (n=20) and Southern (n=54) parts of India. Bacterial reporter strains have been developed by engineering the genome of *Escherichia coli* and *Vibrio cholerae* for high throughput screening of Antibiotic and Antibiotic potentiator

Influenza: THSTI is developing Next-Gen Influenza vaccines under the DBT-EU Horizon 2020 projects viz., INDIGO, INCENTIVE and ENDFLU. A repository of more than 50, well-characterized, authenticated Influenza A and B viruses and virological and serological assays have been established to support Influenza R & D.

Dengue: THSTI has successfully developed a preclinical animal model, AG 129 mouse, for the

Dengue virus that will help in the rapid screening of novel antivirals and vaccines against Dengue.

Cancer Biology: Researchers at THSTI reported the effect of a high salt diet (HSD) in the regulation of T cells in tumour immunity, wherein it was found that HSD induces natural killer (NK) cell-mediated tumour immunity by modulating gut microbiome that induces NK cell-dependent tumour immunity.

PUBLIC SECTOR UNDERTAKINGS

BIOTECHNOLOGY INDUSTRY RESEARCH ASSISTANCE COUNCIL (BIRAC), NEW DELHI, DELHI

BIRAC is a Government of India Enterprise, not-for-profit, Section-8 company, set up in 2012 under Department of Biotechnology, Ministry of Science & Technology. BIRAC as a central enabler aims to strengthen and empower the emerging Biotechnology ecosystem to undertake strategic translational research and development and create innovative, globally competitive products/technologies addressing unmet needs.

As a central interface agency, it facilitates Biotechnology sector by nurturing a pipeline of entrepreneurs, Startups, capacity building, connecting Academia-Industry, Investors, Policy initiatives for Medium and Large scale industries in the country. This includes dedicated schemes and programs meant for providing risk capital, targeted funding, establishing high-end Bioincubation centres; technical, business mentorship; legal, IP and regulatory guidance; technology management that help bring innovation excellence for biotechnology firms and making them globally competitive.

According to the “Indian Bioeconomy Report” published by DBT’s Make in India Cell at BIRAC along with ABLE in July 2022, India’s Bioeconomy grew to \$ 80.1 billion USD for calendar year 2021 up from \$70.2 billion in 2020. India registered 14.1% growth

last year in Bioeconomy despite covid challenges leading to widespread lockdowns, breakdown of logistics services and losses seen in business, jobs, and health.

BIRAC schemes and activities are meant to create a pipeline of entrepreneurs & Startups in the country by providing systematic and value-added handholding during the journey of an idea maturing into a product for commercialization.



Fig. 10.19: BIRAC Schemes and Programmes

Over the last 10 years, BIRAC has contributed significantly to the growth of biotech ecosystem. Constantly growing numbers of applications received for funding support, increasing number of Startups, awards, recognition of Indian startups at national and international platforms, and commercialization of Made in India products reflect a tangible growth of the Biotech Startup Ecosystem in the country.

BIRAC has over the years supported 4000+ beneficiaries.

To showcase the strengths of Biotech Startup Ecosystem, first of its kind, a mega national event called Biotech Startup Expo 2022 was recently organized. The Expo was inaugurated by Hon'ble Prime Minister Shri Narendra Modi Ji. The event witnessed a footfall of 5000+ delegates over 2 days.



Fig. 10.20: Glimpses of Startup Expo

BIRAC has established national and international strategic partnerships, networks and platforms involving industry-academia Innovation research and facilitate novel, high quality affordable products development through cutting edge technologies. BIRAC also integrates with National Missions (Make in India, Startup India, National Biopharma Mission, Ayushman Bharat), Policy initiatives, G2G and Multilateral collaborations for International Ecosystem Connect to scale the Biotechnology Innovation Ecosystem across India. BIRAC also contributes to the Government's national programs such as "Make in India", "Startup India", "Swachh Bharat", "Ayushman Bharat", international alliances

through program management units for National Biopharma Mission, Bill & Melinda Gates Foundation, Wellcome Trust and USAID.

BIRAC SCHEMES AND THEIR OUTCOME

BioNEST : BioNEST (Bioincubators Nurturing Entrepreneurship for Scaling Technologies) scheme supports establishment of specialized bioincubation facilities across the country. Over the last 10 years, BIRAC has created a vibrant network of 65 bio-incubators spread across the country catering to more than 1500+ biotech start-ups and entrepreneurs with the cumulative area of 6,85,000 sq. ft.

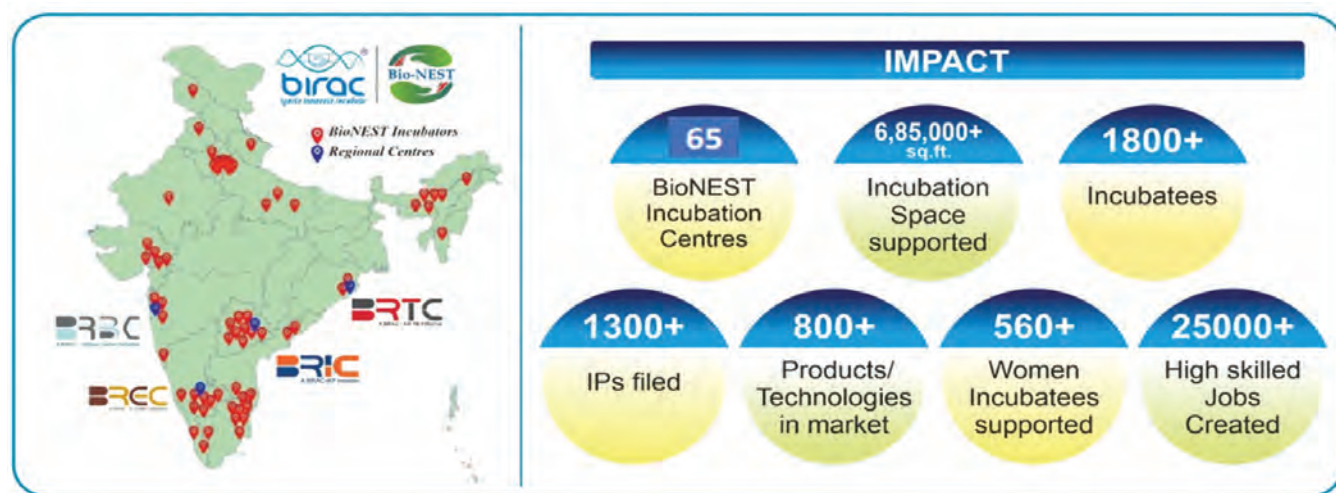


Fig. 10.21: Network of BioNEST Incubation centres across the country and its Impact

E-YUVA: E-YUVA (Empowering Youth for Undertaking Value-Added Innovation Translational Research) is an early-stage scheme to promote a culture of applied research and need-oriented (societal or industry) entrepreneurial innovation among young students and researchers. During the FY 2021-22, the First National Call for proposals of the E-YUVA scheme was announced under which 179 E-YUVA Fellows (Undergraduate) and 18 Innovation Fellows (Postgraduate and/or Post-Doctoral) have been selected nationwide.

Biotechnology Ignition Grant (BIG): Biotechnology Ignition Grant (BIG) scheme provides the right admixture of funding fuel (up to INR 50 lakhs for a period of 18 months). The scheme is implemented through 8 BIG Partners and 11 Associate Partners to expand the outreach and local mentoring in deeper pockets of the country especially Tier 2, Tier 3 cities and aspirational districts. 800+ projects that have been supported through BIG so far out of ~10,000 applications received.

SITARE: Students Innovations for Translation & Advancement of Research Explorations (SITARE) scheme aims to develop and nurture early-stage entrepreneurship by supporting innovative student projects in biotechnology. The scheme has two components-SITARE GYTI (15 innovative student projects receive funding support of up to INR 15 lakhs each) and SITARE-BIIS (3-4 weeks long Residential workshop). 88 Student projects have been supported through SITARE GYTI; 12 BIIS workshops have benefited more than 600 students

across 26 states and 90+ districts.

Equity Schemes: Equity schemes of BIRAC offer funding support for the early-stage start-ups which have potential for differential growth. It also helps startups to attract investment opportunity from prospective investors.

SEED Fund : 102 startups have been supported through SEED Fund.

LEAP Fund: 44 startups have been supported through the LEAP Fund.



Fig. 10.22: Impact of Equity Fund Schemes

Fund of funds-AcE : The AcE Fund has been able to infuse more than INR 700 Cr private equity commitment into the Biotech ecosystem using AcE fund as a catalyst. 65 Companies have been provided investment through AcE Fund.

Biotech Showcase Portal: Biotech Showcase e-Portal (<https://biotechinnovations.com/>) was launched by Hon'ble Prime Minister Shri Narendra Modi ji during Biotech Startup Expo 2022. The portal features 750 BIRAC supported startup Products and Technologies. This is accessible globally to provide an opportunity to showcase solutions from India's Biotech Startups solving unmet needs.

Intensifying the Impact of Industrial Innovation (i4): The programme supports biotechnological product/technology development by strengthening R&D capabilities of start-ups/companies/LLPs. The programme is operated through two schemes based on the Technology Readiness Level (TRL):

- **Small Business Innovation Research Initiative (SBIRI):** Supports development and initial validation of products/technologies (up to TRL6).
- **Biotechnology Industry Partnership Programme (BIPP):** Supports validation, demonstration and pre-commercialization of products/technologies (TRL7 and above).

Proposals funded under i4 are categorized under the following thematic areas:

- Drugs (including Drug Delivery), Biosimilar and Stem cells (including Regenerative Medicines) & Vaccines and Clinical Trials
- Devices and Diagnostics
- Energy, Environment and Secondary Agriculture
- Agriculture (including Aquaculture & Veterinary sciences)

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. The Programme has two components as below:

- **Academia Innovation Research (AIR):** The objective of AIR program is to promote development of Proof-of-concept (PoC) for a process/product by academia with or without the involvement of industry/LLP.
- **Contract Research Scheme (CRS):** CRS aims at validation of a process or prototype (developed by the academia) by the industrial partner/LLP.

Social Innovation programme for Products Affordable & Relevant to Societal Health (SPARSH): SPARSH is aimed at promoting the development of innovative solutions to society's most pressing social problems through biotechnological interventions. In the year 2022, the project from KBCols Sciences Pvt. Ltd., achieved TRL 8. The product is now being tested with various Industrial partners with the objective of launching products with KBCols natural bio-colors.

Social Innovation Immersion Program (SIIP): Social Innovation Immersion Program (SIIP), a component of SPARSH, is a fellowship program. The programme provides young social innovators an opportunity for clinical and rural immersion, a monthly fellowship and funding support to develop a product (prototype)/technology through a mini kick start grant.

The program is implemented through BIRAC supported SPARSH centres and mentored by knowledge partner TISS (Tata Institute of Social Sciences). SPARSH centre are homed in BioNEST Incubators. Currently, 14 SPARSH Centres spread

over 9 states are in operation and house 65 Social innovators working on various societal problems.

65 fellows of the 1st cohort of the program graduated in 2022. The completion certificates were distributed to them on the "Graduation Day". 64 SPARSH fellows were selected for the 2nd cohort.

Product Commercialization Program Fund (PCP-Fund): Product/technologies from six start-ups (Aspartika, Aarna Biomedical, Innaumation, Fibroheal, Jublen and Medtra Pvt Ltd) were approved for funding and first/second tranche of funds were released to the start-ups.

Accelerated Translational Grant for Commercialization (ATGC)

Program on Guar Gum

Looking at the agricultural and industrial importance of this marginalized crop, BIRAC is working on overall development of guar production, R&D and processing industry, aligning the views of all the stakeholders in the value chain in the form of single vision strategy.

- 08 projects have been considered for BIRAC funding in the areas of building material mixtures, sealants, bioplastics, biomedical patch and guar derivatives.
- Out of these 8 project 02 projects are from industry and 06 from academia and association.

BIRAC-QUT, Australia-Bio-fortification & Disease resistance in Banana

BIRAC has supported a technology development and transfer program of bio-fortified and disease resistance banana from Queensland University of Technology (QUT), Australia being translated by the 5 identified Indian Research Institutes.



Fig. 10.23 Promising lines of GM Banana overexpressing PVA genes

Covid-19 Crisis: BIRAC Response

In the wake of the first report of SARS-CoV-2 infection in India, DBT-BIRAC along with its partners have got into action by forming teams to identify the major gaps which existed in knowledge base, technology, facilities, manpower, regulations and funds. BIRAC also worked quickly on bringing in new SOPs for accelerated processing for addressing the challenges posed by COVID-19. As a result of these focused efforts, DBT-BIRAC along with its partners has been able to address most of the identified gaps parallelly through different calls, schemes, mission programs, outreach activities and facilitation. Below section provides a snapshot of all those activities focused on addressing the challenges posed by COVID-19 pandemic.

DBT-BIRAC COVID-19 Research Consortium Call

DBT-BIRAC COVID-19 Research Consortium Call was one of the earliest responses from Govt. side for supporting technologies under Diagnostics, Vaccines, Novel Therapeutics, Repurposing of Drugs or any other intervention for control of COVID-19. This call was announced in March 2020 and received an overwhelming response in the number of applications. In the following month, a follow-up call focused on the same theme was also announced to accommodate the request from both Industry and academia. Overall, from two calls, around 1073 applications were received for funding under the consortium and around 120 proposals were selected for support. Out of these, 46 proposals have been supported by BIRAC and remaining under National Biopharma Mission, INDI-CEPI and DBT.

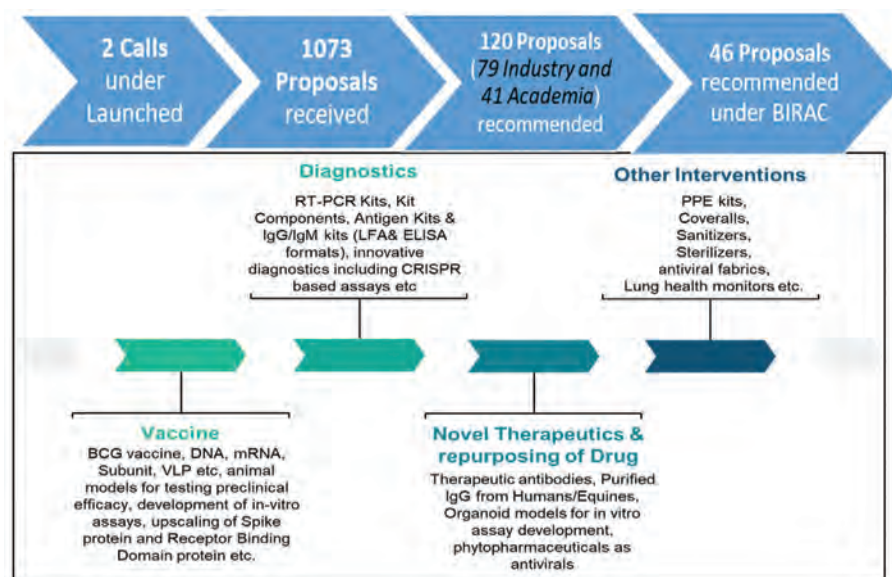


Fig. 10.24 COVID response at BIRAC

Few of the technologies funded under each of the areas are as follows:

As the pandemic progressed, the need for novel therapeutics or repurposed drugs to treat and manage COVID-19 and related complications had become paramount importance. In continuation to

earlier two calls DBT/BIRAC jointly announced a special call in October 2020 for development of therapeutics to create a rapid response towards the COVID-19 outbreak. Under this call a total of 39 proposals were received and finally 05 proposals were supported.



Fig. 10.25 Few Successful Outcome from COVID-19 Consortium funding

Start-up India Challenge

A joint initiative with DST, Atal Innovation Mission and BIRAC was announced by Start-up India as “Start-up India Challenge” to invite solutions for handling Covid-19 crisis. Amongst more than 150 proposals received for evaluation by BIRAC (projects based on biotechnological interventions), 12 proposals with potential of immediate deployment were identified and provided for consideration of NITI Ayog, and PSA, Government of India. These are taken ahead by the other partners for funding.

COVID-19 Start-up Solutions

BIRAC supported 35 technology solutions from Start-ups, relevant for COVID-19 pandemic situation, were identified and compiled into a single booklet for ensuring relevant stake-holder connect to the

technologies.

BIRAC special COVID-19 call under i4

In addition to the above efforts and calls, special calls under i4 (BIPP, SBIRI) and PACE (AIR and CRS) were announced under the area inviting proposals on Biomedical waste treatment/ management in the context of COVID-19, APIs for COVID-19 drugs, indigenous manufacturing of enzymes used in NAAT diagnostic kits, development of anti-viral surface coatings, sanitization and disinfection of food/food-based products.

MISSION COVID SURAKSHA

To ensure a steady supply of vaccines in the next 12-18 months, DBT has established Mission COVID Suraksha under Atma Nirbhar Bharat package 3.0.

The focus of this mission is to consolidate and streamline available resources towards a warpath for accelerated vaccine development.

Four calls were launched, and 34 proposals are being supported (5 projects pertaining to candidate vaccine development, 6 proposals under capacity enhancement; 3 for Clinical Immunogenicity testing and 3 for BSL-3 Animal facilities, 19 projects for strengthening clinical trial capacities and 4 projects under facility augmentation).

Vaccine projects supported are mainly for completing the Phase I, II or Phase III clinical trials of Recombinant vaccine (CorbeVax) by Biological E Pvt Ltd, RNA Vaccine (HCG019) by Gennova Biopharmaceuticals Pvt Ltd, DNA based vaccine (Zycov D), Nasal vaccine BBV154 (Bharat Biotech Pvt Ltd) and VLP vaccine PRAK-03202 (Genique Life Sciences Pvt Ltd).

Below Fig. shows geographical location of 19 Clinical trial Sites supported under National Biopharma Mission: Out of the 19 sites, 13 are supporting Covid-19 vaccine trials already or have undergone feasibility study by sponsor.

Indian Immunological has made progress towards achieving the first phase of production from its repurposed facility and has supplied 2 million doses of Drug Substance to BBIL. The other PSUs i.e. HBPCL and BIBCOLD have made significant progress

in finalizing the terms and condition of technology transfer, finalizing the facility design and obtained the initial feedback from DCGL.

COVID-19 FIRST-HUB

During COVID-19, the industry has witnessed the challenge of understanding the various new regulations, guidelines, policies and processes for COVID-19 medical products. To mitigate this and facilitate the fast development of COVID-19 products, BIRAC has taken up this important task of providing clear guidance and direction to the start-ups through FIRST HUB. FIRST HUB provided the platform wherein queries related to various governmental organizations like CDSCO, ICMR, DBT, BIS, NIB, GeM, KIHT and BIRAC can be discussed and resolved. In addition to monthly meetings, FIRST HUB team conducted special virtual sessions every month for COVID-19. 500+ queries were discussed during these sessions. One special webinar with 150+ queries on COVID-19 was conducted to provide guidance on the regulations, standards, policies and funding opportunities.

Grand Challenges India (GCI)-led COVID-19 efforts

Grand Challenges India is supporting programs to find solutions for COVID-19 pandemic. Few activities under support are:

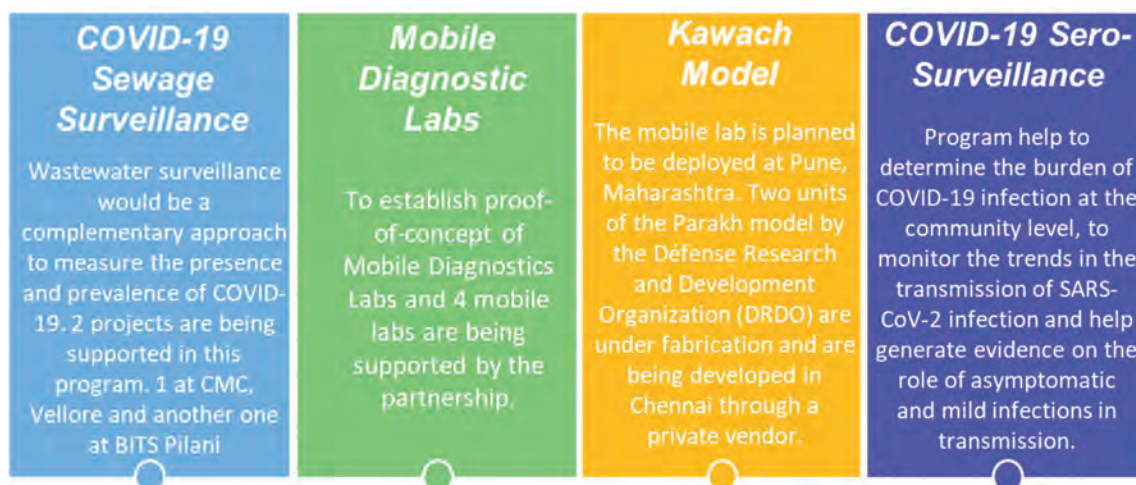




Fig. 10.26 The Mobile Virology Lab ready for deployment

INDIAN VACCINES CORPORATION LIMITED (IVCOL), NEW DELHI

IVCOL was incorporated in March 1989 as a Joint Venture Company promoted by the Govt. of India (Department of Biotechnology-DBT); Pasteur Meraux Serum & Vaccines (PMSV) France; and Indian Petrochemicals Corporation Ltd. (IPCL merged with the Reliance Industries Limited in 2007) with a paid-up capital of Rs. 18.78 crores, and with the objectives of manufacturing (i) vaccines based on Vero cell Technology and (ii) Injectable Polio Vaccines (IPV) However IPV did not get approvals from the World Health Organisation. Thereafter P.M.S.V. France exited from the joint venture in 1998 by selling its shares to DBT.

The Company has no trading or commercial activity and is maintaining its establishment from DBT office at CGO Complex to look after its site and complying with the statutory obligations under the Company's Act, 2013. IVCOL is presently being controlled by a Board of Directors, with two directors representing Reliance Industries Limited and three Directors representing Government of India Department of Bio-technology (DBT).

In the year 1999, National Brain Research Centre (NBRC) (An Autonomous Body of the Department of Bio-technology (DBT) was given 46.20 acres of its land on thirty years lease, at a nominal lease rent of

Rs. 11.91 lacs per annum. This is the only income of the Company at present. The Company has been incurring losses for the last two years (Rs. 3.71 lakh for 2020-21 and Rs.369.86 lakh for 2021-22) and has accumulated losses of Rs. 373.57 lakh as on 31.03.2022.

BHARAT IMMUNOLOGICALS AND BIOLOGICALS CORPORATION LIMITED (BIBCOL), BULANDSHAHR, UTTAR PRADESH

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 & Technology, Government of India with primary objective of eradication of Polio from the country. With continuous support of Department of Biotechnology, BIBCOL has achieved this vision of Government of India and now Company is in diversification mode and one project namely Oral Cholera Vaccine is under execution.

**Healthy Children
Healthy Nation**

Future Plans:
Plasma Derived
Medicines (Albumin & Immunoglobulins)

Severe Acute Malnourishment:
Lactated Ringers to Stop
Diarrhoea, Food
(SL/TF)

Diarrhoea Management Kit:
Zinc Tablet + ORS

Research & Development:
Collaboration with
Traditional Health Science
and Technology Institute
(THSTI) for development
of various biotech
products

Polio Free India:
Contributed billions of
doses of polio vaccine to
Government Program

Diarrhoea Management:
Contributed Millions
of Zinc Dispersible
Tablets

Zinc
(Zinc Sulphate 20 mg)

Combo Kit (Zinc + ORS)

Oral Polio Vaccine

BIBCOL

Bharat Immunologicals & Biologicals Corporation Limited
(WHO GMP Certified Company)
(PSU of Department of Biotechnology)
OPV Plant Chola, Bolandshahr, Ph: 05732236757, Email: bibcolindia@gmail.com, www.bibcol.com

Fig. 10.27 BIBCOL products

BIBCOL has contributed in the vision of Government of India to eradicate the polio from the country. BIBCOL has ambitious plans not only for its long term sustainability and better growth but making significant contributions for the better health of the masses of our country. The company will soon start the production of Vaccines for the country at very affordable prices. In addition to bOPV in vaccine segment, BIBCOL has manufacturing facility of dispersible Zinc Tablet in Pharmaceutical segment. BIBCOL is doing for pilot scale formulation of Oral Cholera Vaccine and setting up the manufacturing facility.

11

REGULATION, INTELLECTUAL PROPERTY & LEGISLATIONS

11

REGULATION, INTELLECTUAL PROPERTY & LEGISLATIONS

11.1 Regulation

In exercise of the powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986) and with a view to protecting the environment, nature and health, in connection with the application of gene technology and micro-organisms, the **Rules for the Manufacture, Use, Import, Export and Storage of Hazardous micro-organisms/Genetically engineered organisms or cells (Rules 1989)** were notified by the Ministry of Environment, Forest and Climate Change (MoEF&CC), on December 5, 1989, under the **Environment (Protection) Act 1986**. In order to implement the Rules in the entire country, six competent authorities and roles have been prescribed under the Rules 1989. Of these, **Review Committee on Genetic Manipulation (RCGM)** functional in the Department of Biotechnology to monitor the safety related aspects in respect of on-going research projects and activities involving genetically engineered organisms/hazardous microorganisms. It brings out manuals of guidelines specifying procedure for regulatory process with respect to activities involving genetically engineered organisms in research, use and applications with a view to ensure environmental safety. All ongoing projects involving high-risk category and controlled field experiments shall be reviewed to ensure that adequate precautions and containment conditions are followed as per the guidelines. The Review Committee on Genetic Manipulation lays down procedures restricting or prohibiting production, sale, importation and use of such genetically

engineered organism of cells as are mentioned in the Schedule.

Major achievements during 2022-23:

Number of RGCM Meetings	24
Number of Biopharma Applications considered	586
Number of Agriculture Applications considered	99
Awareness generation cum Interactive Sessions for Researchers	20
New IBSC registered	91

DBT notified the **Guidelines for Safety Assessment of Genome Edited Plants, 2022**, vide OM dated 17.05.2022. The Guidelines provide a road map for the development and sustainable use of Genome Editing Technologies for plants in India, specifying the biosafety concerns, and describing the regulatory pathways to be adopted while undertaking genome editing of plants.



DBT notified the Standard Operating Procedures for Regulatory Review of Genome Edited Plants under SDN-1 and SDN-2 Categories, 2022, vide OM dated 04.10.2022. The SOPs have been notified to facilitate regulatory review for research and development of genome edited plants falling under the categories of SDN-1 and/or SDN-2 until free from exogenous introduced DNA. These SOPs are applicable only for research and development under contained conditions.

Biological Research Regulatory Approval Portal (BioRRAP) Launch: In keeping with the spirit of “One Nation, One Portal”, Union Minister Dr.Jitendra Singh launched Single National Portal for Biology researchers on May 21, 2022. BioRRAP will cater to all regulatory approvals required for biological research and development activity in the country, thereby emphasizing on the “Ease of Science as well as Ease of Business”.



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 comments on 03 applications received from DGFT for fixation of I/O norms. Comments on 78 applications pertaining to export/import of restricted items were also shared with Directorate General of Foreign Trade (DGFT). Keeping in view of the technical expertise, merit & essentiality of the projects, resources & manpower and intellectual property (IP) generated, the Department had also recommended 25 R&D units in biotechnology sector for in-house R&D recognition scheme to the Department of Scientific & Industrial Research (DSIR).

11.2 Patent Facilitation Cell

The Department of Biotechnology (DBT) is promoting Research & Development in the country through competitive grant-in-aid schemes supporting research efforts across a wide spectrum of public and private academic institutions, clinical research centers and industry. The outcome of this research is publication of knowledge generated and also intellectual property, mostly as patents and in some instances as industrial designs. Biotechnology Patent Facilitation Cell of the Department facilitates IP management and its commercialization from public funded research.

Major initiatives taken during the year 2022-23

In year 2022-23, two patents have been granted through DBT support.

IP Commercialization Strategies: During the year, DBT has considered reforms in IP commercialization

strategy to enable options for technology transfer on exclusive basis for maximizing socio-economic impact from public-funded research along with non-exclusive clause that is currently practiced as per the grant Memorandum of Association (MoA).

12

**ADMINISTRATION AND
FINANCE**

12

ADMINISTRATION AND FINANCE

General Administration

The General Administration Section of the Department ensures that all the activities related to housekeeping, cleanliness, stores, canteen, R&I, library, staff car arrangements, various procurements, issuance of Identity cards/CGHS cards, booking of domestic and international flight tickets etc. function effectively and smoothly. Cases of procurement of specialized equipment required for research purposes in various Autonomous Institutes of this Department under Global Tender Enquiry system are also processed in Administration branch.

Administration branch also provides caretaking services and ensures a clean and healthy working atmosphere to the employees working in different sections of the department. It also provides logistic support in organizing various official meetings that take place between DBT Scientists and technical experts, specialists, academicians, scholars, foreign dignitaries from all over the national and international fraternity.

e-Office

One of the achievements of this department is the implementation of e-office version 7.0 with the active co-operation of NIC in a full-fledged manner for which all the employees have been given in-house practical training. Almost all the work is now being performed through e-files. In addition, the e-bill regime has been completely active in Admin section and all mandatory payments/releases eligible under this are being processed through e-bill system and Admin Section is dedicatedly working towards achieving the paperless work goal. A total number of 1371 new e-files have

been opened from 1st April, 2022 till 15th December, 2022.

Government e-Marketplace (GeM)

As per Government directives, it is now mandatory to make all procurements of such goods and services from Government e-Marketplace (GeM) as are available on GeM. Administration branch endeavours to make all procurements of goods and services through GeM as are available in it, thereby complying with government instructions and maintaining the transparency under such procurement. During this Financial Year, a total procurement of **Rs. 7212488/- (Rupees Seventy Two Lakh Twelve Thousand and Four Hundred and Eighty Eight)** has been done through GeM from the period 1st April, 2022 – 15th December, 2022

Swachh Bharat Abhiyan

In its endeavour to maintain Swachhta in the Department premises, sweeping and mopping of rooms, corridors, floors, bathrooms is done on daily basis and this is a year-round exercise. Also, keeping in view the pandemic situation, sanitization is done on regular basis.

Waste Management

e-waste and other obsolete items were identified in the Department for auction as per Govt. Norms. Recently obsolete furniture and IT equipment were identified and the process of disposal is under process and shall be completed at the earliest.

Special Campaign 2.0

A Special Drive/Campaign was launched by the Government of India during 2nd October, 2022 to

31st October, 2022 for expeditiously disposing of various pending issues, namely, Parliament Assurances, Public Grievances, references from Members of Parliament, State Government references, Inter-Ministerial consultations, etc. In addition to this Ministries/Departments were to identify rules and regulations so as to reduce compliance burden. The Department of Biotechnology as well as all AIs & PSUs under DBT implemented the Special Campaign for disposal of Public Grievances, inspection of Sections, cleanliness drive (indoor & outdoor) and Record Management etc., in letter and spirit and made it a grand success.

Parliamentary Matters

The meeting of the Parliamentary Standing Committee on Science and Technology, Environment & Forests was held on 14.02.2022 in the Parliament House Annexe regarding detailed demand for grants of the Department of Biotechnology. Replies to about 23 Parliamentary Questions pertaining to the Department were duly provided within the prescribed time frame.

Grievance Redressal

The Department has established an effective grievance redressal mechanism to deal with the public as well as staff grievance petitions. The Department regularly updates progress, disposal and pendency of public grievances on the website of Department of Administrative Reforms & Public Grievances. A total of 331 grievances were received by the Department, from 01.01.2022 to 23.12.2022, through the CPGRAMS portal, out of which, 319 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 (AIs) and Public Sector

Undertakings (PSUs) under its administration from 31st October, 2022 to 6th November, 2022. An office-wide awareness was spread towards the theme of "Corruption free India for a developed Nation – भ्रष्टाचार मुक्त भारत – विकसित भारत, which was adopted by the Central Vigilance Commission (CVC) as theme for the year 2022.

RTI Cell

RTI Cell is functioning in the Department & quarterly reports are filed timely on the RTI portal. A total of 175 RTI applications were received by the Department, from 1.4.2022 to 23.12.2022, through the RTI portal, out of which 154 have been disposed, similarly a total of 27 RTI appeals were received by the Department, out of which 22 have been disposed respectively.

Progressive use of Hindi in the department:

Hindi division ensures progressive use of Hindi and implementation of Government policies on Official Language in the Department. An Official Language Implementation Committee constituted under the chairmanship of the Joint Secretary (Administration) in the Department reviews the progressive use of Hindi in every quarter and suggests corrective measures for promoting the use of Hindi. During the year, all documents issued under Section 3(3) of the Official Languages Act, 1963 were in bilingual form and the letters received in Hindi were replied to in Hindi only. In order to strengthen the monitoring system of progressive use of Hindi, the officers who sign the papers have been made the check-points. Under Rule 8(4) of the Official Language Rules, 1976, Establishment, Administration, PVGRC and Cash section in the Department have been notified to do their 100% work in Hindi. Hindi fortnight was organized in the Department during 16-29th September 2022, in which 10 different competitions namely, Vaigyanik shodh par bhashan, Noting & Drafting, Kavita path, General knowledge competition in hindi, Hindi Vyavahar competition, Essay writing, Hindi official language knowledge quiz,

Hindi Typing competition for regular and contractual staff, Debate Competition and Antakshri were held. The competition for general knowledge was especially held for encouraging the multi-tasking staff and speech on scientific thesis for all scientists in the department. Around 175 officers/employees participated in various competition, out of which 115 officials won different prizes.

Successful participation in different competitions of Hindi fortnight were awarded in a prize distribution ceremony. The first prize of Rs. 5000/-, second prize of Rs. 3500/-, third prize of Rs. 2500/- and 5 consolation prizes of Rs. 1500/- each have been awarded. The department also organized Joint Hindi Advisory Committee meeting under the chairmanship of Hon'ble State Minister (Independent Charge) of Science & Technology and Earth Sciences, Dr.

Jitendra Singh in which progressive use of Hindi, Scientific Research and Administrative work was analyzed. The Hon'ble minister appreciated the efforts of the department in different fields.

FINANCE

Budget details:

Department of Biotechnology (DBT) was allocated an amount of Rs.2581.00 crores in the Budget Estimate (BE) for FY 2022-23. The allocation has, however, been reduced to Rs. 2192.92 crores at RE stage. The financial statement showing the stage details of Actual Expenditure during 2021-22, BE & RE for 2022-23, and BE for 2023-24 in respect of various programmes/ Schemes/ autonomous institutions are given in Table below:

(Rs. in crore)

S.No.	Name of the Programme/ Scheme	Actual 2021-22	BE 2022-23	RE 2022-23	BE 2023-24
1	2	3	4	5	6
	REVENUE SECTION				
1	Secretariat Economic Services				
1.01	Secretariat	31.16	35.18	36.85	46.39
2.01	BIRAC	24.80	35.00	40.00	40.00
2.02	Support to 16 Autonomous R&D institutions	664.09	830.82	866.07	902.47
3.01	Biotechnology Research and Development, Human Resource Development, Research Resource Facilities	1424.66	1315.00	1000.00	1345.00
4.01	Industrial and Entrepreneurship Development	706.43	365.00	250.00	300.00
5.01	International Centre for Genetic Engineering and Biotechnology (ICGEB)	0	0	0	50.00
	Total	2851.14	2581.00	2192.92	2683.86

The Budget Estimates and Revised Estimates for last five years is given below:

Amount in Crores of Rupees		
Year	Budget Estimates	Revised Estimates
2017-18	2222.10	2260.11
2018-19	2411.53	2411.53
2019-20	2580.34	2381.10
2020-21	2786.76	2300.00
2021-22	3502.37	2961.00

Pending C&AG Audit Paras

The updated status on Action Taken Notes on pending C&AG Paras is revised as under:

Sl. No.	C&AG Audit Para Number and Subject	Present position
1.	Para No.4.2 of Report No.2 of 2018	-Regarding Irregular Grant of Promotion and entitlement and pertains to National Centre for Cell Science (NCCS), Pune. 2nd ATN was sent to C&AG on 04.09.2019. C&AG after vetting the ATN, asked for revised ATN/ additional information. NCCS, Pune has been requested to expedite compliance of the Audit para. Follow-up through reminders, FCs and GBs of the Institute etc. is being done on regular basis. Since the para involves relaxation from MOF for regularising the action of NCCS, Pune, it is taking time. As soon as the compliance report is received from NCCS the same will be forwarded to C&AG Deptt. for settlement of the Audit Para.
2.	Para No. 4.3 of Report No. 2 of 2018	regarding "Non-utilization of land procured for construction of staff quarters) pertaining to National Institute of Immunology (NII), New Delhi. 3rd ATN was sent to C&AG on 28.09.2021 with a request to drop the para. In response, O/o C&AG, New Delhi. stated that their comments issued vide letter No. 339-40 dated 31.12.2020 may be treated as final vetting comments and the Department has to upload the final ATN on APMS portal after completion of the construction work. After discussion with the C&AG Deptt., 4th and final ATN with latest status (with the concurrence of AS&FA and approval of SBT) has been uploaded on the APMS Portal on 12.12.2022 with a request to settle this para.
3.	Para No. 14.2 of Report No.6 of 2020	regarding Extra Expenditure towards grants of allowances to employee in National Brain Research Centre (NBRC), Manesar. Follow-up through meetings is being done on regular basis. Also formal reminders to NBRC are also being issued for compliance of the Audit para. With respect to one of the C&AG observation regarding inadmissible project allowance

Sl. No.	C&AG Audit Para Number and Subject	Present position
		given to employees of NBRC, this has been stopped and a proposal has been sent to Ministry of Finance for one time waiver from recovery for the excess payment already made. For other observation as soon as the compliance report is received from NBRC the same will be forwarded to C&AG Deptt. for settlement of the Para.

Abbreviations

ATLs	Accredited Test laboratories
μPAD	Microfluidic paper-based analytical device
AAU	Assam Agricultural University
ACE	Angiotensin-converting-enzyme
ACTs	Artemisinin-based combination therapies
ADMaC	Advanced Animal Diagnostic and Management Consortium
AGR	Anaerobic Gas lift Reactor
AI	Artificial Intelligence
AI-DARDS	AI-Detection of Acute Respiratory Distress Syndrome
AIIMS	All India Institute of Medical Sciences
ALI	Acute Lung Injury
ALSBH-LR	Advanced-level State Biotech Hubs with Leadership role
AM fungi	Arbuscular Mycorrhizal fungi
AMR	Antimicrobial Resistance
ANmbr	Anaerobic Membrane Bioreactor
APSCS&T	Arunachal Pradesh State Council for Science & Technology
ARDS	Acute Respiratory Distress Syndrome
ATREE	Ashoka Trust for Research in Ecology and the Environment
AYUSH	The Ministry of Ayush
BAL	Bronchoalveolar Lavage
BBIL	Bharat Biotech International Limited
BBSRC	Biotechnology and Biological Sciences Research Council
BCG	BacilleCalmette-Guerin
BELSPo	Belgian Federal Science Policy Office
BHU	Banaras Hindu University
BioRRAP	Biological Research Regulatory Approval Portal
BIRAC	Biotechnology Industry Research Assistance Council
BMBF	Bundesministerium for Bildung und Forschung
BRSD	Bioresources and Sustainable Development
BSARCIST	BS Abdur Rahman Crescent Institute of Science and Technology

BSL	Bio Safety Level
bTB	Bovine tuberculosis
CAU	Central Agricultural University
CDDEP	Center for Disease Dynamics, Economics & Policy;
CDFD	Centre for DNA Fingerprinting and Diagnostics
cDNA	Complementary Deoxyribonucleic acid
CDTI	Centre for the development of Industrial Technology
CEPI	Coalition for Epidemic Preparedness Innovations
CGB	Citrus Greening Bacteria
cGMP	Current Good Manufacturing Practice
CHO	Chinese Hamster Ovary
CIAB	Center of Innovative and Applied Bioprocessing
CL	Cardiolipin
CMC	Christian Medical College
CMV	Cytomegalovirus
CoE	Centre of Excellence
CRISPR	Clustered regularly interspaced short palindromic repeats
CSIR	Council of Scientific & Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTV	Citrus tristeza virus
CXCL	Chemokine ligand
DAF	Diffusion Afflotation Bioreactor
DAMP	Damage Associated Molecular Patterns
DBT	Department of Biotechnology
DBT-IABF	Department of Biotechnology-Indo Australian Biotechnology Fund
DFG	Deutsche Forschungsgemeinschaft
DGFT	Directorate General of Foreign Trade
DIIS	Department of Industry, Innovation and Science
DSIR	Department of Scientific & Industrial Research
DST	Department of Science & Technology
EDP	Entrepreneurship Development Programme
EDSS	Electronic Decision Support System
ELISA	Enzyme-linked immunosorbent assay

EPSRC	Engineering and Physical Sciences Research Council
ESRC	Economic and Social Research Council
EUA	Emergency Use Authorization
FOA	Funding Opportunity Announcement
GABA	Gamma Amino Butyric Acid
GCCDP	Global Chikungunya vaccine Clinical Development Program
G-CSF	Granulocyte – Colony Stimulating Factor
GDM	Gestational Diabetes Mellitus
GlcNAc	N-Acetylglucosamine
GLP	Good laboratory Practice
GMCH	Guwahti Medical College and Hospital
GMEC	Goat Mammary Epithelial cells
GnRH	Gonadotropin-releasing hormone
HA	Human influenza hemagglutinin
HFIAS	Household Food Insecurity Access Scale
HIV	Human Immunodeficiency Virus
HMOs	Human milk oligosaccharides
HTSPs	High throughput screening platforms
IABF	Indo-Australian Biotechnology Fund
IBIN	Indian Bioresource Information Network
IBR	Infectious bovine rhinotracheitis
IBSD	Institute of Bioresources and Sustainable Development
ICAR	Indian Council of Agricultural Research
ICAR-CIFT	ICAR-Central Institute of Fisheries Technology
ICAR-CSSRI	Indian Council of Agricultural Research-Central Soil Salinity Research Institute
ICAR-IVRI	ICAR - Indian Veterinary Research Institute
ICAR-NEH Region	ICAR Research Complex for North Eastern Hill Region
ICAR-NIVEDI	ICAR - National Institute of Veterinary Epidemiology and Disease Informatics
ICGEB	International Centre for Genetic Engineering and Biotechnology
IC-IMPACT	Innovative Multidisciplinary Partnership to Accelerate Community Transformation and Sustainability
ICMR	Indian Council of Medical Research
ICT	Information and Communication Technology

ICT Mumbai	Institute of Chemical Technology, Mumbai
ICU	Intensive Care Unit
IDA	International Depository Authority
IEC	International Electrotechnical Commission
IFNg	Interferon Gamma
IGRA	Interferon Gamma Release Assay
IHT	Institute of Horticulture Technology
IICT	Indian Institute of Chemical Technology
IIP	Indian Institute of Petroleum
IIPS	International Institute for Population Sciences
IISER	Indian Institutes of Science Education and Research
IIT	Indian Institute of Technology
IL-10	Interleukin 10
IL-6	Interleukin-6
ILS	Institute of Life Sciences
IMHA	Immune-mediated haemolytic anaemia
IMTP	Immune-mediated thrombocytopenia
IMU	Inertial Measurement Unit
InSTEM	Institute for Stem Cell Science and Regenerative Medicine, Bangalore
IOCL	Indian Oil Cooperation Limited
IP	Intellectual Property
ISO	International Organization for Standardization
IVI	International Vaccine Institute
JNK	c-Jun-N-terminal Kinase
KBS	Knowledge Based System
KP	Klebsiella Pneumoniae
LAT	Latex Agglutination Test
L-DOPA	Levodopa and L-3,4-dihydroxyphenylalanine
LFA	Lateral flow assay
LH	Luteinizing hormone
LPS	Lipopolysaccharide
LSD	Lumpy skin Disease
MAPK	Mitogen-Activated Protein Kinase

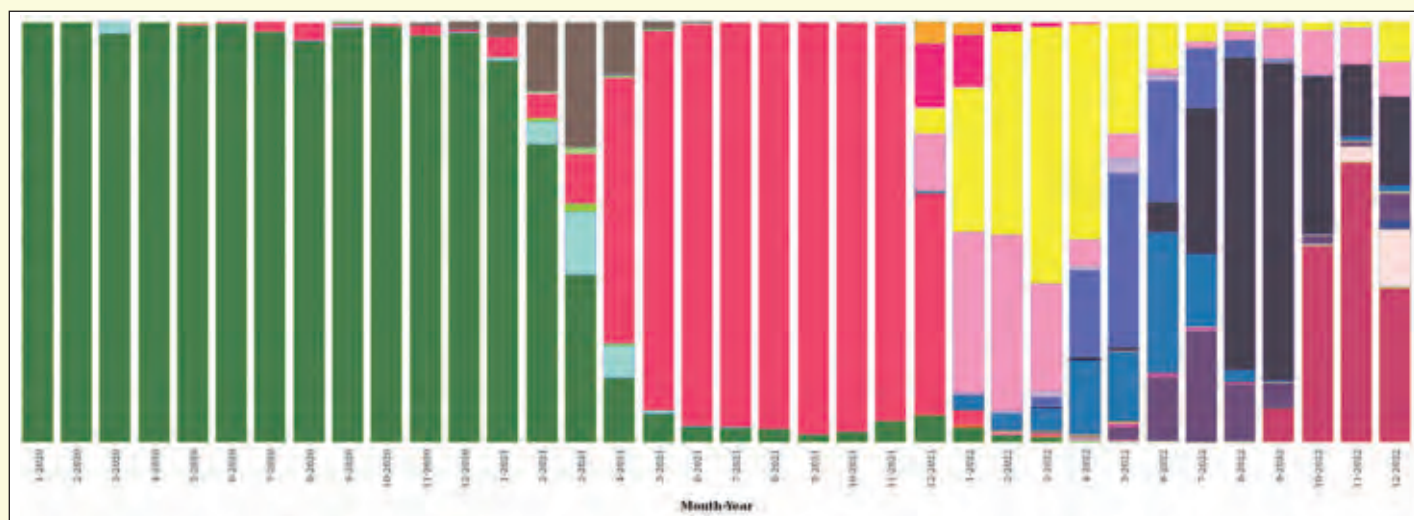
MAPs	Medicinal and Aromatic Plants
MCC	Microbial Culture Collection
MDR	Multi Drug Resistant
MDR-TB	Multidrug resistant Tuberculosis
MDSCs	Myeloid-Derived Suppressor Cells
MIT	Maharashtra Institute of Technology
MNRE	Ministry of New and Renewable Energy
MoA	Memorandum of Association
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoES	Ministry of Earth Sciences
MQTL	META- Quantative tract loci
MRC	Medical Research Council
MSW	Municipal Solid Waste
MTBC	Mycobacterium tuberculosis complex
MTCC	Microbial Type Culture Collection
N ₂ O	Nitrous Oxide
NABL	National Accreditation Board for Testing and Calibration Laboratories
NARI	National AIDS Research Institute
NBM	National Biopharma Mission
NCE	Network of Centres of Excellence
NCMR	National Centre for Microbial Resource
NCS-TCP	National Certification Systems for Tissue Culture Raised Plants
NECAB	North East Centre for Agriculture Biotechnology
NEERI	National Environmental Engineering Research Institute
NEHU	North Eastern Hill University
NER	North East Region
NER-BPMC	North East Region Biotechnology Management Cell
NERC	Natural Environment Research Council
NETs	Neutrophil extracellular traps
NGS	Next Generation Sequencing
NIAB	National Institute Animal Biotech
NTBN	National Technical Board on Nutrition
NTM	Non-Tuberculosis Mycobacterium

PAT	Process Analytical Technology
PCR	Polymerase Chain Reaction
PCV2	Porcine Circovirus 2
PGP	Plant growth promoting
PHFI	Public Health Foundation of India
PIAS	Protein Inhibitor of Activated STAT
PIH	Pregnancy-Induced Hypertension
PoC	Program of Cooperation
PPAR	Peroxisome Proliferator-Activated Receptor
PPD	Purified Protein Derivative
PTM	Post Translational Modification
PVA	Polyvinyl alcohol
qHPV	Quadrivalent Human Papilloma Virus
QMS	Quality Management System
QTL	Quantitative trait loci
RCGM	Review Committee on Genetic Manipulation
RD&D	Research, development, and demonstration
RET	Rare Endangered Threatened
RMRC	Regional Medical Research Centre
SASRD	School of Agricultural Sciences and Rural Development
SCC	Somatic Cell Count
SCTIMST	Sree Chitra Tirunal Institute for Medical Sciences and Technology
SDN	Site-Directed Nuclease
SHG	Self-help group
SICCT	Single intradermal comparative cervical tuberculin
SIT	Skin irritation Test
SOP	Standard Operating Procedure
SPRERI	Sardar Patel Renewable Energy Research Institute
SSC – NTBN	Scientific Sub-Committee under the National Technical Board on Nutrition
SSR	Simple Sequence Repeats
STFC	Science and Technology Facilities Council
STRING	Search Tool for Retrieval of Interacting Genes/ proteins
SUMO	Small Ubiquitin-like Modifier

SUTRA-PIC	Scientific Utilization through Research Augmentation Prime Products from Indigenous Cows
SYBR	Synergy Brands
T2D	Type 2 Diabetes
TANUVAS	Tamil Nadu Veterinary and Animal Sciences University
TB	Tuberculosis
TCPFs	Tissue Culture Production Facilities
TERI	The Energy and Resources Institute
TIFR	Tata Institute of Fundamental Research
TLR	Toll-Like Receptors
TNF	Tumor Necrosis Factor
TRIHMS	Tomo Riba Institute of Health & Medical Sciences
TRL	Technology Readiness Levels
TRPVB	Translational Research Platform for Veterinary Biologicals
Ube2N	Ubiquitin-conjugating enzyme E2 N
UIP	Universal Immunization Programme
USA	United States of America
VAP	Vaccine Action Programme
vdr ^{-/-}	vitamin D receptor knock out
VSI	Vasantdada Sugar Institute
VSV	vesicular Stomatitis Virus
WFCC	World Federation for Culture Collections
XDR	Extensively Drug Resistant

Front Cover: Illustration of viral fragmentation (virus death)

Back Cover: Graphical representation of SARS-CoV2 variants sequenced, month-wise, in India



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