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ANNUAL REPORT

2023-24

Department of Biotechnology
Ministry of Science & Technology
Government of India

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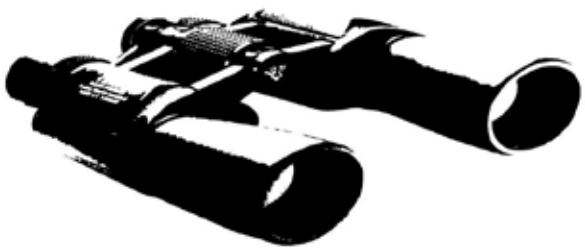

1. OVERVIEW

1 OVERVIEW

About the Organization

The journey of the Department of Biotechnology started as the *National Biotechnology Board (NBTB)* in 1982, evolving soon after in 1986 into a full-fledged Department under the Ministry of Science & Technology. The Department aims to be at the forefront of the *Biotech Revolution*, which possesses a potential for socioeconomic transformation far exceeding even the *Information Technology Revolution* of the past decades. The DBT is committed to support the National Development Programmes (NDPs) and achievement of the Sustainable Development Goals (SDGs) through the creation of biotechnology tools and technologies that address the problems of agricultural productivity, food production, nutrition security, healthcare and environmental sustainability. The DBT has also renewed its focus on Biomanufacturing as a tool to provide new and emerging products and services at affordable prices, generate employment opportunities, and make India one of the top players in the world *BioEconomy*. The DBT also plays a crucial role in guiding policy, regulation, and legislation for ensuring the safe, responsible, and peaceful use of biotechnology.

Vision

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

Mission

Accelerating the pace of research, innovation, development and technology transfer to advance biotechnology as strategic area by taking India's strengths in foundational sciences to globally competitive levels and expanding the application of biotechnologies for overall growth of bio-economy within the framework of inclusive development.

Major Activities

The Department's activities in 2023-24 were carried out under two schemes — Biotechnology Research and Development (BRD), and Industrial and Entrepreneurship Development (IED).

Biotechnology Research and Development

The R&D activities are mainly carried out in project mode with the country's premier scientific research institutions, both government and non-government, as the implementing agencies (IAs). The DBT provides financial support in the form of grants-in-aid to the IAs, in return for deliverables belonging to the following categories:

(a) Knowledge Generation — Incremental gains in knowledge which may, or may not have immediate commercial or practical application, but which contribute significantly to the collective knowledge of humanity. This is usually measured in terms of peer reviewed scientific publications such as research articles, reviews etc.

(b) Human Resource Development — Ensure availability of required numbers of world class scientists and professionals relevant to R&D and technology development, along with a well-trained and skilled technical work force for industry.

(c) R&D Infrastructure Development — Establish adequate infrastructure, biotechnology parks, incubators, clusters etc. to sustain current and future biotechnology research.

(d) Intellectual Property (IP) — Patents, trademarks, copyrights, etc. which have significant potential for commercial exploitation, such as products of social relevance for applications in agriculture, healthcare, environment and industry.

The R&D projects funded by the DBT are mainly selected through a rigorous competitive screening and selection process, while a small number of projects are developed in a top-down manner to address carefully deliberated specific issues, or niche areas not suitable for the routine selection process.

Institutes of Biotechnology Research and Innovation Council (iBRIC), RCB, ICGEB (iBRIC+) and Public Sector Undertakings

The DBT, in line with the recommendation of the Department of Expenditure, and with the approval of the Cabinet, has subsumed 13 Autonomous Institutions (AIs) under one Autonomous Body, the *Biotechnology Research and Innovation Council (BRIC)*, a registered Society. The institutions under BRIC are known as *iBRIC*, and together with the Regional Centre of Biotechnology (RCB), and International Centre for Genetic Engineering and Biotechnology (ICGEB), form the *iBRIC+*. The Department provides *core funding*, that is, financial support towards salaries, infrastructure, and intramural research/ other essential activities, to the 15 *iBRIC+* institutions, and 3 Public Sector Undertakings (PSUs). Each institute has a specific scientific theme, while the PSUs act as special purpose vehicles (SPVs) for achieving their specific mandates (Table 1).

Table 1 List of DBT Autonomous Institutions and Public Sector Undertakings

BRIC Institutes	BRIC Centre for DNA Fingerprinting and Diagnostics (BRIC-CDFD), Hyderabad
	BRIC Institute for Stem Cell Biology and Regenerative Medicine (BRIC-InStem), Bengaluru
	BRIC Institute of Bioresources and Sustainable Development (BRIC-IBSD), Imphal
	BRIC Institute of Life Sciences (BRIC-ILS), Bhubaneswar
	BRIC National Agri-Food Biotechnology Institute (BRIC-NABI), Mohali
	BRIC National Brain Research Centre (BRIC-NBRC), Manesar
	BRIC National Centre for Cell Science (BRIC-NCCS), Pune
	BRIC National Institute of Animal Biotechnology (BRIC-NIAB), Hyderabad
	BRIC National Institute of Biomedical Genomics (BRIC-NIBMG), Kalyani
	BRIC National Institute of Immunology (BRIC-NII), New Delhi
	BRIC National Institute of Plant Genome Research (BRIC-NIPGR), New Delhi
	BRIC Rajiv Gandhi Centre for Biotechnology (BRIC-RGCB), Thiruvananthapuram
	BRIC Translational Health Science and Technology Institute (BRIC-THSTI), Faridabad

PSUs	Biotechnology Industry Research Assistance Council (BIRAC), New Delhi Indian Vaccines Corporation Limited (IVCOL), New Delhi Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL), Bulandshahr
Institute of National Importance established by an Act of Parliament	Regional Centre for Biotechnology (RCB), Faridabad
Intergovernmental Agency	International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi

Summary of Achievements

The significant achievements of the DBT under various thematic areas are briefly summarized below.

Human Resource Development, Training, Workshops, and Infrastructure Support

The Department has implemented several programmes for human resource development and infrastructure support for enhancing the biotechnology ecosystem in the country.

A major role of the DBT is to establish infrastructure facilities to support R&D, and this is done through the Research Resource Service Facility and Platform (RRSFP), which operated through 2 major arms:

- DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research Programme (DBT-BUILDER) – BUILDER focuses to upgrade the post-graduate teaching and training laboratories by enabling advanced interdisciplinary research and teaching.
- 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 on the DBT website consolidates the information of all facilities supported and established by the DBT under a single window, enabling potential users/individuals access to these facilities. Some major facilities established include a Viral Bioassay Facility (VBaF) at Institute of Advanced Virology, Thiruvananthapuram, a Single-molecule and Super-resolution Imaging Facility at IIT Hyderabad, and an Advanced Mass Spectrometry facility at BRIC-ILS Bhubaneswar.

The national fellowship programmes of the DBT provide financial support at various levels to students and researchers for developing and maintaining a pool of skilled human resources in the frontier areas of biotechnology (Table 2).

The DBT Post Graduate (DBT-PG) Teaching Programme in Biotechnology supports high-quality teaching and state-of-the-art facilities at 70 Universities and Institutions across 28 states and 3 UTs. The candidates for the various courses including general biotechnology and specialized courses such as medical, industrial etc., were selected through the national level GAT-B examination 2023, in which more than 9000 students appeared, with 760 students finally enrolled in the postgraduate programme.

The Star College programme supports colleges offering undergraduate education to enhance the quality of teaching of science subjects. More than 300 undergraduate colleges, including 84 rural colleges, have been supported since 2014, with around 3000 faculty and 35000 students benefiting

annually. The annual Star College Coordinators' Meet was held in Coimbatore, in which 65 Star Colleges participated and benefited from the networking opportunities. Star Webinar sessions were organized to extend outreach to colleges, especially from Aspirational Districts, for providing mentoring and awareness towards networking opportunities as well as the various relevant schemes and programmes of the Government.

The DBT also supported the following international fellowships, internships, and partnerships programmes:

- Khorana Programme for Scholars – This programme annually supports 75 students to visit the USA in their pre-final year of graduation and post-graduation to pursue research internships in scientific institutions in the USA such as University of Wisconsin, Massachusetts Institute of Technology (MIT), Harvard Medical School, etc. The programme is implemented through Indo-U.S. Science and Technology Forum (IUSSTF), established under an agreement between the Governments of India and the USA.
- Institute of Technology Bombay - Monash Joint PhD Programme – This is an Indo-Australian Collaboration for Ph.D. Fellowship Programme with an annual intake of 10 PhDs. So far 63 scholars have been supported under this Programme.
- TWAS Programme: The Department of Biotechnology, Ministry of Science & Technology, Government of India has signed MoA with UNESCO-The World Academy of Science (TWAS), to help early-career researchers from developing countries to gain education and experience at the top science institutions in India. Till date more than 150 scholars have been supported.
- DBT-Wellcome Trust Partnership/India Alliance (IA) - Biomedical Research Career Programme (BRCP)
- Partnership Programme with European Molecular Biology Organization (EMBO) – India became an associate member of EMBO by signing a Cooperation Agreement with EMBC in 2016. In 2023 EMBO has supported 4 Global Investigators, 1 Young Investigator, 2 Postdoctoral Fellowships, 13 Scientific Exchange Grants, 1 Core Facility Fellowships, 1 Workshop, and 2 Lecture Courses, with 676 Indian scientists attending EMBO Courses & Workshops.
- Partnership Programme with The International Human Frontier Science Programme Organization (HFSPO): The HFSPO provides opportunities for interdisciplinary inter-country high-risk, high-gain blue-sky research to understand complex biological interactions between organisms. In 2023, One HFSPO Research Grant and Six HFSPO Fellowships were awarded to Indian scientific community.
- Foldscope Programme – Foldscope is an ultra-affordable paper microscope invented by an Indian researcher Dr. Manu Prakash at Prakash Lab, Stanford University, USA. It was brought to India after the signing of a Statement of Intent wtih the DBT. In 2023, the Department organized three hands-on training workshops on the use of Foldscope at Vidisha, Madhya Pradesh; Mahasamund, Chhattisgarh; and Dhenkanal, Odisha, where 1080 school students and 164 school teachers from 26 Aspirational Districts of Madhya Pradesh, Chhattisgarh, and Odisha were trained on the use of Foldscope as an educational tool for their science-related projects.

The following training programmes are supported by the DBT:

- Skill Vigyan State Science and Technology Partnership Programme in Life Science and Biotechnology (Skill Development Programme) – Skill training under student training, technician training, faculty training, entrepreneurship training, and biotechnology finishing school programmes. This programme has been implemented in 12 states through their State Science and Technology Councils.
- Biotech Industrial Training Programme (BITP) – Support to Biotech students for industry-specific training in an industrial setting through apprenticeship model for skill development and enhancing their job opportunities in biotechnology.

The DBT Outreach Programme also supports popularization of Biotechnology related activities through the Conference, Travel, Exhibition and Popular Lectures (CTEP). This programme provides coverage to the major scientific events through dissemination of information using various social media platforms including Youtube, X, Facebook etc.

For further details and other achievements under this area, please see Chapter 2 of this Annual Report.

Table 2 DBT Fellowships

Fellowship	Target Beneficiaries	Achievements
DBT Junior Research Fellowship (JRF) programme	Post-graduates/ Graduates desirous of pursuing research in biotechnology and life-sciences	1099 continuing and 252 new fellows supported in 2023-24
DBT Research Associateship (DBT-RA) programme	PhD graduates desirous of post-doctoral research in frontier areas of Biotechnology and Life Sciences	221 fellows supported in 2023-24
Tata Innovation Fellowship	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	15 ongoing fellows supported and 10 new candidates selected in 2023-24.
Har Gobind Khorana-Innovative Young Biotechnologist Fellowship (IYBF)	Young scientists up to 35 years of age with innovative ideas and desirous of pursuing research in frontier areas of Biotechnology/ Biotechnology-related fields	17 fellows supported in 2023-24

Fellowship	Target Beneficiaries	Achievements
Ramalingaswami Re-entry Fellowship (DBT-RRF) Programme	Indian Nationals working at overseas research laboratories/ institutions in various fields of Biotechnology and life sciences interested in taking up scientific research in India	300 ongoing fellows supported and 30 new candidates selected in 2023-24.
M K Bhan-Young Researchers Fellowship Programme	PhDs desirous of continuing their research in India	38 ongoing fellows supported and 30 new candidates selected in 2023-24
Biotechnology Career Advancement & Re-orientation (BioCARe)	Women researchers having PhD/M.Tech./M.Pharma., up to 55 years of age, and especially those with career breaks requiring re-entry in mainstream research in Biotechnology and allied areas	55 fellows supported in 2023-24

Research and Development (Extramural Research Funding)

Agriculture Biotechnology and Allied Areas

The Department has created a vibrant ecosystem across the country involving Universities / State Agriculture Universities and National Institutions for the growth of Agriculture sector. Through these concerted efforts, improved crop varieties, therapeutics, vaccines and diagnostics for livestock & aquaculture have been developed for the benefit of society. Few of the achievements are highlighted below.

- Under the mission mode programme on "Characterization of Genetic Resources", genotypic and phenotypic characterization has been carried out for a number of targeted accessions (> 69000) available in germplasm banks across the country, including Oilseeds (Sesame, Linseed, Safflower, Niger), Cereals (Rice and Wheat) and Pulses (Chickpea). This adds value to the existing germplasm repositories by facilitating their use for the development of improved crop varieties.
- An Amaranth Genomic Resource Database, Near Infrared Spectroscopy (NIRS) techniques for screening nutritional qualities of amaranth grain, and a 64K SNP chip have been developed. Amaranth accessions screened using the above resources have been shown to counteract high fat diet induced obesity. This is a significant enabler for rapid screening of amaranth accessions for cultivation as well as varietal development.
- A stable fungal enzyme nanoformulation from *Myrothecium verrucaria* has been developed for eco-friendly biocontrol of powdery mildew in tomato and grape.
- Multiple veterinary technologies have been developed and transferred to industry for commercialization, including mRNA vaccine platform technology for Lumpy Skin Disease, CRISPR/Cas based rapid point of care Lateral Flow Assay platform for dog parasites *Babesia gibsoni* and *Ehrlichia canis,* and a field level, affordable, farmer friendly quantitative method to diagnose intra-mammary infection as well as subclinical mastitis in bovines.

- Under aquaculture, a vaccine named "CIFA-Brood-Vac" has been developed which can prevent diseases and mortality of fish spawn. A user-friendly software, Interactive Fish Feed Designer (IFFD) version 2, has been developed for the formulation of cost-effective fish feed with non-conventional ingredients.

  For further details and other achievements under this area, please see Chapter 3(A) of this Annual Report.

Bioenergy, Bioresources, Environment and Forest

This area of R&D focuses on constructing an enabling environment for research and innovation in the area of clean energy, biofuels and waste to value. Some of the targets are sustainable biofuel from agricultural residue & municipal waste, algal fuels, sustainable aviation fuels, integrated biorefineries, feedstock development, biohydrogen and biorefinery based technological demonstrations & coproduction. Some significant achievements are:

- Better enzymes for efficient biomass processing have been developed, including a novel beta-glucosidase engineered for improved glucose and pH tolerance, and chimeric enzymes with cellulose and endoglucanase activity, engineered for better specific activities. These enzymes have great potential to be used for efficient and low-cost biomass processing, which is a key step for bioenergy production.
- Biorestoration technology for degraded mangrove ecosystem is being demonstrated over approximately 65 ha (~163 acres) of degraded mangrove sites at Indian Sundarbans outside the protected area. Out of 31 selected sites, 16 have shown successful restoration.
- The ecology and genetics of the living root bridges of Meghalaya have been characterized in terms of the biology, genetic diversity and population structure of the trees and pollinators within the mutualism between the rubber tree (living root bridge component) and its pollinating fig wasps. This knowledge has been used to design long-term conservation strategies for this iconic relationship between trees, wasps and humans.

  For further details and other achievements under this area, please see Chapter 3(B) of this Annual Report.

Healthcare and Medical Biotechnology

Biotechnology is an ideal tool to develop affordable quality healthcare for all, and to study and find solutions to issues related to emerging infections, antimicrobial resistance, non-communicable diseases, genetic disorders, maternal and child health, and nutrition. The activities of the DBT in this area encompass national mission programmes, R&D programmes, and various initiatives.

Some of the major achievements of the DBT have been through the National Biopharma Mission (NBM), such as the development of vaccines for Covid-19 (ZyCOV-D® and Corbevax®), pneumococcal disease (Pneuteger 15®), chikungunya, and dengue, biotherapeutics like Pegylated Interferon for COVID-19, and the biosimilar Liraglutide (Lirafit). Medical devices and diagnostics, including MRI scanners and dental implants have also been launched. NBM is an Industry-academia collaborative mission aimed at accelerating discovery research to early development for biopharmaceuticals under *Innovate in India for Inclusiveness (i3)*. NBM is approved by the Union Cabinet with a budget outlay of ₹1500 Cr, and co-funded 50% by the World Bank. It is implemented by the DBT-BIRAC Program Management Unit and aligns with *Make-in-India* and *AatmaNirbhar Bharat*.

There are 14 major programmes under healthcare and medical biotechnology umbrella, catering to specific areas (Table 3). These further support certain focused initiatives designed to address particular immediate or long-term needs such as the GenomeIndia Initiative for building a reference Indian genome, or the UMMID Initiative for inherited disorders (Table 4). Some of the significant achievements during the year are:

- Emergency use authorization (EUA) obtained for India's first Omicron booster mRNA vaccine, which has been developed with DBT support.
- India's first gene therapy clinical trial for Hemophilia A using Lentiviral vector transduced haematopoietic stem cells.
- Launch of the *DBT-Handbook on Biodesign for Med-Tech Innovations,* to promote Med-Tech entrepreneurship through the Biodesign process of *Identify, Invent and Implement*.
- Development of Spatially Resolved Polarization Digital Holography Microscope (PDHM) for non-destructive 3D imaging of biological samples for diagnostic applications.
- Dual-sensitive fluorescent nanoprobes for the detection of matrix metalloproteinases and low pH in a 3D-tumour microenvironment, with potential application in cancer detection and imaging
- Development of a patented hydrogel-based technology for anaemia, incorporating iron-dextran in a pH-responsive hydrogel alongside probiotic bacteria
- An Endoscopic Third Ventriculostomy Simulator has been developed using patient CT and MRI data to create highly accurate digital models of head anatomy, enhanced by CAD modeling. This realistic simulator is a valuable tool for neurosurgical training and skill evaluation

For further details and other achievements under this area, please see Chapter 3(C) of this Annual Report.

Table 3 Major Programmes under Healthcare and Medical Biotechnology

Programme	Focus area
Biomedical Engineering	Indigenous solutions to local healthcare needs
Biodesign	Affordable indigenous Med-Tech innovations through the process of Identify, Invent and Implement
Cancer Disease Biology	Basic and translational research in our fight against cancer
Chronic/ Lifestyle Disease	High disease burden areas such as diabetes, cardiovascular diseases, liver & kidney disorders, etc
Genome Editing	High-throughput, precise and efficient genome editing for healthcare applications
Human Genetics and Genome Analysis	Address the burden of genetic disorders by understanding the mutation spectrum, developing cost-effective diagnostic methods, and development of affordable and personalized therapies
Infectious Disease Biology	Solutions to infectious diseases of global concern such as HIV/AIDS, tuberculosis (including MDR & XDR TB), vector-borne diseases, emerging or re-emerging threats such as influenza, Japanese Encephalitis and antibiotic-resistant microbes
Nanotechnology Applications in Healthcare	Nanotechnology-based diagnostics, point-of-care sensors/detectors, therapeutics, targeted drug delivery, and smart-nanomaterials for medical applications

Programme	Focus area
Neurobiology	Understanding the nervous system and its disorders at a granular cellular and molecular level.
Public Health & Nutrition	Address issues of micronutrient & macronutrient deficiencies, overnutrition, agri-nutrition linkages etc.
Stem Cells & Regenerative Medicine	Research in developmental biology, novel cell-based and gene therapies, creation of GMP grade manufacturing facilities, enabling regulatory framework etc
Vaccine Research and Development	Candidate vaccine development from available leads, pre-clinical and clinical vaccine development, epidemic preparedness etc.
Drug Development	Development of drugs from existing leads with established Proof-of-Concept, lead optimization, preclinical development and clinical therapeutic validation, as well as discovery and development of novel therapeutic antibodies.
Woman and Child Health	Unmet health needs of women and children

Table 4 Major Initiatives under Healthcare and Medical Biotechnology

Initiative	Description
The GenomeIndia Project	More than 10000 genomes from 99 different populations have been sequenced so far and archived at the Indian Biological Data Centre (IBDC) to develop a reference genome for the population of India.
Indian SARS-Cov-2 Genomics Consortium (INSACOG)	National surveillance of SARS-CoV-2 genomic variants using next generation sequencing technologies to detect virus mutations and/or lineages that may pose a threat to public health
The Human Microbiome Initiative (HMI)	First reference human microbiome study from healthy Indian individuals, paving the way for future research on disease models and precision probiotics, and aiding dietary and probiotic recommendations.
The Unique Methods of Management of Inherited Disorders (UMMID) initiative	Generating data, material resources, trained manpower and infrastructure to build the ecosystem for research in the area of rare and genetic disorders in the country.
Data Driven Research to Eradicate TB (Dare2eraD TB)	An umbrella programme in alignment with the vision of TB Mukt Bharat by 2025, which includes setting up of the Indian Tuberculosis Genomic Surveillance (InTGS) Consortium, evidence-based regimen for treating Extra-Pulmonary Tuberculosis, and Host Directed therapies as adjunct to anti-TB therapy (ATT) for shortening therapy.
Antimicrobial Resistance (AMR)	In alignment with the National Action Plan- AMR (NAP AMR), the DBT has supported the development of novel cost-effective therapies, and rapid cost-effective diagnostic kits.
Garbh-Ini	An Inter disciplinary Group for Advanced Research on BirtH outcomes

Theoretical & Computational Biology (Bioinformatics, BTIS-Net, AI & Big Data), and Indian Biological Data Center (IBDC)

Computational Biology and Bioinformatics constitute an interdisciplinary field that encompasses processing of biological information to unravel the underlying principles of biological phenomena. Deployment of machine intelligence for analyzing biological data has led to development of predictive and generative models using statistical, machine learning (ML) and artificial intelligence (AI) techniques. The major achievements in this area are:

- A total of 47 bioinformatics centers were supported across the country, each involved in cutting edge Bio-medical research, synthetic biology and development of artificial intelligence based tools for healthcare and agriculture, under unique domain areas such as Structural Bioinformatics, Drug discovery, Chemiinformatics, Metagenomics, Systems Biology etc.
- The *Indian Biological Data Centre (IBDC)* is the national digital data repository mandated to archive all life science data generated from publicly funded research in India, and the primary enabler of the *Biotech-PRIDE Guidelines*. The primary computational infrastructure includes a High-Performance Computing (HPC) facility with a computing power of about 800 Tera Flops with 4.5 PB (PetaByte) of storage data. Currently, IBDC is operating through five specialized data portals dedicated to the management of diverse biological data types. It was a moment of pride for IBDC to co-host the 17th Annual International Biocuration Conference (AIBC-2024), for the first time in India, from 6th -8th March, 2024. This event also saw the launch of the Integrated Computing Environment (ICE), and 3 new data submission portals on IBDC.
- The *India Retinal Image database platform* has been developed using artificial intelligence methods, in a significant step towards achieving affordable screening and prediction of Diabetic Retinopathy (DR), with over 863 Retinal colour photograph images, and OCT image video files. A large Optical Coherence Tomography image database of people with diabetes with corresponding retinal colour fundus photographs and clinical metadata has also been created.

For further details and other achievements under this area, please see Chapter 3(D) of this Annual Report.

Building International Collaborations and Partnership

The International cooperation programme of DBT aims at bridging the technology and capacity gap in emerging areas of biotechnology and life sciences by bilateral and multilateral sharing of knowledge, resources, and expertise. The DBT has been supporting various R&D bilateral programmes with Switzerland, Sweden, Australia, Netherlands, Belgium, Germany, Canada, South Korea, UK, and USA and Multilateral Partnerships with European Union, BRICS, Globalstars (EUREKA), QUAD, G20, HFSPO and EMBO. Under the scheme Department also partnered with Philanthropic Organizations Bill & Melinda Gates Foundation (BMGF)-the USA and other NGOs. Some significant developments over the past year are:

- G20 Research and Innovation Initiative Gathering (RIIG): Under India's Presidency of G20, the Department of Biotechnology led G20 Research and Innovation Initiative Gathering (RIIG) conference was held in Dibrugarh and Itanagar on 24th-25th March 2023. More than 100 delegates from G20 member countries, guest countries and international organisations, as well as the scientific community, gathered to

discuss and explore ways to build a sustainable and circular bio-economy.

- DBT-NSF Research Collaboration Programme: Department of Biotechnology (DBT) Ministry of Science & Technology, Republic of India and National Science Foundation (NSF), Republic of United States of America have signed an Implementation Arrangement (IA) on Research Collaboration.
- Human Influenza Vaccine: Indo- European Consortium for Next Generation Influenza Vaccine Innovation (INCENTIVE) study at NII, New Delhi has down-selected Pentavalent COBRA mix formulation for GMP manufacturing in India for the clinical trials.
- CERVAVAC vaccine: India's 1st indigenously developed quadrivalent Human Papilloma Virus (qHPV) vaccine against cervical cancer supported under DBT and BMGF cooperation received market authorization from DCGI in 2022 to be rolled out in seven states of India for immunization of girls aged 9-14 years age, as announced in the Interim budget of GoI 2024.

For further details and other achievements under this area, please see Chapter 4 of this Annual Report.

Societal Program

The Biotechnology Based program for Societal Development has been disseminating the benefits of significant biotechnological developments to the marginalized sections of the society, especially focusing on farmers and unemployed youth in Aspirational Districts and rural areas. Additionally, through the Biotech Krishi Innovation Science Application Network (Biotech-KISAN) program, farmers (especially women), are being empowered with knowledge about the problems and solutions related to water, soil, seed and markets.

Knowledge of sustainable and modern practices in agriculture, forestry, aquaculture, etc., have been disseminated to local communities in several Aspirational Districts, who are successfully using them to substitute prevalent unsustainable or inefficient practices, thereby protecting their future. A few examples are:

- Tribal communities are moving to Broom Grass plantation in favour of the ecologically damaging "podu" cultivation practices, preventing degradation of forest land and associated reduction of non-wood forest produce (NWFP), and creating further employment for broom weavers.
- Fishermen in Ramanathapuram, Tamil Nadu, have been trained to recycle fish waste into fish feed and manure using modern biotechnology.
- Artificial insemination has been promoted In Bahraich, UP, for increasing productivity in goat production.
- Workshops for local communities in Kandhamal, Odisha, have led to formation of self-employment ventures producing value added food products from millets and sweet potato flour.

For further details and other achievements under this area, please see Chapter 5 of this Annual Report.

Promoting Biotechnology in the North East Region of India

The North East Region (NER) of India is a major biodiversity hotspot of the world. The region, however, faces several challenges in terms of poor agricultural/ horticulture outputs, high disease burden in the homogeneous ethnic communities, degradation of the fragile ecosystem, lack of skilled manpower, good research infrastructure etc. In order to give focused attention for the region, the Department has earmarked 10% of

its annual budget every year for implementing special programmes for the NER. Some significant achievements over the past year are:

- Biotech Hubs were established in NER universities, colleges, and institutions to support and promote biological sciences and biotechnology education, research through the provision of necessary infrastructure and advanced technology training to students, faculty, researchers, and local entrepreneurs. This year, 54 biotech hubs of Phase-I were further supported under Phase II.
- In view of promoting sustainable bioresources, a total area of 64.1 acres was covered for captive cultivation of selected medicinal crops like *Curcuma caesia* and compound-rich lemongrass (elemicin-rich and methyl-eugenol-rich). About 649 farmers and entrepreneurs from NER benefited from the training and awareness program.
- In one of the project under the Himalayan Bioresource Mission (HBM) 1 lakh rooted plants of *Picrorhiza kurroa*, a well-known herb in Ayurveda, were planted by 100 farmers.

  For further details and other achievements under this area, please see Chapter 6 of this Annual Report.

Promoting Entrepreneurship and Industrial Growth

Through various activities under the **Industrial and Entrepreneurship Development (IED) scheme,** 1461 entrepreneurs/Industries, most of them start-ups (>94%), were supported. For further promotion of biotechnology industry and entrepreneurs, the following activities have been undertaken:

- Establishment of 12 Biotechnology Parks in partnership with State Governments, for supporting industry through technology incubation, technology demonstration and pilot plant studies for accelerated commercial translation of research leads into commercial products or technologies.
- *Global Bio-India 2023* was organized by the DBT, through DBT-BIRAC, at Bharat Mandapam, Pragati Maidan from 4-6th December 2023. The highlight of the event was the launch of 29 new products by Indian Biotech Startups. The event was attended by over 7000 delegates from more than 25 countries, including over 500 biotech startups, incubators, industry, and other stakeholders.

  For further details and other achievements under this area, please see Chapter 7 of this Annual Report.

Data Monitoring and Analysis

The DBT has a robust data capture and processing system, which not only aids the Department in the monitoring and supervision of projects, but also allows collaborative monitoring by agencies such as NITI Aayog.

- The Biotech-PRIDE (Promotion of Research and Innovation through Data Exchange) Guidelines have been issued for ensuring the secure and ethical processing, storage, and sharing of the biological data generated from public funded research.
- The DBT is presently operating 11 web portals and 3 online dashboards. APIs have been developed for automation of data submission from data collection portals to various dashboards and reporting platforms, including Minister's Dashboard, and Prayas Dashboard. The DBT-Dashboard reports data from 16 Autonomous Institutes/ PSU / Statutory Institutions, including details of publications, patents, technology transfer, scientific information, RTIs, and public grievances.

- The Common Fellowship Portal (CFP) was inaugurated by Hon'ble Union Minister Dr. Jitendra Singh on March 12, 2024, at the National Media Centre, New Delhi. The CFP, available at https://fellowships.gov.in , serves as a unified interface for various fellowship schemes offered by the Departments under the Ministry of Science & Technology, including DST, DBT, and DSIR/CSIR. This portal has potential to be used by other GoI agencies such as ICMR, UGC, and AICTE for their fellowship programs as well. A unique feature of the portal is the Eligibility Calculator, which helps applicants check their eligibility for various fellowship schemes on entering their details.
- Under the Output-Outcome Monitoring Framework (OOMF) devised by NITI Aayog, the Department has identified 68 output indicators and 42 outcome indicators for FY2023-24, in order to streamline scientific indicators related to each scheme/programme for monitoring & evaluation.
- The DBT obtained a Data Governance Quality Index (DGQI) score of 4.68 (out of 5) in FY2023-24 Q3, securing 1st position among scientific Ministries/Departments for that quarter.
- Cyber Crisis Management Plan (CCMP) has been developed which clearly outlines comprehensive strategies for addressing various types of cyber incidents, establishing policies, defining actions, and assigning responsibilities to ensure a coordinated response.

  For further details and other achievements under this area, please see Chapter 8 of this Annual Report.

Regulation and Intellectual Property

An important role of the Department is to assist the implementation of the Environment (Protection) Act, 1986 (EPA 1986), on matters related to Genetically Engineered organisms (GE organisms) or cells and hazardous microorganisms and products thereof, through the Review Committee on Genetic Manipulation (RCGM), which monitors the safety related aspects in respect of on-going research projects and activities involving above organisms/ products. A few significant activities carried out under this area are as follows:

- Notification of *Guidelines and Standard Operating Procedures for Research on Genetically Engineered Insects 2023* - This document has been prepared for GE insects, including vectors of human diseases (such as mosquitoes including *Aedes, Anopheles* etc.), crop insect pests (such as pink bollworm, diamond back moth etc.) and beneficial insects (such as silkworm, honeybee etc.). It aims to specify the regulatory pathway for import, export, transfer and receive as well as for conducting research on GE insects. It also addresses the containment requirements as well as data requirements for ensuring biosafety and trait efficacy.
- Notification of the entry of 05 micro-organisms in the List of Infective Microorganisms corresponding to different Risk Groups, 2021, superseding the Annexure I of Regulations & Guidelines for Recombinant DNA Research and Biocontainment, 2017.

Significant changes have been made in the Intellectual Property policy of the Department. The DBT-IP Guidelines 2023 have been notified, which enable seamless transfer of IP at academic institutes/ research laboratories towards commercialization into technologies/products for larger societal impact. The major change has been the rescinding of the DBT's co-ownership of IP, conceding full ownership to the implementing agencies. Further, as against the earlier mandated non-exclusive IP licensing, provision has been made for exclusive

licensing under certain circumstances, if it is found more conducive for successful commercialization.

For further details and other achievements under this area, please see Chapter 9 of this Annual Report.

iBRIC, RCB, ICGEB and Public Sector Undertakings

The research outputs of DBT Autonomous Institutions include more than 1300 Publications and 90 patents (applied & obtained). More than 40 technologies / products/ processes have been developed, and over 8000 human resource have been trained.

The iBRIC+ institutions have rolled out a globally competitive interdisciplinary PhD program - "i3c BRIC-RCB PhD Programme in Biosciences" based on the principles of *ideate, immerse, innovate and collaborate (i3c)*. This collaborative initiative offers a multidisciplinary PhD program in Biosciences to students with a Master's degree in Life Sciences as well as B.Tech/BE in Non-biological sciences & Medicine graduates. The program shall provide an unique course curriculum as well as hands-on experience into high-end facilities to all the research scholars. It will also include an Immersion Program to identify unmet needs, frame key research hypothesis and questions based on the exposure of students to real-world challenges in biotechnology.

In the area of R&D, some significant achievements of the institutes and PSUs are given below:

- BRIC-CDFD has published more than 60 research articles in peer reviewed international journals including Nature Communications, Cell Reports, etc. A patent has been granted in Nov, 2023 for a novel therapeutic for treatment of sepsis, and another patent filed in Oct 2023 for a promising Sub-Unit Vaccine to manage TB-associated diabetes complications.
- BRIC-IBSD organized Traditional Healers Meet at Meghalaya centre on April, 18, 2023 in coordination with Bio Resource Development Centre (BRDC), Shillong and Society for Ethnopharmacology (SFE), India. Many traditional healers from East Khasi Hill, West Khasi Hill, Garo and Jantia Hill shared their ideas, experiences and showcased their products/ formulations, providing avenues for scientific validation and leads for future discoveries.
- BRIC-ILS has established a biotech incubator focused on domains such as bioinformatics, biopharmaceuticals, bioprocessing, industrial biotechnology, MedTech, food and wellness, indigenous biotech products, agriculture, and allied areas. This incubator has received Emerging Incubator Award of the year 2023 by MSME Department, Govt. of Odisha.
- BRIC-inStem scientists have created a detailed 3D map of how heart muscle cells are arranged in terms of direction and orientation, filling a significant knowledge gap in the field of cardiovascular biology for the first time.
- BRIC-NABI has been granted 13 patents during the year and four have been filed. One of the technologies related to 'Dehydrated Natural Saffron Colour' has been commercialized during the year. Lignin-based biofertilizer and biopesticide technology have also been licensed to industry for commercialization.
- BRIC-NBRC researchers have joined an international effort to develop image analysis protocols for low magnetic field, portable, "Hyperfine" MRI machines in collaboration with the Bill & Melinda Gates Foundation.
- BRIC-NCCS, through its National Cell Repository, has facilitated cell biology research across India by providing 5747 cell cultures to 500 organizations. The institute has also published 98 research papers.

- BRIC-NIAB has made significant achievements in mammary gland bioreactors for biotherapeutic production, by isolating mammary epithelial cell-specific promoters from the Indian river buffalo genome and creating milk-specific expression vectors.
- BRIC-NIBMG has developed an advanced toolkit called Mapinsights, which performs quality control (QC) analysis of sequence alignment files, capable of detecting outliers based on sequencing artifacts of High-throughput Sequencing (HTS) data at a deeper resolution compared with existing methods.
- BRIC-NII has developed SG001, a potential disease-modifying therapeutic small molecule for the prevention and management of Alzheimer's disease. The compound has been shown to improve cognition in animal models, and a US patent has been obtained.
- BRIC-NIPGR has developed superior climate smart chickpea variety "ADVIKA", which gives 15-20% increase in yield under drought over the parent.
- BRIC-RGCB has secured 2 US patents and a European Patent for the invention, "Uttroside B and derivatives thereof as therapeutics for hepatocellular carcinoma" This molecule extracted from the medicinal plant *Solanum nigrum*, demonstrates therapeutic promise against liver cancer, and is presently undergoing clinical trials.
- BRIC-THSTI has been selected as one of the World Health Organization's (WHO) Global CoronaVirus Network (CoViNet) reference laboratories as a part of its Epidemic & Pandemic Preparedness and Prevention program.
- RCB has developed hydrogel-mediated localised delivery of a combination of docetaxel (DTX) and carboplatin (CPT) (called DTX-CPT-Gel therapy) with enhanced anticancer effect and tumor regression, providing a potential platform for DTX-CPT therapy.
- ICGEB leads a Translational Research Consortium on Dengue and has made ~350 human monoclonal antibodies (MAbs) from dengue acute or recovered individuals, and also made ~100 human MAbs from Chikungunya patients and recovered individuals. Two of the MAbs from this panel potently neutralise Chikungunya virus and have been patented for further development.

Public Sector Undertakings

BIRAC

BIRAC is a not-for-profit, Section-8 company, which aims to strengthen and empower the growing Biotechnology ecosystem to undertake strategic translational research & development, for creating innovative, globally competitive products/ technologies addressing unmet needs. BIRAC spearheaded the Global Bio India 2023 at Bharat Mandapam, Pragati Maidan, New Delhi, which was attended by over 5500 delegates. BIRAC has successfully created an ecosystem comprising 95 Bio-incubators across 21 States and 4 UTs across the country. More than 4800 beneficiaries have been supported by BIRAC. This has enabled over 1300 IP filings, 800+ biotech products/technologies reaching the market. INR 5500 Cr follow-on funding have also been generated by supported startups and companies. BIRAC also integrates with National Missions (Make in India, Startup India, National Biopharma Mission, Ayushman Bharat), Policy initiatives, G2G and Multilateral collaborations.

IVCOL

Indian Vaccines Corporation Limited (IVCOL), New Delhi, is a Company with 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.

BIBCOL

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

For further details and other achievements under this area, please see Chapter 10 of this Annual Report.

Administration and Finance

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 procurement, booking of domestic and international flight tickets, issuance of Identity cards/CGHS cards, etc. function effectively and smoothly. A few highlights are listed below:

- The Department has successfully implemented e-office version 7.0, with a total number of 1796 new e-files were opened since 1st April, 2023. In addition, Admin section processed all eligible mandatory payments/releases through ebill system.
- All procurement of goods and services to the tune of ₹70.42 lakh (FY2023-24) was done from Government e-Marketplace (GeM) as per availability.
- Obsolete items, e-waste, and other scrap items were identified, segregated and disposed off through e-auction Govt Norms.
- Accessible toilets for Persons with Disability have been provided and are being optimally utilized.
- Hindi Division ensured progressive use of Hindi and implementation of Government policies on Official Language in the Department. 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.
- Replies to about 25 Parliamentary Questions pertaining to the Department were duly replied within the prescribed time frame.
- A total of 217 RTI applications were received by the Department from 01.04.2023 to 31.03.2024, through the RTI portal, out of which 208 have been disposed off, similarly a total of 32 RTI appeals were received and disposed off by the Department respectively.

The Department of Biotechnology (DBT) was allocated an amount of ₹2683.86 crores in the Budget Estimate (BE) for FY 2023-24. The allocation has, however, been reduced to ₹1607.32 crores at RE stage. The BE for FY 2024-25 is ₹ 2275.70 crores.

For further details and other achievements under this area, please see Chapter 11 of this Annual Report.

2. HUMAN RESOURCE DEVELOPMENT, TRAINING & WORKSHOPS AND INFRASTRUCTURE SUPPORT

2 HUMAN RESOURCE DEVELOPMENT, TRAINING & WORKSHOPS AND INFRASTRUCTURE SUPPORT

Human Resource Development

The Department of Biotechnology (DBT), Government of India initiated the Human Resource Development Programme as early as 1985-86. This programme has been a pioneering effort aimed at addressing the need for skilled manpower in the field of Biotechnology. Since its inception, the Department has been continuously supporting Teaching Programmes at postgraduate level for imparting quality hands-on training in multidisciplinary areas of Biotechnology. The Department has implemented human resource development programmes for enhancing the Biotechnology ecosystem in the country, including the Star College Programme at undergraduate level, Skill Vigyan Programme in close collaboration with respective State/Union Territories Science and Technology Councils, doctoral and postdoctoral fellowships, fellowships for recognitions of young, mid-career and distinguished scientists, special programmes for retaining young pool of researchers under M K Bhan-Young Researcher Fellowship Programme and Ramalingaswami Re-entry Fellowship Programme to address the brain-drain issues in science and Technology and a women centric programme, BioCARe, to support women researches to give them opportunity to join mainstream science after career break. The Department has also supported young investigators' meetings, webinars for awareness about science and technology opportunities in the country among researchers and faculties, as well as workshops, popular lectures, and exhibitions for doctoral and postgraduate students. A number of international partnerships are being also supported for capacity building in cutting edge technologies and priority areas. The HRD Programmes of the Department have had a significant impact on the development of Biotechnology in the country. The significant achievements made during the year under various HRD Programmes are highlighted below:

(A) Teaching Programme:

(i) DBT Post Graduate (DBT- PG) Teaching Programme in Biotechnology: Since its inception, the Department has been implementing a Post Graduate Teaching Programme in Biotechnology with an aim of ensuring high-quality teaching standards and state-of-the-art facilities at Universities and Institutions across India. This initiative promotes an ecosystem of a skilled workforce in Biotechnology, essential for both academic and industrial activities in the country. The programme provides financial aid for various needs, including equipment, consumables, studentship, and thesis grants, with selection through the National GAT-B Exam. Department of Biotechnology has supported 70 Universities/ Institutes and Colleges for postgraduate teaching courses across the country, offering general biotechnology courses and specialized courses such as Medical, Agricultural, Marine, Veterinary, Industrial, Food, Pharmaceutical Biotechnology, and Molecular & Human Genetics. In 2023, the GAT-B examination was held on 13th May 2023

at 72 centres in 55 cities across India, where 9116 candidates appeared in the examination. Based on the results of GATB 2023; 760 candidates have been admitted in DBT supported postgraduate programmes in Biotechnology in 70 programmes running in 63 participating host universities/ institutes. At present 1304 DBT supported Post Graduate students are studying in first and second year in these universities/institutes. A total of 374 research articles were published, and 25 patents were filed by Students and faculties associated with Programme. Additionally, 70 students from this programme have qualified national level exam i.e. DBT-JRF/CSIR-NET and 155 students passed other national examinations, showcasing the programme's success in fostering high academic and research achievements.

(ii) Star College Programme: The Star College Programme supports colleges offering undergraduate education to enhance the quality of teaching of science subjects. Since 2014, approximately 300 undergraduate colleges across the country have been benefited from the DBT Star College Programme, impacting around 3,000 faculty members and 35,000 students annually. To extend the Programme's reach to remote and underserved regions, it was divided into Urban and Rural categories in 2018-19, ensuring equitable opportunities for rural colleges. This initiative has significantly reduced the rural-urban gap, with 84 rural colleges benefitting. Additionally, 8 colleges from Aspirational Districts and 54 women's colleges have received support. To expand the Programme's presence in the North-East states, a special call has been announced for colleges in NER states. Recent guideline revisions now permit colleges to apply at three different stages: for support under the Strengthening component, Star Status, and Mentor Status, with a mandatory two-year cooling period between each stage. The Star College Programme has enhanced hands-on exposure for science students, enabled colleges to undertake student research projects, and facilitated more seminars and expert talks.

Star College Mentorship Programme & Coordinators Meet: As per guidelines, yearly Coordinators Meetings are held to foster support and networking among Colleges. This year, the Coordinators Meet took place in Coimbatore, inviting Coordinators and Principals from 65 ongoing Star Colleges, providing an opportunity to interact with other faculty and Expert members. Special lectures by prominent Scientists were also organized.

Star Science Setu Series: Under the DBT-Star College Programme, colleges are mandated to arrange visits of students to neighbouring industries, research institutions, or academic places and to organize lectures by eminent scientists and career counselling sessions to raise awareness about future career options in science. To this end, Star Colleges organized the 'Star Science Setu Series' in collaboration with DBT-Autonomous Institutes, which arranged laboratory tours, webinars, lectures by eminent scientists, live Q&A sessions, and related interactive initiatives. An example is Durgapur Government College, Durgapur, which has been organizing Star Science Setu Series lectures in association with DBT-BRIC-NIBMG, Kalyani.

Star Webinar: The DBT-Star College Programme has launched 'Star Webinar' sessions to extend outreach and ensure equitable dissemination of the Star College scheme's benefits. During these sessions, aspiring and ongoing Star Colleges are invited to interact with DBT officials and with each other to discuss the scheme's propagation. The primary goal of the Star Webinar Sessions is to mentor colleges beginning their journey under the "Strengthening Component," is to implement the scheme's mandate, and raise awareness

about other programmes being implemented byteh Department, emphasizing networking, support, and outreach, particularly for colleges in Aspirational districts.

Centre for Training Teachers in Using *Drosophila melanogaster* for Biology Laboratories under the Star College Programme: This project aligns with the Star College Programme's objectives by training teachers, especially those from DBT 'Star' Colleges, to use Drosophila in classroom learning through hands-on workshops and providing long-term support for their periodic needs of flies of the desired genotypes and follow-up training. It also aims to train young researchers in advanced fly techniques to enhance their potential as future researchers and teachers, prepare well-illustrated laboratory manuals with supporting videos on fly techniques for UG, PG, and research students, and conduct National Drosophila Meetings to bring researchers and undergraduate teachers together. The training sessions have commenced and are progressing well.

(B) National Fellowship Programme:

(i) Junior Research Fellowship (JRF) Programme: Since 2004, the Department is implementing "DBT-Junior Research Fellowship (JRF)" Programme to facilitate fellowships for pursuing research in biotechnology and life-sciences. This programme has played a pivotal role in nurturing and strengthening skilled human resource in frontier areas of Biotechnology. Candidates are shortlisted through an online Biotechnology Eligibility Test (BET) held annually, wherein two categories of merit list are prepared (Category-I &Category-II) in-line with the Government of India norms for reservation.

- Candidates shortlisted under the Category-I are eligible to avail fellowship which are tenable at any university/ institution in India where the selected fellow registers for PhD under DBT-JRF Fellowship programme.
- Candidates shortlisted under the Category-II are eligible to be appointed in any DBT sponsored project with fellowship equivalent to NET/ GATE qualification as per DST guidelines and/ or enrol in PhD programme subject to selection through institutional selection process.

  During the year 2023-24, a total of 1099 ongoing students and 252 new fellows have been supported under the DBT JRF Programme. Fellows have published 228 research articles, filed 12 patents out of which 02 patents granted during 2023-24. The Department conducted Biotechnology Eligibility Test (BET), 2023 at national level, a total of 14,234 applications were received out of which 11,904 candidates appeared for the examination and exam was conducted at 86 centres located in 55 cities across the country. A total of 523 candidates were selected under Category-I for award of JRF and 204 candidates were selected under Category-II in the year 2023-24.

(ii) DBT Research Associateship (DBT - RA) Programme: DBT- RA programme aims at training and nurturing young researchers, scientists and generate a critical mass of trained manpower in the area of Biotechnology. It lays the foundation for building a robust postdoctoral base for the growth of Biotechnology sector in the country. DBT Research Associateship programme provides fellowship for post-doctoral research in frontier areas of Biotechnology and Life Sciences at premier institutions in India. There is a provision for 100 fellowships per year. For the Research Associate (RA) Call-I for the year 2023-24, a total of 1,074 applications were received. Out of these, 50 candidates (38 National and 12 from North-Eastern region) were selected. During the year, a total of 221 fellows were supported by the Department. The Fellows have published 33 research articles.

(iii) 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 for two years on fresh appraisal. The Department published the advertisement for 2023-24, and received 179 applications out of which 10 candidates were selected for award of fellowship. In year 2023-24, 15 ongoing fellows have been supported under the programme; 4 patents granted to TATA Fellows.

(iv) Har Gobind Khorana-Innovative Young Biotechnologist Fellowship (IYBF): The Innovative Young Biotechnologist Fellowship (IYBF), initiated in 2005, is an attractive Research Fellowship to identify and nurture outstanding young scientists up to 35 years of age with innovative ideas and desirous of pursuing research in frontier areas of Biotechnology/Biotechnology-related fields. Scientists with regular employment only are eligible for this fellowship. The fellowship consists of Research grant for the proposed innovative project for 3 years and a cash Fellowship of Rs.1,30,000/- every year for a period of three years along with non-recurring support to be provided in first year only for procurement of equipment essentially required to carryout research activities. In year 2023-24, 17 ongoing fellows have been supported under the programme; 9 research articles published by IYBF Fellows. The Department has published the advertisement for 2023-24, and have received 87 applications out of which 9 candidates selected for award of felllowship.

(C) Building Critical Mass of Science Leaders

(i) Ramalingaswami Re-entry Fellowship (DBT-RRF) Programme: The Department of Biotechnology instituted Ramalingaswami Re-entry Fellowship Programme for Indian Nationals working at overseas institutions in various fields of Biotechnology/life sciences and are interested in taking up scientific research in India. During the year 2023-24, the Department supported 300 ongoing fellows. In the year 2023-24, Department advertised call for applications and against which a total of 171 applications were received and 75 candidates were screened in for final selection. So far, 635 fellows have been supported under this programme, out of which 411 fellows have already secured regular positions in Indian institutions. In the current year, 321 research articles have been published, 23 patents have been applied and 21 process/products/technologies have been developed by Ramalingaswami fellows.

(ii) M K Bhan-Young Researchers Fellowship Programme: 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/- per 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. There is a provision for 50 fellowships per year. As of now there are 38 ongoing fellows for the financial year 2022-23 and this year the Department has received 103 applications out of which 30 fellows have been selected for the financial year 2023-24. In 2023-24, a total 47 publications, 1 technology perfected, 3 Patent granted, 3 patent filed by MK Bhan Fellows.

(iii) Biotechnology Career Advancement & Re-orientation (BioCARe): Biotechnology Career Advancement & Re-orientation Programme (BioCARe) is an unique programme of the Department, which aims to enhance the participation of women researchers in India towards research in Biotechnology and allied areas. It provides a special opportunity to women researchers who had a break in their career to help them re-enter into the mainstream research and to provide a launch pad for further forays into the field of Biotechnology and allied areas and hence, support in their overall career development. Under this programme, unemployed/not in a regular position Indian Women Researchers/ Scientists of age up to 55 years & having a qualification of Ph.D. in any discipline of Life Sciences or allied areas/ interdisciplinary sciences/ MD/ MDS/ M.V.Sc (Category-I) or M.Tech in Biotechnology or in allied areas/M.Pharma degree holders (Category-II) are supported with a consolidated fellowship and a Research Grant upto ₹ 40.00-60.00 lakhs to carry out their research endeavours in Indian universities, research institutions and laboratories. In the year 2023-2024, a total of 55 fellows out of 390 applicants have been selected & supported under the various areas of Biotechnology. In this period, a total of 26 articles were published and 4 process/ product/technology developed by BioCARe fellows.

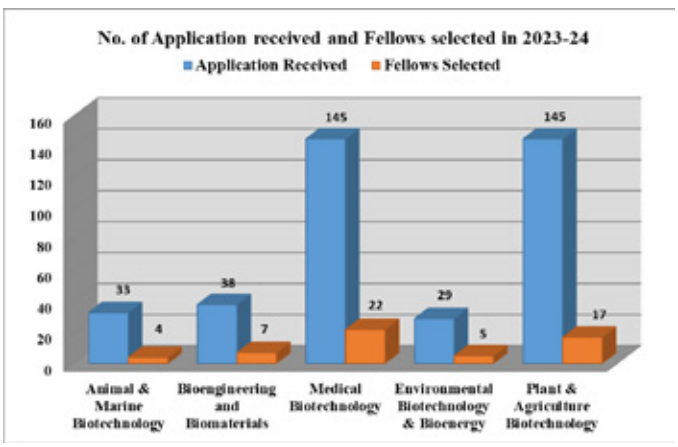

Figure 2.1: Number of applicants and fellow selected for support under BioCaRe Programme in 2023-24.

Since the inception of the scheme, around 415 women researchers have been supported under this programme and a total of 450 research articles have been published & 11 patents have been filed. The BioCARe programme has made a huge societal impact by helping the women researchers to restart their career in research and provide a platform to further polish their research skills. For a women researcher to maintain a familial as well as professional life and to stay ahead in the research field where they always find themselves at disadvantage position in their career due to their responsibilities, this programme offers a onetime opportunity to encourage them to re-enter into the mainstream research and strengthen their research potential and also to build confidence in establishing themselves as an independent research investigator.

(D) International Fellowship/ Internship/ Partnership Programme:

(i) Khorana Programme for Scholar: The Khorana Programme for Scholars is an International Fellowship programme of the Department of Biotechnology under which students of the pre-final year of graduation and post-graduation are provided opportunities to pursue research internships in the eminent Scientific Institutions in the United States of America (USA) such as - University of Wisconsin, Massachusetts Institute of Technology (MIT), Harvard Medical School/Harvard University, Yale University, etc. The programme is implemented through Indo-U.S. Science and Technology Forum (IUSSTF), an organization established under an agreement between the Governments of India and the USA.

The Khorana Programme provide opportunities to Indian students currently pursuing B.Tech., M. Tech., B.Sc., MSc., B.E., M.E., M.S., Integrated B.S-M.S., B.V.Sc., M.V.Sc., B. Pharm., M. Pharm., MBBS., and Master in Medical Science and

Technology (MMST) at recognized institutions of higher education in India in Biotechnology and allied areas (including agriculture, food, health, biomedical sciences and interdisciplinary areas such as Computational Sciences, Big Data, and Machine Learning), to undertake research internships at premier U.S. Universities each summer, for a period of 10-12 weeks.

The broad objectives of the programme are: (a) To provide exposure to world class scientific research facilities. (b) Nurture the next generation of scientists and technologists to build long term R&D collaborations. (c) Enable post-graduate students to pursue higher education and research-based careers. (d) Promote capacity building in frontline areas of biotechnology and bio-quantitative sciences. The programme annually supports 75 students to visit the USA. Since its inception, a total of 419 students have benefited from the Khorana Programme for Scholars, gaining valuable international exposure and research experience. In the fourteenth Call (Call - 2023), more than 700 applications were received from top Institutes and Universities across the country and finally total 66 students have successfully availed the internships.

The programme has been advertised for the year 2023-24. The Khorana Call (Batch 2024) was announced on September 27, 2023, with a submission deadline of October 31, 2023 and received 844 applications. Based on detailed evaluation, total 75 candidates were selected for this year's summer internship programme.

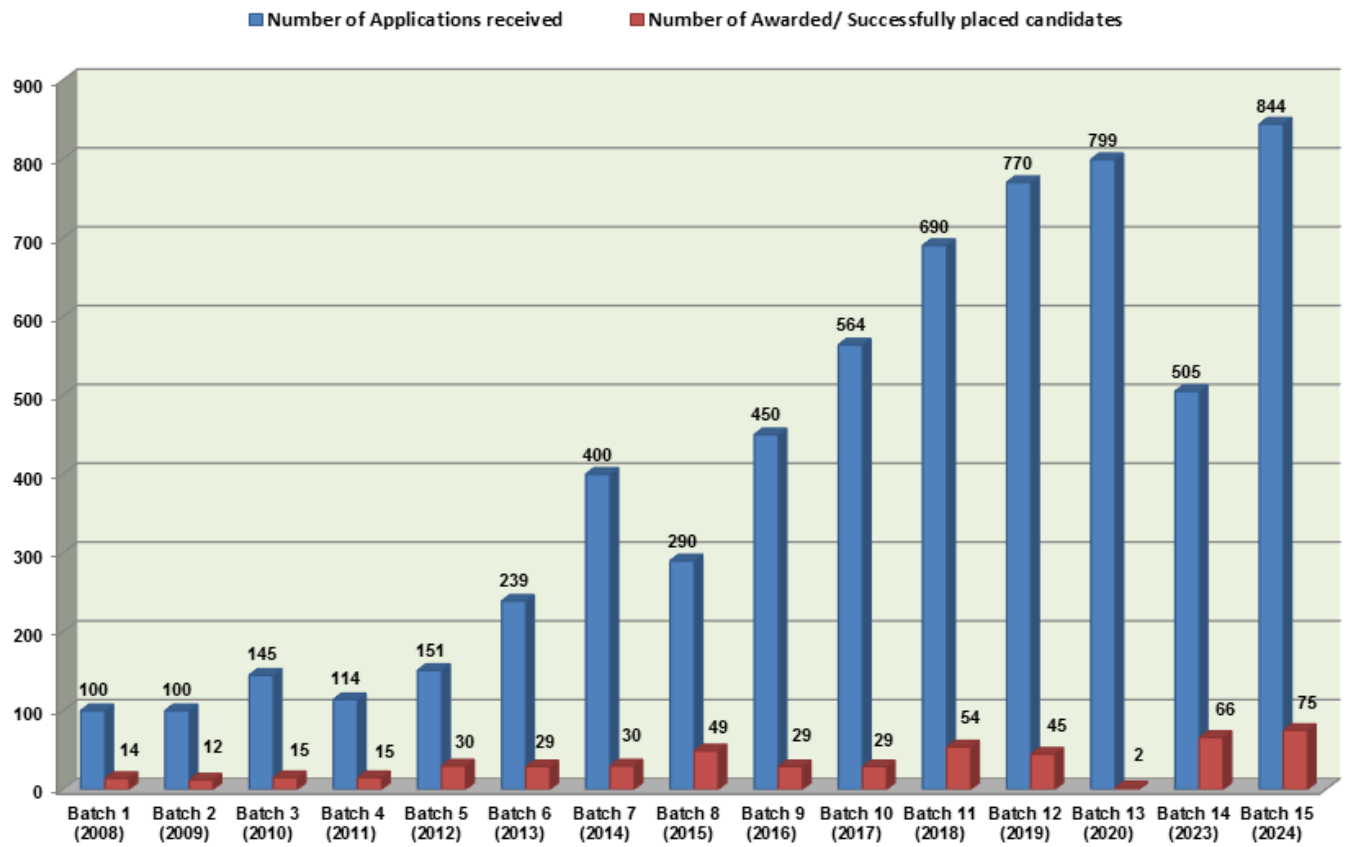

Figure 2.2: Total Number of Applications received over 15 Batches under Khorana Programme

(ii) Indian Institute of Technology Bombay - Monash Joint PhD Programme: In January 2017, the Department in its visionary approach recognized the value of the IITB-Monash Research Academy Indo-Australia Collaboration for Ph.D. Fellowship Programme and initiated annual intake of 10 PhDs under this collaborative Programme which has greatly contributed to the Academy's growth in scaling the number of PhDs. Leveraging this unique partnership, the programme has curated research projects that seek solutions for the challenges that humanity faces in the bio and allied sphere and attracts the best talent from across the country. The induction of students for the Phase II of the Programme has been started from July 2023. Five students have been inducted in July 2023. So far 63 scholars have been supported under this Programme including 39 women scholars.

The Academy students reap the benefits of supervisors mentoring in two countries, exposure to industry and a jointly badged PhD. The Academy has established a number of industry and research partnerships, including with CSIRO, BHPB and Orica Mining Services in Australia, and Infosys, Reliance Industries, Jindal Steel Works and Tata Consultancy Services (TCS) in India. The Academy has produced more than 300 publications, four patents and 28 PhD graduates, with 63 students currently in the Programme. PhD students at the IITB-Monash Research Academy are facilitated by the Department with over 30 placements **across sectors to date including in COMSOL, India; Infosys, Amazon Labs, NEC Labs, Japan; Taiwan Semi-Conductor Ltd, Michelin, Vikram Sarabhai Space Centre, and various post-doctoral positions at leading universities around the world. One of the** student has joined IIT Bombay as an Assistant Professor.

(iii) DBT TWAS Programme: Acknowledging India as a Founding Member of United Nations Educational, Scientific and Cultural Organization (UNESCO) since 1946, the Department of Biotechnology, Ministry of Science & Technology, Government of India had signed MoA with UNESCO-The World Academy of Science (TWAS) in the year 2004. By the end of 2023, TWAS had 1,400 elected Fellows; 13 of them Nobel laureates; representing 112 countries.

With the world's largest South-South PhD and postdoctoral research fellowship programme, DBT-TWAS helps early-career researchers from developing countries (https://twas.org/66-countries) to gain education and experience at the top scientific institutions in India. Till date, more than 150 scholars from various developing countries have been benefitted through this joint activity of the TWAS and the Department.

The programme provides fellowship under two categories: a) Full-Time Postgraduate Fellowship to pursue a PhD research programme in India for 5 years for full time fellows & for 12 to 18 months for Sandwich Fellowships (for those registered for a PhD in their home country); b) DBT-TWAS Postdoctoral Fellowship to pursue a postdoctoral research in India for 12-18 months to candidates of the developing Countries to promote capacity building and training in the field of Biotechnology. The programme extends support to the selected candidates through Fellowship/Stipend, HRA, medical insurance and contingency for research during the tenure of the award. The programme aims to support the research in emerging areas of biotechnology such as agriculture sciences, biological systems and organisms, chemical sciences, medical and health sciences, structural and molecular biology for scientists from developing countries.

The Department with UNESCO TWAS team is proactively engaged for programme improvisation, streamlining and value addition in the joint activities. The Department has announced DBT-

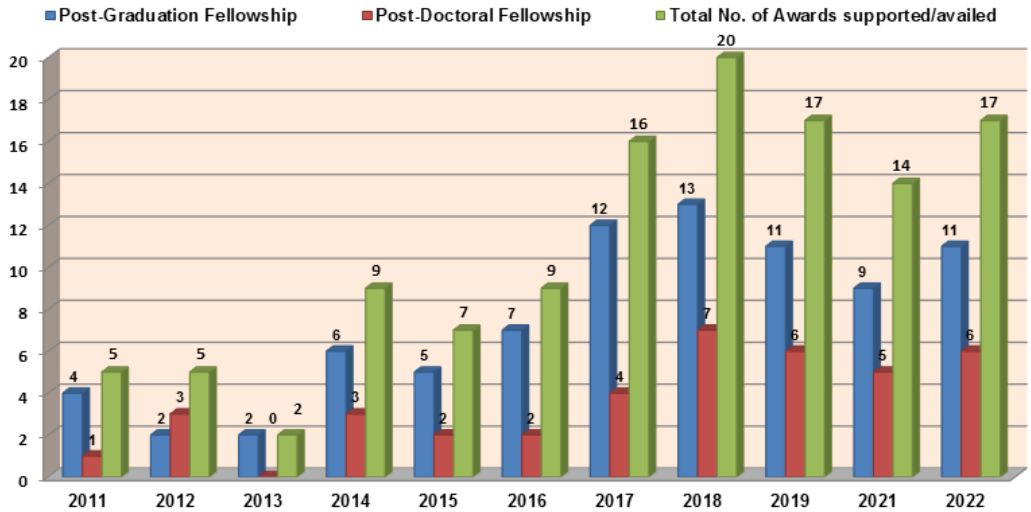

Figure 2.3: Year wise Fellows supported in DBT TWAS Fellowship Programme

TWAS Joint Call for 2023 in mid-December 2023 to receive applications and the selection process is underway.

(iv) DBT-Wellcome Trust Partnership/India Alliance (IA): Biomedical Research Career Programme (BRCP): The Biomedical Research Career Programme, also called the **DBT/WT India Alliance**, is a partnership between the Department of Biotechnology (DBT), Government of India and the Wellcome Trust (WT), UK. The founding principle of this programme was to establish a research ecosystem comparable to the best in the world in biomedical sciences, clinical and public health research and propel our researchers to leadership positions in Biomedical and Life Science Research. The programme awards Fellowships across career stages and interdisciplinary collaborative Grants, addressing public health challenges in the country. The DBT/WT India Alliance (India Alliance) funds research endeavours of the highest scientific and ethical quality for the development of resources and advancement of knowledge for maximum benefit. The funding portfolio reflects the shared vision of DBT and WT to nurturing excellence in basic and clinical research, and establishing an enabling research ecosystem in India. India Alliance boosts research capacity through research fellowships, attracting scientists to establish competitive programmes in India and fostered research on key public health challenges through collaborative grants in clinical and public health, involving a minimum of three partnering institutions. India Alliance has actively worked to bring more diversity and inclusion into science and health, and support needed in research to drive action, translation, and policy change.

Key objectives include:

- Attracting globally competitive researchers in biomedical and clinical sciences, to establish research programmes in institutions and universities in India and support professional aspirations for a fulfilling research career.
- Fund research of international standard by various programmes that support independence and career progression of outstanding early career researchers in India.
- Support open, equitable and ethical research environments through programmes creating awareness and training in allied careers in Research Management, Science Administration, Regulatory Processes etc.

- Expanding the footprint of India Alliance activities to new locations in the country and under-served research communities.

Brief of Major initiatives taken

- Calls for proposals were made for the following programmes and applications processed via peer review and shortlisting for interview

Jan 2023 to Mar 2024	Applications received	Shortlisted for Interview	Selected for Award
Research Fellowship: Early Career	83	19	10
Research Fellowship: Intermediate Call 1	49	13	7
Research Fellowship: Intermediate Call 2	62	18	12
Research Fellowship: Senior Call 1	21	7	4
Research Fellowship: Senior Call 2	23	4	3
Clinical & Public Health Fellowships	60	16	6
Team Science Grants (Collaborative) [2 calls]	87	13	8
Clinical Research Centre Grants (Collab.) [2 calls]	35	11	5
Research Management Grants (awarded to the Institute) [2 calls]	20	NA	10
Research Management Fellowships [2 calls]	14	NA	7

- Selection Committee meetings were convened in February 2023, July 2023, December 2023 and February 2024.
- The India Alliance Annual Conclave was held from July 13-15, 2023 in Hyderabad. The conclave included scientific talks by Awardees and invited speakers.
- Reviews to monitor progress of relevant awardees (In year 2-2.5 and year 4-4.5), by committee members and external experts, was also undertaken during the Conclave.

Notable Outcomes and Achievements of the programme

A. **Recognition:** Several DBT/WT India Alliance Fellows have received national and international recognition.

Figure 2.4: Recognition of DBT Wellcome Trust India Alliance Fellows 2023

Societal impact of the Programme: India Alliance funding acts as a catalyst, channeling support towards evolving societal and scientific priorities as guided by expert committees. This "dynamic funnel" approach ensures that resources can pivot towards the most pressing needs. India Alliance supports projects that study under-served communities, tribal groups, vulnerable mothers and children, the aging population, and those facing accessibility issues in rural and urban areas. Several projects related to mental health include, self-harm management, promoting psychological well-being among marginalized groups or exploring the potential of yoga for opioid use disorder. National health priorities such as diabetes, respiratory diseases, and antibiotic-resistant infections are also supported by India Alliance. Together, these contribute to a balanced funding portfolio that recognizes the importance of both basic and applied research, laying a foundation for future breakthroughs while addressing emerging societal needs.

(v) Partnership Programmes with EMBO, HFSPO

European Molecular Biology Organization (EMBO): The Government of the Republic of India became an associate member of EMBO by signing a Cooperation Agreement with EMBC in 2016. This cooperation has strengthened scientific interaction and collaborative research between Indian and European scientific community by creating opportunities for participation in all EMBO Programmes and activities. In 2023, EMBO has supported 4-Global Investigators, 1-Young Investigator, 2-Postdoctoral Fellowships, 13-Scientific Exchange Grants, 1-Core Facility Fellowships, 1-Workshops, 2-Lecture Courses, 676-Indian scientists have attended EMBO Courses & Workshops, 88-Travel stipends for scientists from India to attend EMBO Courses and Workshops, 4-Childcare grants for scientists from India to attend EMBO Courses and Workshops, 1-Young Investigator Lecture, 2-Global Lecture and 6-Laboratory Leadership Courses.

The International Human Frontier Science Programme Organization (HFSPO): HFSPO supports frontier research on the complex mechanisms of living organisms through its various programmes. The HFSPO provide opportunities for interdisciplinary inter-country high-risk, high-gain blue-sky research to understand complex biological interactions between organisms. In 2023, One HFSPO Research Grant and Six HFSPO Fellowships (5- Long-Term Fellowships and 1- Cross-Disciplinary Fellowship) were awarded to Indian scientific community.

Foldscope Programme: The Department, as part of its science outreach and societal development activities to popularize science among teachers and young students, has implemented the Foldscope 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 2023, the Department organized three hands-on training workshops on the use of Foldscope at Vidisha, Madhya Pradesh; Mahasamund, Chhattisgarh; and Dhenkanal, Odisha, wherein 1080 school students and 164 school teachers from 26 Aspirational Districts of Madhya Pradesh; Chhattisgarh and Odisha were trained on use of foldscope as an educational tool for their science-related projects. The students were also encouraged to make curriculum-based projects using Foldscope in biodiversity, ecology, botany, zoology and explore the world of microorganisms.

(E) Training Programmes:

(i) Skill Vigyan State Science and Technology Partnership Programme in Life Science and Biotechnology (Skill Development Programme): The Department of Biotechnology's Skill Vigyan Programme, launched in 2017-18, aims to provide hands-on training in biotechnology and related fields to create a skilled workforce. The programme provides skill training under student training, technician training, faculty training, entrepreneurship training, and biotechnology finishing school programmes. The programme has been implemented in 12 states viz., Arunachal Pradesh, Himachal Pradesh, Meghalaya, Odisha, Punjab, Uttarakhand, Karnataka, Telangana, Andhra Pradesh, Gujarat, Chandigarh and Kerala through State Science and Technology Councils of respective states. During the current financial year, the programme has been implemented in 3 more states Gujarat, Chandigarh and Kerala through State Science and Technology Councils of respective states. In Kerala, the programme collaborates with 15 academic and research institutions, registering 134 students and 140 technicians for training. In Gujarat, the programme is benig managed by the Gujarat State Biotechnology Mission. The state has partnered with six institutions, involving 20 faculty members and 90 students. In the Union Teritory of Chandigarh, the programme is executed by the Department of Science, Technology & Renewable Energy, focusing on student and technician training with 125 students and 19 technicians enrolled. The Andhra Pradesh Medtech Zone coordinates the programme in Andhra Pradesh, training 60 students and 111 faculty members, while Karnataka's programme, run by the Karnataka State Council for Science and Technology, has benefited 89 faculty members and 63 entrepreneurs. The Telangana's programme, is being coordinate by the Telangana State Council of Science & Technology, focuses on quality assurance and control training, with comprehensive faculty training and an active entrepreneurship development component.

(ii) Biotech Industrial Training Programme (BITP): With the aim to provide industry-specific training to Biotech students for skill development and enhancing their job opportunities in biotech industry. The Department of Biotechnology initiated Biotech Industrial Training Programme (BITP) in 1993-94, to facilitate practical industrial training for M.Sc./M.Tech./B.E. /B.Tech/MBA Biotechnology students. Through this programme, the Department has envisioned to facilitate both students and industries in order to build and nurture future skilled workforce in the area of Biotechnology as well as to close the knowledge gap between the academic course and the real world of work. This programme gives students a first-hand experience of working in an industrial setting, as well as an opportunity to evaluate their future employers. This programme is designed for Biotechnology students who have completed their education and aspire to join the industry by providing an opportunity to gain practical training/ skills set and experience by working on projects alongside industry experts. Simultaneously, the programme also serves as a platform for the industry to identify potential candidates who meet their human resource requirements.

The Department has adopted Apprenticeship model for the implementation of DBT-BITP Programme, and linkages have been developed with Life Science Sector Skill Development Council (LSSSDC), New Delhi and Food Industry Capacity & Skill Initiative (FICSI) Council for selection of partnering industries for providing apprenticeships in Biotechnology sectors. The Department has advertised a Call for Applications from candidates and requisitions from industries for the "DBT - Biotech Industrial Training Programme (BITP) 2023-24." The BITP exam for the 2023-24 session was conducted nationwide on January 21, 2024, at 36 centres in the country. A total of 1131 candidates registered for the exam

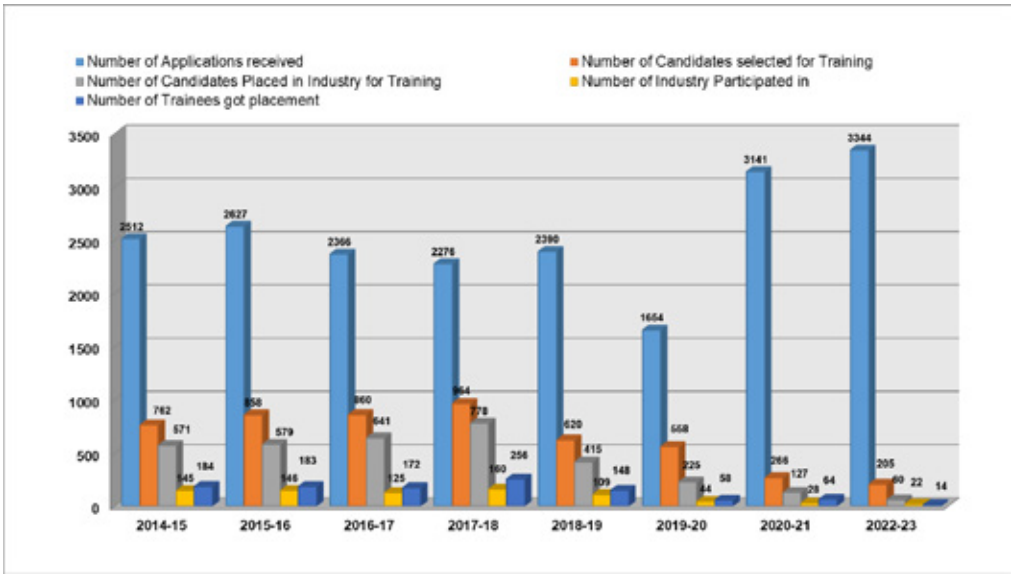

Figure 2.5: Industrial Training and placement of candidates under BITP

out of which 909 candidates appeared in exam and 209 have qualified. A total of 400 requisitions were received from 36 companies, with 185 training slots finalized. Industrial Training and placement of candidates under this programme since 2014 depicted in figure below.

(F) Research Resource Service Facility and Platform (RRSFP)

One of the major objective of the Department of Biotechnology (DBT) is to establish Infrastructure Facilities to support R&D in the country. The Department has been 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 programme has evolved considerably during the past five year and has gone multiple changes in nomenclature and realignment of objectives. Currently the Programme is known as Research Resource, Service Facility and Platform (abbreviated as RRSFP) Programme, which in turn operates through 2 major arms:

DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research Programme (DBT-BUILDER): BUILDER programme focuses to upgrade the post-graduate teaching and training laboratories by enabling interdisciplinary advanced research and teaching capacity emphasizing discovery and innovation in proposed research areas, addressing emerging technologies with inter-disciplinary cross talk.

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 the Deaptment. Through the SAHAJ portal, potential users/individuals can obtain information and access to these facilities through a single window.

Major achievements:

1. "DBT-BUILDER-Lady Brabourne College Interdisciplinary Life Science Programme for Advance Research and Education (Level I)" at Lady Brabourne College, Kolkata; Several hands-

on-training programmes have been organized on a regular basis for the M.Sc. students as well as for the Junior Research Fellows. Seminars have been organized for the students to interact with renowned personalities in the field of biosciences and motivate them towards higher learning and for pursuing research work in their near future. For identifying indicators of climate change and pollution effect', the departments of Botany, Zoology and Microbiology collected samples during the pre-monsoon, monsoon and post-monsoon season from six stations namely Canning, Gadkhali, Satjelia, Kumirmari, Dobanki, and Frasergunj with different salinity regimes. Soil and water analysis has been done from these areas. Biological specimens including phytoplankton, Zooplankton, soil and salinity tolerant angiosperms, microbes, fish and others have been collected, identified and their density measured. Ethnomedicinal, timber yielding and other economically important plants have also been identified and their anatomical studies done. Microbial strains capable of Phosphate solubilization and nitrogen fixation under drastic conditions like high salinity, those producing novel bioactive compounds, antimicrobials and various enzymes of industrial, agricultural, medical and environmental importance, and those degrading complex organic polymeric (plastic) compounds and complex organic dyes are being isolated, identified and characterized. Physico-chemical parameters such as temperature, salinity, pH, dissolved oxygen, total dissolved solids (TDS), and transparency, depth, nitrate, phosphate and silicate levels in the water column were recorded. Also, monsoon increases river flow due to which majority of phytoplankton got flushed out into the Bay of Bengal. Maximum abundance was observed during summer season followed by winter and least in monsoon. Pennate diatoms were predominant during Monsoon whereas Centrales during summer and winter. Preliminary screening and isolation of bioremedial cyanobacteria from marine saline water from Frazerganj and fresh water from Bidyadhari river in Dobanki in monsoon season show textile dye degradation, with the marine cyanobacteria showing higher bioremediation of textile dyes than the fresh water cyanobacteria isolated.

Similar qualitative preliminary screening for biofertilizers from soil has shown that high concentration of free-living nitrogen fixing and phosphate solubilising bacteria are present in soil samples from forest areas of Sunderban (eg. Sudhanyakhali) compared to areas without forestation like Edward Creek, Frazergunj. Potent cellulolytic bacterial strains have been isolated and will be purified for further studies. Preliminary screening of bacteria with antimicrobial activities has been done from soil sample of Kumirmari and Dobanki. The isolated bacteria show zones of inhibition when tested against a test microorganism like *E. coli*.

2. DBT-BUILDER-University of Siksha O Anusandhan Interdisciplinary Life Science Programme for Advance Research and Education" (Level II) at Siksha O Anusandhan University, Bhubaneswar, Odisha

The primary mandates of the DBT Builder project are to develop state-of-the-art laboratories in different corners of India, to ensure efficient conduct of scientific activities even in aspirational districts of India, to promote academic and industrial collaborations and to provide training and state-of-the-art facilities to the investigators in need to ensure a skilled workforce in upcoming future. They have developed SOA-DBT-Builder National Laboratory, funded by DBT in the School of Pharmaceutical Sciences, Siksha O Anusandhan University, Bhubaneswar, Odisha that is equipped with state-of-the-art equipment. These facilities were supported by the additional support provided

by the management of Siksha o Anusandhan University. The Institute has signed MOUs with various state and national-level institutions, and some of the work has been done in collaboration. Facilities are also open for the regular practical work and project work of most bachelors' and master's students of these institutes. To date, 105 students of B. Pharmacy have taken up to 7 days of training on these instruments, as and when required. Moreover, one of the industry partners, named "JEEVA ORGANIC Pvt. Ltd., Bhubaneswar, Odisha" is actively involved in utilizing three instrument facilities: HPLC fraction collector, Vertical freeze dryer, and particle size analysis to develop and optimise their investigational herbal products.

3. DBT-BUILDER - Birla Institute of Technology and Science Pilani, Pilani Campus Interdisciplinary Life Science Programme for Advanced Research and Education in Epigenetics and Genome editing" at Birla Institute of Technology and Science-Pilani, Pilani , identify the epigenetic pathways especially histone H4 acetylation and its associated HATs and HADCs which are responsible for hyperglycemia induced endothelial dysfunction during diabetic kidney disease. Epigenetic regulation of the LIM family protein- Ajuba and lncRNA Neat1 under chemotherapeutic stress, currently characterizing its downstream function. Exploring the therapeutic potential of epigenetics modulation for Brain Cancer and neurodegenerative disorders. Blood DNA/ RNA isolation from clinical isolates for gene amplifications and Real time PCR. PCR Primers Designed for Set 3 gene amplification, trials under progress. Real time primers also designed for other SET genes. All facilities arranged for the parasite culture (including blood and mixed gas facility); to start the culture from January 2024. Synthesized compounds to be tested in culture (For the same initially took the Human ethics approval and IBSC approval). Homology modelling of Pf SET3 domain of Histone Lysine Methyl Transferase (HKMT) protein and a comparative study with Alpha fold modelled structure. Active site prediction of the modelled protein. Synthesized N-(1-isopropylpiperidin-4-yl)-7-methoxy-2-phenyl-2,3-dihydro-1H-benzo[e][1,4]diazepin-5-amine. Synthesis of new series of compounds N-(1-isopropylpiperidin-4-yl)-6,7-dimethoxy-2-phenyl-2,3-dihydro-1H-benzo[e][1,4]diazepin-5-amine (completed up to pre-final compound). High throughput virtual screening (HTVS) protocol was validated and used for screening of the ZINC database (164203 molecules) and in-house chemical library (450 molecules) that led to the identification of 5 HITs (3 from the ZINC database and 2 from the in-house chemical library) for SET7 inhibition. The Molecular mechanics with generalized Born and surface area solvation (MM-GBSA) and Molecular dynamics (MD) study of HITs have been performed and validated to confirm Protein-ligand (PL) complex stability and desirable crucial PL interactions to impart selectivity amongst isoforms. Synthetic scheme has been designed, developed and optimized for HITS and analogues. Synthesis and characterization of 5 analogues has been completed and Purification of other analogues is in progress. Optimization of the polymer modification process for kidney-targeted nano-particles formation

4. "DBT-BUILDER, Sambalpur University Interdisciplinary Life Science Programme for Advance Research and Education (Level II)" at Sambalpur University, Burla, Odisha, a polyherbal formulation has been developed with 6 selected medicinal plants of Gandhamardan for the treatment and management of lymphatic filariasis. The polyherbal formulation has been evaluated in the in vitro model on microfilaria and adult worms. The formulation was found to be effective in both stages of the worms. The lead molecules have been identified. Production of elite chemo types of preferred endangered

medicinal plants for conservation into their natural habitat. The University has also setup an analytical instrumentation facility equipped with sophisticated analytical instruments (LC-MSMS, Analytical HPLC with multiple detectors, Microwave extraction of flavors/fragrance/pesticide compounds) to carry out quantitative and qualitative analysis and characterization and also accessed the prevalence of CKD (Chronic Kidney Disease) in Bargarh district, through random-cluster sampling. Sixteen Hot-Spot villages having 2% higher prevalence of CKD than the average national burden were identified in the district. Eight known nephrotoxic pesticides were identified which are in heavy use in these region. The leaching of pesticides from agricultural land to ground water and into the crops (i.e. rice grain and vegetables), were now assumed to be a major culprit for such higher incidence of CKD in these area.

Major Facilities Established

1. Viral Bio-assay Facility (VBaF) for Recombinant Monoclonal Antibody Generation and Pseudovirion-based Service for Vaccine Response and Therapeutics Evaluation, at Institute of Advance Virology, Thiruvananthapuram

Studying and handling pathogenic viruses needs highly trained personnel in BSL-3/4 facilities, which are not widely available to the majority of the worldwide R&D community. To avoid the higher biosafety requirement, the production of non-pathogenic, replication-defective pseudotyped viruses is a proven and practical alternative method for studying many aspects of viral biology in a low confinement biosafety level (BSL)-1/2 facilities. The development of these assays helps to minimize the biosafety requirement.

Using this Holder technology platform, validated assay systems have been successfully developed for Nipah, Rabies, and chikungunya viruses. In the future, this technology could be utilized to create high throughput screening assays for highly infectious emerging and re-emerging viruses in less than two weeks.

In their research, a high-yield mammalian protein expression and purification system for viral proteins was established by the team. This platform enabled the development of various viral antigens, including Nipah F & G glycoproteins, KFD envelope protein, monomeric and stabilized dimeric env proteins of Zika virus, Rabies env proteins, and antigens from SARS-CoV-2 such as the receptor-binding domain (RBD) and spike proteins.

2. Single-Molecule and Super-Resolution Imaging Facility, at IIT Hyderabad

Cellular processes such as replication, transcription, translation, DNA repair etc. are highly dynamic in nature and they involve several DNA-protein or protein-protein, or RNA-protein interactions in the range of seconds (high koff). Decades of research using traditional biochemical/ cell biological approaches (such as chromatin immunoprecipitation (ChIP), immuno-fluorescence, western blot analysis, mass-spectrometry etc.) has provided population-based average (ensemble average) estimations about the dynamics of biomolecules in live cells. Several microscopic methods (such as Fluorescence Recovery after Photobleaching (FRAP), and Fluorescence Correlation Spectroscopy (FCS)) have been used for estimating such fast dynamics of the bio-molecules. However, all these methods provided population-based average estimations about the biophysical properties of the biomolecules. Hence, to capture

such fast dynamics of biomolecules, a method that offers high spatiotemporal resolution is required. Recent advancements in single-molecule imaging approaches now offer this capability to capture the fast dynamics of biomolecules (DNA/RNA/protein/fatty acids) at the single-molecule level in live cells or in vitro systems (Podh et al. 2021). Additionally, recording the positions of the fluorescent dye using its stochastic blinking behaviour unveils the biological structural details at unprecedented resolution. In this project, the coordinator aims to establish a Single-Molecule Super-Resolution Imaging facility at IIT Hyderabad (IITH) that can offer various single-molecule and super-resolution imaging technologies (such as single-molecule FRET (smFRET), single-molecule mRNA FISH (smFISH), single-molecule localization microscopy (SMLM)/ Stochastic Optical Reconstruction Microscopy (STORM)/Photoactivated Localization Microscopy (PALM), live-cell single-molecule imaging, data analysis, and visualization) to the IITH fraternity as well as any other academic/research institutes/ industry in the country.

Some of the major achievements are as follows:

1. Establishment of Central Molecular Lab In GIPMER To Study The Diagnosis For Precision Medicine In Order To Understand The Disease Process And Utilize It As Clinical Research Facility at GB Pant Hospital, New Delhi

Researchers conducted exome sequencing on 103 tumor samples from 83 colorectal cancer (CRC) patients to explore the differences and similarities among various CRC types: Conventional adenocarcinoma (both microsatellite stable (MSS) and microsatellite instability (MSI)), mucinous adenocarcinoma (MAC), and signet-ring cell carcinoma (SRCC). The goal was to understand their malignant behavior and identify genetic variations that could help in creating personalized treatments. They found that the UBR5 and LRP1B genes were frequently mutated across all CRC types. However, common CRC gene mutations like TP53, APC, and PIK3CA were rare or absent in MAC and SRCC subtypes. Both MAC and SRCC showed similarities to MSI conventional tumors, but SRCC's clinical behavior was more like MSS-CoAD, potentially explaining SRCC's poor prognosis.

Additionally, the study began identifying why some CRC patients do not respond to chemotherapy by analyzing genetic data from samples taken before and after treatment. Changes in these samples pointed to alterations in Notch receptors and their downstream targets as key factors in CRC development. Among Indian CRC patients, a higher prevalence of the CC genotype in Notch1 and AA genotype in Notch3 was found compared to healthy individuals. Specifically, the Notch3 G>A (rs1043994) polymorphism was linked to advanced disease stages, suggesting the A allele increases CRC progression risk. Increased expression of the Notch gene family, particularly NOTCH3, was associated with CRC progression.

2. Advanced Mass Spectrometry facility at DBT-ILS, Bhubaneswar

The Advance Mass Spectrometry (MS) Facility includes two major mass spectrometers. i) Orbitrap Fusion Lumos Mass Spectrometer which is basically Orbitrap based High-Resolution Mass Spectrometer (HRMS) suitable for various discovery mass spectrometry applications such as Global & Quantitative Proteomics, Metabolomics, Posttranslational modifications (PTMs) identification, etc. ii) TSQ Quantis plus Triple Quadrupole Mass Spectrometer, which is LC-MS/MS with Triple Quadrupole technology suitable for targeted mass spectrometry applications and

validation of peptides and small molecules. Overall, this facility is capable of all major discoveries and targeted mass spectrometry applications such as proteomics, metabolomics, glycomics, and lipidomics.

Figure 2.6: National workshop-cum-CME Recent Advances in Cancer Research: Diagnostics to Therapeutics.

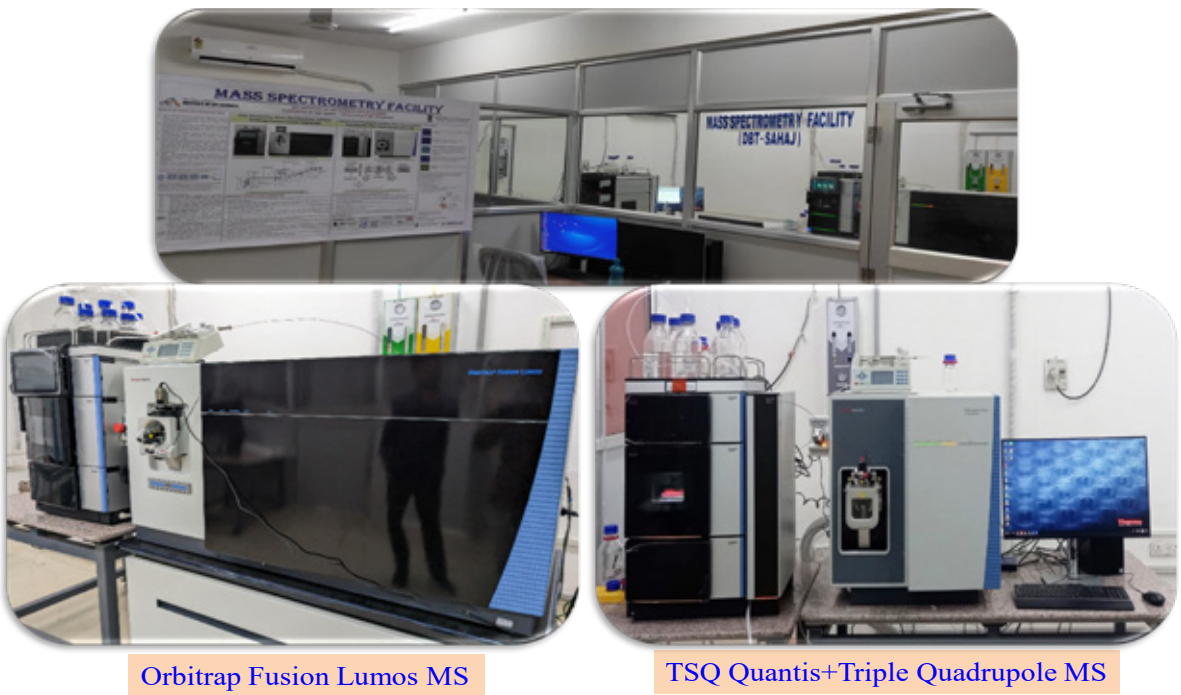

Figure 2.7: Advanced Mass-spectrometry facility.

3. Facility for micro-architectural and histomorphometric assessment of bone in osteoporosis and metabolic bone diseases (MBD) at SGPGIMS, Lucknow

The Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS) in Lucknow offers advanced facilities to assess bone health, particularly for conditions like osteoporosis and metabolic bone diseases (MBD). Osteoporosis is a condition where bones become weak and brittle due to loss of bone mass and structure, making them more prone to fractures. Traditional methods like bone densitometry, which measures bone mineral density (BMD), often don't capture the full picture of bone health. There's a need for better ways to study bone structure in clinical settings. This can be done using high-resolution peripheral computerized tomography (HRpQCT), trabecular bone score (TBS), and dynamic bone histomorphometry.

SGPGIMS has screened 600 postmenopausal women over 50 years old, with 300 undergoing detailed evaluations, including blood tests, calcium levels, bone turnover markers, and vitamin D status. BMD measurement, HRpQCT, and TBS were performed in 369, 140, and 90 women, respectively. Bone histomorphometry procedures are being perfected.

The average age of the women was about 58 years, with menopause occurring around age 46. They had an average weight of 63.5 kg and a BMI of 27.5 kg/m^2. Among these women, 29% had type 2 diabetes and 13% had hypothyroidism. About 10% had a history of fractures due to fragile bones. Out of the 300 women, only 34.45% had normal bone density, while 39.53% were classified as having low bone mass (osteopenia), and 26.02% had osteoporosis according to WHO standards.

4. DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research (DBT-BUILDER) (Level I) at Pachhunga University College, Mizoram

The bioactive compounds of ginger, *Zingiber officinale Roscoe*, were investigated for their potential antiallergic or anti-inflammatory properties. These compounds, including ß-bisabolene, α-curcumene, 6-dehydrogingerdione, α-lamesene, gingerol, gingerenone-A, β-sesquiphellandrene, zingerone, and zingiberene, were subjected to molecular docking against anti-inflammatory receptors, namely cysteinyl leukotriene receptor 1 (CysLT1, PDB code: 6RZ5) and histamine H1 receptor (H1R, PDB code: 3RZE), using the AutoDockVina platform. The molecular interactions were compared with known agonists and antagonists of these receptors, including cetirizine, histamine, montelukast, and paradol. The results indicated that the ginger compounds exhibited high binding affinity for both CysLT1 and H1R, comparable to that of conventional antiallergic medications. Notably, gingerenone-A (-7.3 kcal/mol) and zingiberol (-7.2 kcal/mol) demonstrated the highest binding affinities for CysLT1, while gingerenone-A (-8.7 kcal/mol) and α-curcumene (-8.0 kcal/mol) showed the highest affinities for H1R.

(G) DBT Outreach Programme

Conference, Travel, Exhibition and Popular Lectures (CTEP): To popularize Biotechnology activities in India, Department of Biotechnology (DBT), Government of India provides financial assistance towards

A. Organizing national and international Conference/ Symposium/ Workshop within India
B. Travel support to the researchers for presenting their papers in the international conferences which are being organised outside the country.
C. Organising DBT stalls in Exhibitions held within the country as well as outside the country.

D. For organising Popular Lectures.

The collective term for these four activities is CTEP (Conference, Travel, Exhibition and Popular Lectures). A web portal i.e., Online Submission and Monitoring System (OSMoSys) act as a single window for the submission, processing and settlement of grants. 488 proposals have been received under the four categories during January 2023 - March 2024. 279 proposals have been recommended by the DBT-CTEP Committee based on the novelty and new innovation/research. The percentage of recommended proposals is around 57%.

Global Bio India 2023 – The theme of the event was "***Transforming Lives: Biosciences to Bioeconomy*."** The event was organized from 4-6 December 2023, at Bharat Manadapam, Pragati Maidan, New Delhi. Global Bio-India 2023 showcased India's Biotech growth and opportunities to the world. The Department and it's Public Sector Undertaking, Biotechnology Industry Research Assistance Council (BIRAC) have organized Global Bio-India 2023, a mega international congregation of biotechnology stakeholders, including international bodies, regulatory bodies, Central and State Ministries, SMEs, large industries, bioclusters, research institutes, investors, and the startup ecosystem.

India International Science Festival 2023 - The India International Science Festival (IISF) 2023 has been organized from 17-20th January 2024. The Department of Science and Technology (DST), Govt. of India organized the 9th edition of IISF and its autonomous organization National Innovation Foundation-India is the coordination and implementation body of IISF 2023. The Department of Biotechnology (DBT) institute "Translational Health Science and Technology Institute" (THSTI) located in Faridabad, Haryana was the host institute of the event. The aim of the festival is to celebrate the achievements of India in the frontier areas of science and technology. The festival also aims to acknowledge the achievements of science enthusiasts and inculcate scientific temper among young students and spread the same among the Indian citizens. The central theme of IISF 2023 was "Science and Technology Public Outreach in AmritKaal".

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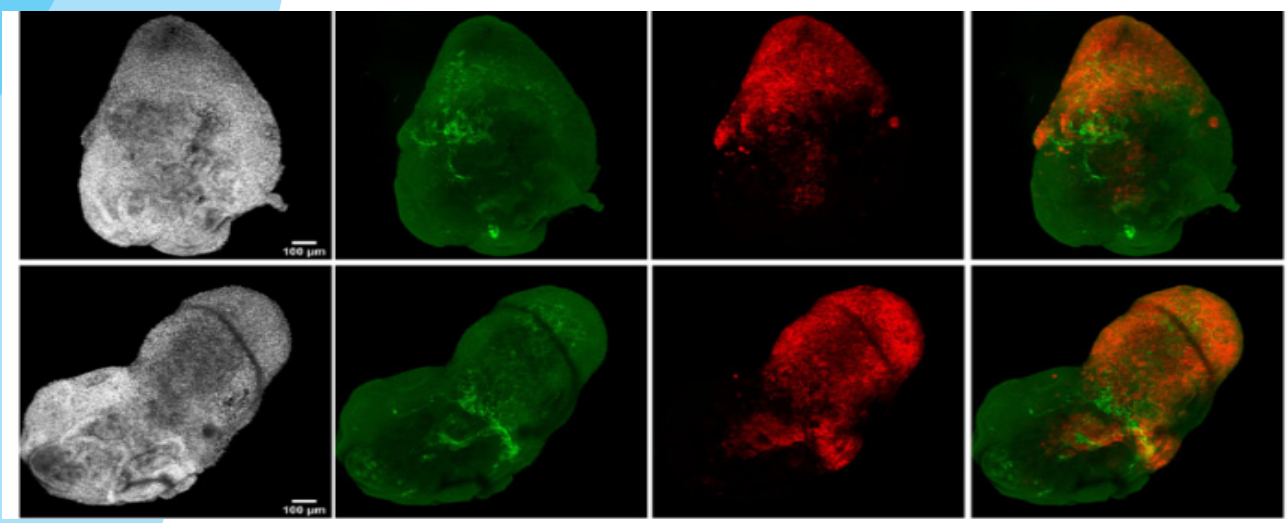

3. RESEARCH AND DEVELOPMENT

3 RESEARCH AND DEVELOPMENT

3.A. AGRICULTURE BIOTECHNOLOGY AND ALLIED AREAS

The Department supports R&D programs and projects in both basic research for understanding complex biological problems as well as translational research for the development of improved crop varieties / livestock / fish brood-stock in terms of yield, better adaptability to abiotic/ biotic stresses and improved nutritional parameters. The Department has created a vibrant ecosystem across the country involving Universities / State Agriculture Universities and National Institutions for the growth of Agriculture sector. Through these concerted efforts, improved crop varieties, therapeutics, vaccines and diagnostics for livestock developed for the benefit of the society. Various improved crop varieties, improved technologies, vaccines and diagnostics have been developed. Achievements through biotechnology interventions for improved crops, livestock and fisheries are detailed below.

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 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	5
Number of Process/Product/Technology Developed/ Transferred to Stakeholders	19
No. of Research Publications	51
No. of Human Resources Trained	268

Major initiatives taken during the year:

The DBT has supported the establishment of "AccelBreed", a speed breeding facility at Punjab Agricultural University (PAU), Ludhiana. AccelBreed spans over 540 square metres and houses eight controlled chambers, which can cultivate over 40,000 wheat or rice plantlets in optimal conditions. AccelBreed works by accelerating crop generation cycles to achieve five to eight generations of crops annually. This is expected to expedite breeding programs by achieving substantial genetic advancements swiftly for several crops, including cereals, pulses, and even fruits such as citrus.

The ongoing major mission mode programme on "Characterization of Genetic Resources" in various crops is aimed at sequencing and phenotypic characterization of available germplasm resources (more than 69000 accessions) of Oilseeds (Sesame, Linseed, Safflower, Niger), Cereals (Rice and Wheat) and Pulses (Chickpea) in the country along with exotic lines from diverse agro climatic regions & elite lines of International Institutes. The

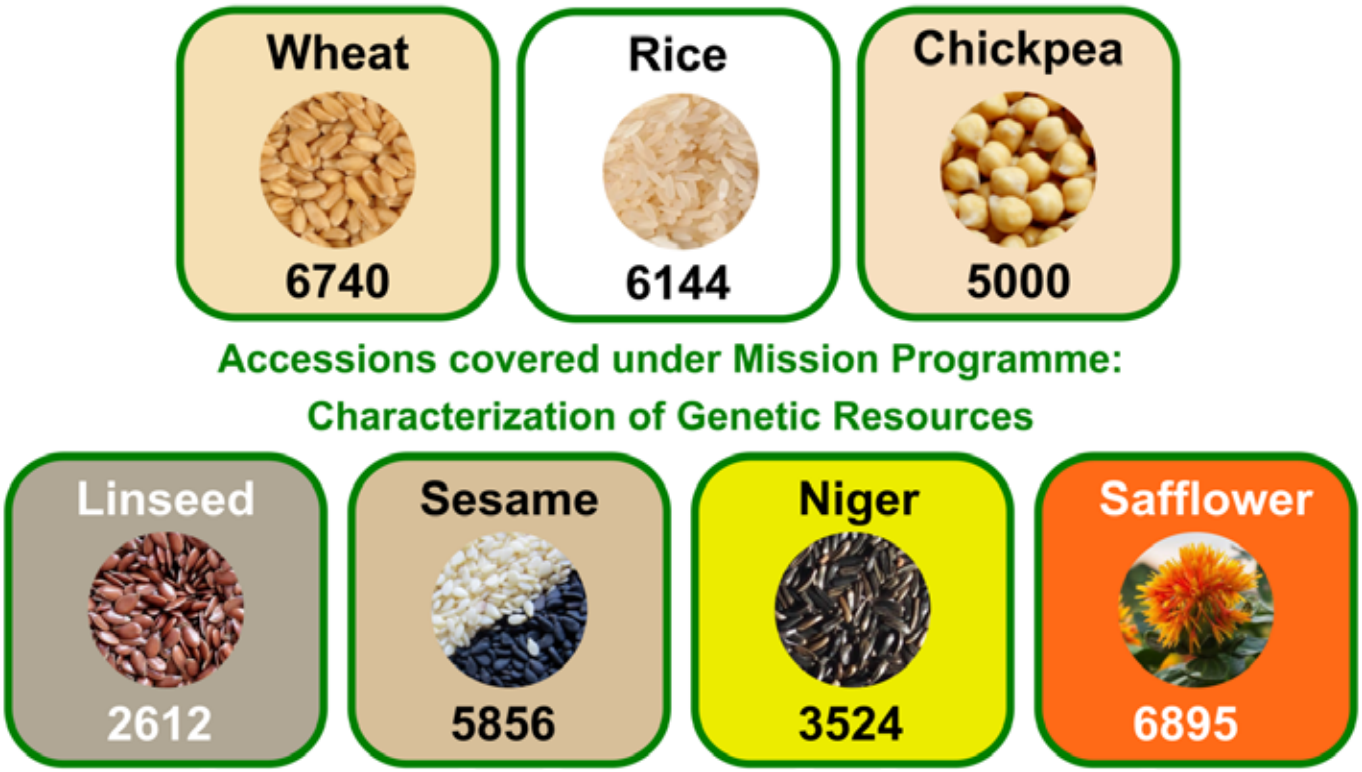

Figure 3.A.1: *Value addition through genomic and phenotypic characterization for thousands of available germplasm accessions for major crops and minor oilseeds.*

projects are providing information on new genes to modulate yield quality and combat biotic & abiotic stresses (Figure 3.A.1).

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

Five Climate-Resilient Rice Varieties has been developed under the network project "From QTL to Variety: Marker-assisted Breeding of Abiotic Stress Tolerant Rice Varieties with Major QTLs for Drought, Submergence and Salt tolerance".

Variety	Trait
KKL (R2)	ADT 46-qSUB11 (Submergence)
TTB Dhan 40 (Dholi)	Ranjit-qSUB1 medium (Submergence)
MTU 1232	MTU 1075-Sub1 (Submergence)
TTB Dhan 42 (Patkai)	Ranjit-qSUB1-xa5-xa13-xa21 medium (Submergence, BLB)
KKL (R3)	ADT 46-qSUB11 (Salt tolerance)

DBT has supported the development of the Amaranth Genomic Resource Database, an integrated database resource of Amaranth genes and genomics. Near Infrared Spectroscopy (NIRS) techniques have been developed for rapid screening of oil, protein, fatty acids, and essential amino acids in amaranth grain. Further, a genome-wide 64K SNP chip for Grain Amaranth has been developed and a patent applied for the same. Differently processed amaranth grains (roasted, boiled and unprocessed grains) could counteract high fat diet induced obesity through modulation of the gut bacteria and decreasing the adiposity indices.

Safflower wilt caused by *Fusarium oxysporum*, is a major concern in safflower growing areas. A DBT supported study has discovered a new pathogen, *Fusarium proliferatum*, causing safflower wilt in the fields of Karnataka and Maharashtra.

Little seed canary grass (*Phalaris minor* Retz.) is a pernicious weed of wheat crop causing enormous yield losses. Lead molecules have been discovered for development of weedicides against *P. minor*. A patent has been applied for an efficient process of preparation of morpholino-1,3,5-triazine derivatives with a potential for herbicidal activity.

A time-resolved fluorescence-detected multi-dimensional electronic spectroscopy (fMES) spectrometer with a visible white light continuum, and a rapid scan white light MES spectrometer suitable for micro-spectroscopy applications providing throughput and sensitivity better than the state-of-the-art, have been developed and demonstrated for elucidating initial steps of cyanobacterial photosynthesis (Figure 3.A.2).

Mission mode programme on "Characterization of Genetic Resources": This programme is aimed at sequencing/re-sequencing and phenotypic characterization of available germplasm resources of Oilseeds (Sesame, Linseed, Safflower, Niger), Cereals (Rice and Wheat) and Pulses (Chickpea) in the country along with exotic lines from diverse agro climatic regions & elite lines of International Institutes. The significant achievements of this programme are given below:

Rice: A total of 6144 accessions have been genotyped with 80K Rice Pan Genome Array (RPGA). More than 4200 rice accessions have been identified for 15 important biotic/abiotic stress traits, including disease resistance, drought tolerance, and nutrient use efficiency. To aid researchers in utilization of this valuable data, the "Rice Phenome Database", a portal for the digitization, management and data exchange of rice phenotypic data has been developed (http://www.genomeindia.du.ac.in/ricelandraces).

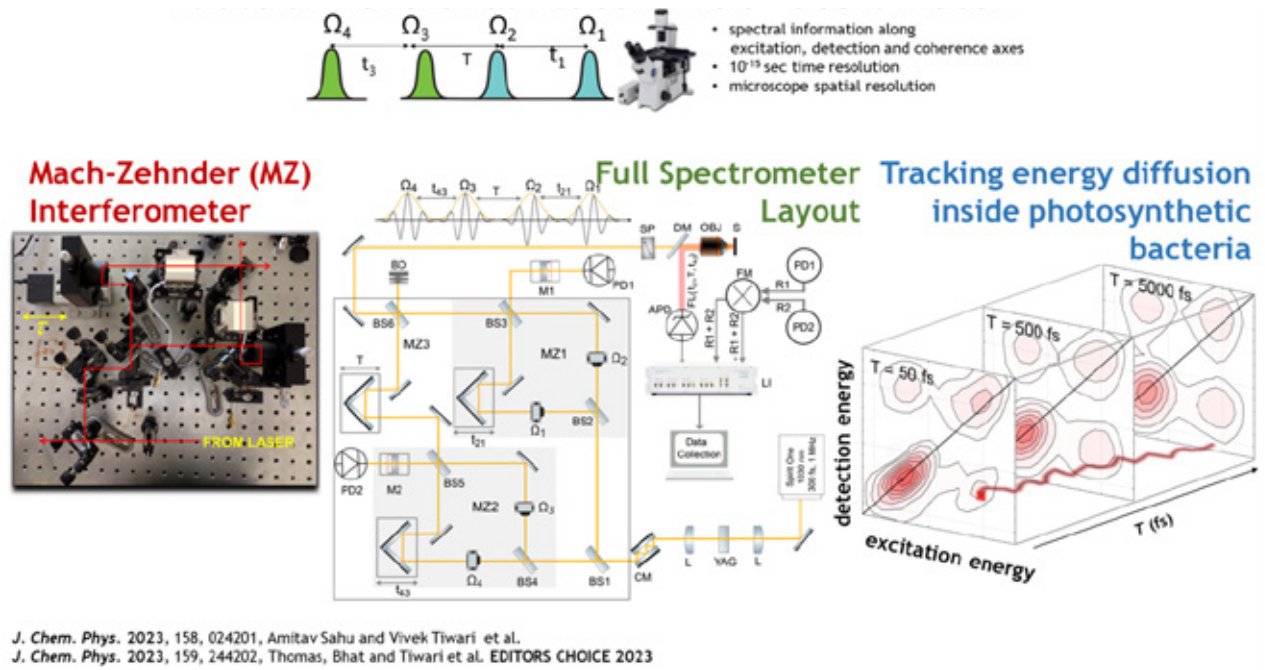

Figure 3.A.2: *Multidimensional electronic spectrometer developed for studying the initial steps of photosynthesis in cyanobacteria.*

Wheat: A total of 6740 accessions have been genotyped using 35K Axiom array for the identification of marker-trait associations (MTAs), including 6461 accession of bread wheat (*T. aestivum*), 173 accessions of Triticum dicoccum and 120 accessions of T. Sphaerococcum. This is the first time this has been done for more than 6000 accessions in the Indian wheat improvement program. De novo genome sequencing of Kharchia and a dwarf ancient India wheat sub-species Triticum sphaerococcum (IC0634028) have been done successfully. A high density 112 K array has been developed for facilitating rapid genotyping and breeding efforts.

Chickpea: Genotypic characterization of 5000 chickpea accessions using whole genome resequencing-based SNP genotyping has been completed. A set of 2500 trait-specific chickpea genotypes contrasting for biotic/abiotic stress tolerance traits and mechanical harvesting have been identified, and protocols and SOPs developed for large-scale phenotypic characterization of chickpea accessions and screening at field and controlled environment conditions. Comprehensive phenotypic characterization of almost 3000 Pan Genebank Core germplasm accessions for promising characteristics has helped to identify 195 accessions for five biotic stresses, and 102 accessions for four abiotic stresses. A total of 260 accessions with erect plant architecture types have been identified, out of which 45 are highly promising erect plant types with superior agronomic performance, amenable to mechanical harvesting.

Linseed: Multi-environment phenotyping of 2612 germplasm accessions has been completed for agronomic, biochemical (oil, protein, fatty acid profile, amino acid composition, SDG lignan content), biotic stresses (Alternaria blight, bud fly resistance), and abiotic stresses (drought, salt tolerance). For development of reference genome of dominant variety of linseed (T-397) telomere-to-telomere genome assembly has been completed with final assembly size of ~495 Mb with well scaffolded 15 chromosomes, 29 telomeres, and 15 centromeres. Re-sequencing of 464 accessions (258 core and 206 trait specific accessions) has been completed. Protocols for embryo rescue, plantlet regeneration and shoot multiplication in wide crosses with L. grandiflorum have been successfully developed and standardized. Wide crosses attempted with L. bienne accessions for agro-morphological traits (branches, capsules/ plant, bold capsules) and bud fly resistance are in F5 generation.

Sesame: A core set of 771 accessions has been developed and validated under field condition at 4 centres. Genetic variability in core set representing the entire germplasm collection was also validated using different statistical tools. For developing the mapping population, 16 traits were selected based on agro-morphological, quality, biotic, and abiotic stress tolerance. Genotyping-by-sequencing (GBS) analysis completed for 5856 accessions and a genomics-assisted coreset of 1193 accessions. A composite core set of 1455 accessions has been developed based on phenotypic and genotypic data. Five phyllody resistant accessions and 6 accessions moderately tolerant against dry root rot were identified. Additionally, five wild accessions highly resistant to dry root rot, and four resistant to phyllody were also identified. Promising sesame germplasm for high quality traits like oil content, protein content, oxidative stability and low phytic acid content were identified. Near-infra-red (NIR) based models for predicting oil and protein content in sesame have been developed. Identified 6 water logging tolerant germplasm accessions and 63 drought stress tolerant accessions. Two phytoplasma strains belonging to peanut witches' broom group associated with sesame phytoplasma were identified using 16S rRNA gene. 12 genes

were identified as key regulatory genes associated with oil content using transcriptome approaches. A Genomic Web Resource (SesameGWR) has been developed.

Niger: Multiplication of 3524 accessions was carried out, followed by multilocation evaluation at five centres over three seasons, for 18 agro-morphological traits including 13 quantitative and 6 qualitative traits and total oil content.

Safflower: Genotyping of entire collection of safflower germplasm (6895 accessions) conserved at ICAR-NBPGR, New Delhi was completed using ddRADseq with standardised enzyme combinations for safflower. A core set of 400 accessions was developed and phenotyped for yield, oil content, resistance to Fusarium wilt and Macrophomina dry root rot, tolerance to aphid and moisture stress. Accessions were identified for resistant to Fusarium wilt (47), Macrophomina dry root rot (3) and tolerance to moisture stress (12). 15 lines showed high yield potential (10-33% increase over check variety, ISF-764) and 20 lines showed high oil content (40-48%) under moisture stress condition. Reference genome of cultivated safflower species, *Carthamus tinctorius* was constructed with the final complete assembly of 1.09 Gb. Genome predictions revealed 65,289 genes; of which, ~70% were functionally annotated. Further, a safflower pan-genome was assembled consisting of an additional ~114.5Mb, bringing the total length of the pan-genome to 1.20 Gb. This additional sequence comprised of 72,939 contigs encompassing 10,215 new genes (~50% are functionally annotated) which brought the total number of genes to 74,425.

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

The program supports R&D to harness new and emerging biotechnology tools for an in-depth understanding of natural and cultivated plant systems, engineering novel biological pathways, and unique plant architectures to transform crop improvement. Besides basic R&D to glean an insight into the physiology and developmental biology of plants, the program aims to support ground-breaking research ideas in systems and synthetic biology to engineer smart plant types for enhanced productivity catering to agriculture and industry, addressing food & bio-security and reduced environmental footprint. The program focuses on utilizing New Breeding Technologies (NBTs) primarily Genetic Engineering/Genome Editing, speed breeding & genotyping/phenotyping platforms for understanding basic plant biology and crop improvement. The program's overarching aim is to contribute to the growing Bioeconomy, food & bio-security, and sustainable technologies to reduce the environmental footprint. Program area will contribute to delve deeper into the complexities of plant systems, leveraging cutting-edge scientific knowledge and tools, we aim to address global challenges and build a sustainable future for generations to come.

Quantitative and Qualitative indicators for Major achievements	
No. of Research Publications	22
No. of Patents Applied/Granted	04
No. of Human Resources Trained	75

Major initiatives taken and R&D efforts:

A call for proposals on **'Genome Editing of crops for enhanced attributes'** launched in February 2023 was processed and 25 high-quality Network proposals received on the closing date were peer-reviewed by the National (2) and International Experts (at least 1). A total of ~80 International and ~60 National experts were approached to seek peer comments on the full proposals. Based on peer comments and Technical Expert Committee

deliberations, the call for proposals finally secured positive recommendations for 11 high-quality proposals wherein 34 legal entities have at least one component of a Network proposal with a financial implication of ~35 crores.

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

Putative genome-edited plants have been generated using cv. Unnat PBW550, Fielder, and CPAN 1676 wheat varieties for enhanced tillering by targeting IPA1 and TB1 genes. A total of 257 lines were sown in at T1 stage, and 66 Cas9-positive plants were selected for genotypic screening. Transgene-free lines are being developed which will help in yield improvement of the target varieties.

Sweet11, bsr-d1 and pi21 SDN1 events have been generated in aerobic rice cultivar (KMP175) and a mega variety (MTU1010) and the selected T0 lines having mutations were advanced to BC0F1, BC0F2 and BC0F3 generations (Figure 3.A.3). The phenotypic and genotypic data generated from BC0F3 sweet11 rice lines have been submitted to the IBSC committee to review and to provide confirmation of the SDN1 genome-edited plants. Multiplex genome edited lines have also been developed and are being advanced to BCF3 generation.

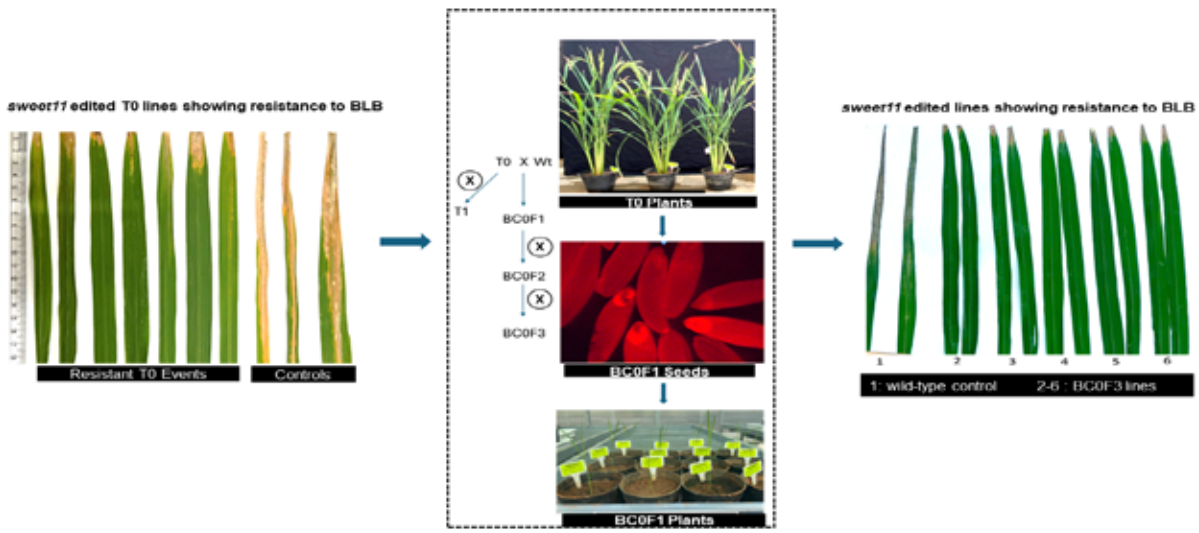

Figure 3.A.3: *Editing of sweet11 EBE region to develop Bacterial leaf blight (BLB) resistance in rice.*

A histone deacetylase, SiHDA9, was identified as a susceptibility factor for drought stress response in foxtail millet.SiHDA9 is significantly up-regulated in the sensitive foxtail milletcultivar; and interacts with SiHAT3.1 and SiHDA19 to form a repressor complex which is recruited onto the upstream of dehydration-responsive genes to decrease H3K9 acetylation levels**.** Silencing of SiHDA9 resulted in the up-regulation of crucial genes SiRAB18, SiRAP2.4, SiP5CS2, SiRD22, SiPIP1.4, and SiLHCB2.3, which imparts dehydration tolerance in the sensitive cultivar (IC41).

A standardized protocol has been developed to assemble multiple sgRNAs for potato SBEI and SBEII in a single construct using a polycistronic-tRNA-gRNA (PTG) system.Validation of the effectiveness of the designed gRNAs was done where the expression cassettes were synthesized within the pKO119 vector and checked through *in vitro* cleavage assays. The construct was efficiently introduced into potato callus through a precise nano-mediated incubation process, facilitating successful transformation and molecular characterization of these putative genome-edited plants.

Myrothecium verrucaria enzyme nanoformulation was developed for effective biocontrol of powdery mildew in tomato and grape in pot trials and field trials at 42 U that was on par with the chemical control. The enzyme nanoformulations showed comparable disease control to soluble enzymes after 3sprays and demonstrated its potential as an eco-friendly, stable, biocontrol preparation for powdery mildew control **(Figure 3.A.4).**

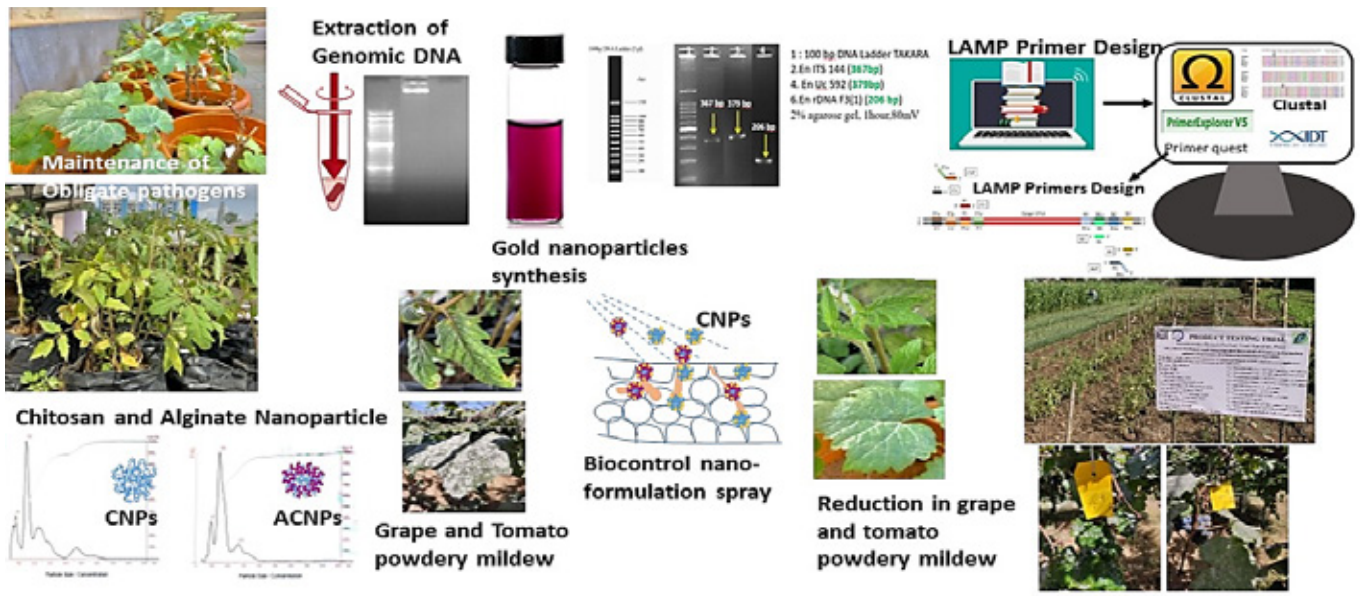

Figure 3.A.4: *Nano-mediated detection and biocontrol of Downy & Powdery Mildew on Tomato.*

The microfluidic channel has been fabricated for the encapsulation of the mycorrhizae individually with the helper bacteria in the continuous flow technology that is compatible with handling 100000 spores /10 hours in a single chip. A successful modification of alginate with arginine and its use for the encapsulation of the mycorrhizae and helper bacteria; shows successful surface charge modification for enhanced root binding and colonization. Further, the preliminary optimization of the seed treatment proves to improve the colonization significantly for yield improvement.

3.A.3. Livestock and Animal Biotechnology

The overall aim of the 'Livestock and Animal Biotechnology' program is sustainable growth of livestock, poultry and other animals for nutritional security and economic prosperity as well as to enhance production and productivity through biotechnological interventions. The program 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. The Department continued its support towards developing newer techniques/ technologies to enhance livestock production and productivity through supporting R&D projects in the areas of livestock Health, Reproduction, Genomics, Transgenesis, Nutrition, Veterinary

Vaccines, Veterinary Diagnostics and Therapeutics, Dairy and Dairy Products, Livestock By-products etc.

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	11
Number of Process/Product/ Technology Developed	09
Process/Product/Technology Transferred to User Agency/Industry/ Stakeholders:	08
No. of Research Publications	52
No. of Patents Applied	03
No. of Patents Granted	02
No. of Human Resources Trained	405

Major initiatives taken during the year:

Bovine sexed semen shorting technology: The Department has announced a Call for Proposal on "**Bovine Sexed Semen Sorting Technology (BSSST)"** and three consortia projects were recommended using different approaches viz Aptamer and protein targeted approaches for sex specific spermatozoa enrichment in Bovines; Integrated Magneto-Acousto-Dielectrophoresis based microfluidics for the sorting of Bovine spermatozoa; and redesigning of FACS instrument for sorting Bovine Spermatozoa.

Canine Research Centre and Networks (CRCN)-Phase-II: The department initiated the Phase-II of Canine Research Centre & Networks (CRCN), based on leads developed during Phase-1 with 12 centres. The major emphasis of phase-II is on the validation, licensing & commercialization of technologies /Products developed in phase-I (*viz.* Dog feed, implants & sutures, iELISA for rabies sero-monitoring, contraceptive vaccines etc.) and development of translational products/ technologies through collaborative efforts in R&D.

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

Translational Research Platform for Veterinary Biologicals (TRPVB): The Translational Research Platform for Veterinary Biologicals (TRPVB) is a partnership initiative between the Department of Biotechnology (DBT), GoI and TANUVAS, to facilitate a collaborative and coordinated approach for the translation of technologies in the area of veterinary vaccines and diagnostics. TRPVB has developed mRNA vaccine platform technology for Lumpy Skin Disease. The mRNA vaccine construct was successfully evaluated for its transcript stability, translation of the target LSDV antigen in Madin-Darby bovine kidney (MDBK) cells and the immune response in mouse model. The CRISPR/ Cas based rapid point of care Lateral Flow Assay platform was developed for dog parasites *Babesia gibsoni* and *Ehrlichia canis* with a limit of detection (LOD) of 100nM. Two patents (i) A tick-controlling formulation of dimethicone and the process thereof (Patent No: 429922) & (ii) A method for detecting RBC/ Platelet bound antibodies in canines and the kit there of (Patent No: 472138) were granted. TRPVB has commercialized 13 products (5 technologies were transferred to M/s Jeshron Biotech Solutions Pvt. Ltd, Chennai and 8 technologies by direct sales). TRPVB is maintaining the ISO/IEC 17025:2017 accreditation for testing two animal diseases, cGMP license for manufacturing of four drugs and received the MD-13 from CDSCO for two its diagnostic kits (TANUCHEK and Ketoquant kit).

One Health Program: The department has supported a multi-institutional project on 'One Health' encompassing 28 centres to understand the prevalence of ten major zoonotic diseases in animals and humans and five transboundary animal diseases. The consortium consists of specialists in the areas of medical, veterinary and wildlife infectious diseases, food safety, statistics

and epidemiology. The group has collected close to 8000 samples from domestic livestock (cattle, buffaloes, sheep, goats, pigs), > 3000 food-related samples (milk, milk products, meat etc.), and 649 wildlife samples. Around 25,000 tests have been performed on these samples, and preliminary analysis of testing revealed prevalence of brucellosis is low in most states and high in Goa state. Positivity for Q fever is low in most states and moderate to high in west central India, suggesting higher prevalence there. Low prevalence was observed for cryptosporidiosis in most of states and higher in the northwest region. Prevalence of LSD ranged from low to high, possibly reflecting the pervasiveness of the disease. Prevalence of swine influenza was widespread in the NER. Cysticercosis was identified in Nilgai and Indian grey langur as well as Calodium hepaticus, a zoonotic parasite, discovered in rats of Chennai. More than 5000 samples were collected from seven tertiary care centres in humans. Most of these samples have been tested, and the preliminary analysis revealed substantial proportion of acute febrile illness (AFI) which may be due to scrub typhus, followed by brucellosis and Q fever. Substantial proportion of acute encephalitis syndrome (AES) is due to JE (all of it in north and NE belt), followed by cysticercosis. This preliminary analysis requires further sampling and testing to infer nation-wide prevalence of the studied diseases.

Anthrax Diagnosis and Control in India: 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 to strengthen the competences for surveillance, outbreak investigation, laboratory capacity, vaccination, specific predictors of outbreak risk and risk mapping. A 'latex agglutination test for detection of *B. anthracis* spores in animal feed supplements and soil samples' and a 'portable UV aluminum cabinet for inactivation of *B. anthracis* spores in the soil' have been developed in this project. Whole genome sequencing and comparative analysis of 17 isolates from several animals (e.g., sheep, cattle, pigs, deer, goat, and contaminated soil sample) infected with *B. anthracis* has also be completed. Further, cryopreservation and molecular characterization of 23 isolates of *B. anthracis* obtained from different infected sites in India has also been done. Transgenic sorghum and rice plants have been successfully generated for the gene encoding for the domain IV of protective antigen and cholera toxin B subunit (Figure 3.A.5).

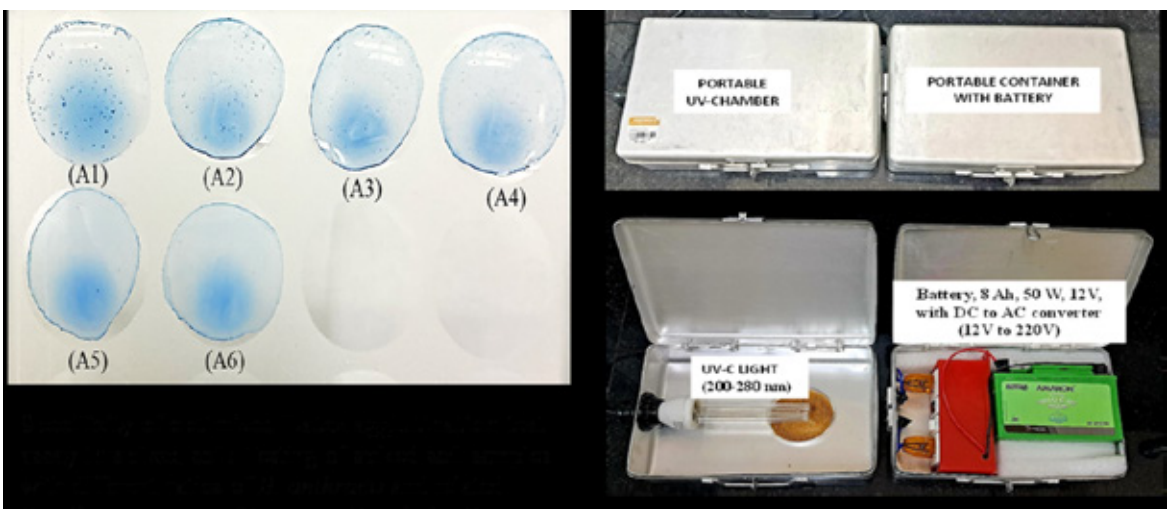

Figure 3.A.5- *Latex agglutination test assay in spiked soil and Portable UV Aluminum Cabinet for inactivation of B. anthracis spores in soil.*

Recessed Nanodisk-Array Electrodes for Electrochemical Detection of β-lactam Antibiotics: An electro-immunosensor has been developed to control and regulate the excessive use of antibiotics in animal-based food products. An amphiphilic block co-polymer poly(ethylene oxide-block-methyl methacrylate) (PEO-b-PMMA) was used to fabricate recessed nano-disk array electrode (RNE) and immobilized with Penicillin and Cefalexin antibodies. The Limit of detection (LOD) of RNE working electrode was found to be 14.8 pM for penicillin and 13.8 pM for cefalexin with good selectivity in presence of non-specific antibiotics. Fabricated RNE electrode could detect trace amounts of spiked antigen in real samples of milk, egg and meat extract. Further, mesoporous thin film and microarrays can eventually be used to develop point-of-care diagnosis of antibiotics in animal-based food products.

Nanostructured paper-kit comprising magnetic nanoparticle for rapid detection of subclinical and clinical mastitis: An early detection of mastitis at subclinical stage holds high prognostic value as starting the medication at an early stage leads to rapid cure of the condition. NIAB- Hyderabad has developed and validated a field level, affordable, farmer friendly quantitative method to diagnose intra-mammary infection as well as subclinical mastitis (Limit of visual detection: 25,000 cells/ml of milk). Further, a technology has also been developed to perform on-field anti-microbial sensitivity testing within 2 hours' time under field condition. Both the assays doesn't require any trained personnel for performing as well as interpreting the assay results and it can be performed at the door step and under field conditions. These technologies have been transferred to ACS Neoteric Technologies LLP Hyderabad for commercialization.

Therapeutic protein production in milk of farm animals to increase their affordability: A multidimensional approach was used to target the udder glands of farm animals to convert them into a bioreactor. A synthetic signal peptide (*CSN2-BLGHyb*) has been engineered and developed that is more efficient for secreting exogenous protein. A comparative analysis of rhBMP2 production by the conventionally used CHO cells and goat mammary epithelial cells (GMEC), upon transfection with hBMP2 expressing construct was carried out which showed that the synthesis and secretion of bioactive rhBMP2 by goat mammary epithelial cells was significantly higher as compared to that by CHO cells. The results provide strong evidence that GMECs may serve as a better alternative to other mammalian cells used for cost-effective bio-therapeutic protein production (Figure 3.A.6).

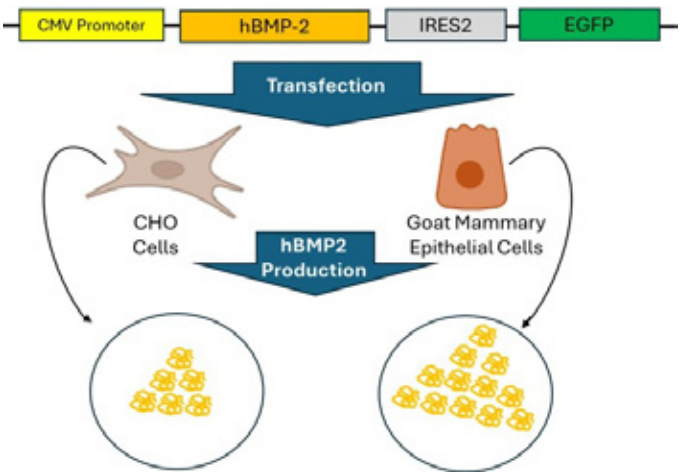

Figure 3.A.6: *Enhanced productivity of bio therapeutics using GMEC based production systems as compared to conventional CHO cells based systems.*

3.A.4 Aquaculture and Marine Biotechnology

The Aquaculture and Marine Biotechnology program has been implemented with the goal of enhancing both aquaculture production and productivity, while also harnessing marine resources for valuable products and processes. This program plays a vital role in the agricultural economy by ensuring food production for nutritional security. The Department has undertaken various initiatives to benefit the aquatic and marine sectors through this program.

These initiatives include the development of novel cell lines, improvement of aqua feed, creation of advanced diagnostics and therapeutics, research on fish genomics and transcriptomics, management of fish and shellfish diseases, exploration of marine ornamental resources, and engagement in bio-prospecting activities.

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

Polychaete worms are rich sources of nutrients such as PUFA, enzymes, and hormones which help in oocyte development and maturation of shrimps. Research supported by DBT at ICAR-CIBA Chennai has developed a simple small scale culture method for Mud worm Polychaete *Marphysa madrasi* and marine sand worm *Perinerisnuntia* spp. Forty adults of *M. madrasi*, when reared in 100L tanks, produced approx. 2016 juveniles in four months, with 90% survival. Around 500 juveniles were mass-reared in a 1000 L FRP tank by feeding with diatom, *Chaetoceroscalciferons* (10^6 CFU/ml) with a mixture of CIBA shrimp larvae feed which produced 400 adults with 80 % survival in 4 months (19± 0.3cm) with SGR under mass culture was 0.33. The net weight gain was 0.33 g for juveniles with biomass.

Perna viridis is considered an important species for aquaculture in India and is widely cultured along the southwestern coast, especially Kerala and Karnataka. The De Novo whole genome and transcriptome sequencing of the Asian green mussel, *Perna viridis* using advanced genomic methods was carried out at ICAR-CMFRI, Kochi. The final assembly resulted in a genome of 723.49 Mb in size with a scaffold N50 of 49.74 Mb. The BUSCO completeness of the assembly has been evaluated as 96.8%. Further, the expansion of inhibitors of apoptosis gene families and caspase gene families was observed indicating their tolerance to environmental challenges.

Disease of spawn and fry and their mortality are one of the major problems in the expansion of aquaculture. To address this problem, a project being implemented at ICAR-CIFA, Bhubaneswar with the support of DBT has led to the development of a vaccine named "CIFA-Brood-Vac" which can prevent diseases and mortality of spawns. This vaccine has been tested extensively in various hatcheries of Odisha and West Bengal confirming its efficacy in producing disease resistance spawns.

An effort was made to develop whole virus vaccines against cyprinid herpesvirus-2 (CyHV-2) and tilapia lake virus (TiLV) under the DBT-supported project being implemented at CAHC, Melvisharam/ICAR-CIFA, Bhubaneswar and KUFOS, Cochin. These viruses are responsible for mortality of goldfish and tilapia respectively. The researchers have produced whole virus vaccine against CyHV-2 and TiLV using susceptible fish cell lines. The vaccine trails are being carried out at ICAR-CIFA and KUFOS. TiLV whole virus vaccine is shown to be efficient in imparting tilapia protection against the virus (Figure 3.A.7).

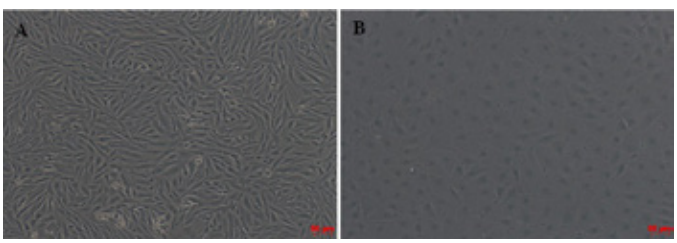

Figure 3.A.7: Susceptible fish cell lines for propagation of whole virus vaccine against TiLV and CyHV-2. A – Snakehead kidney cell line, B – Grouper brain cell line.

Fish meal is the important ingredient in shrimp feeds. Due to its high cost and sustainability issues, replacement of fish meal is an important area of research in aquaculture nutrition. Scientists working in this area at ICAR-Central Institute of Brackish water Aquaculture, Chennai have shown in their studies that yeast fermentation of soybean meal significantly improves inclusion level in shrimp diet by increasing the nutrient digestibility and growth.

The growth trial results indicated that soybean meal can be included up to 35% in the grow-out feed of *P. vannamei* and fermentation improved the growth by approx. 8.5% (Figure 3.A.8).

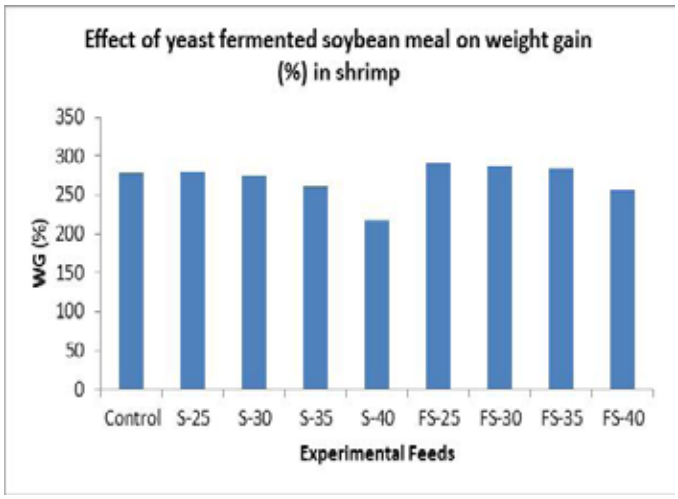

Figure 3.A.8: *Effect of yeast soyabean meal on weight gain (%) in shrimp.*

Fish waste has so far not been exploited for large-scale isolation of glycosaminoglycans (GAGs). Scientists at CSIR-CFTRI, Mysuru have developed a protocol for its isolation, which is novel, sustainable, economical, and eco-friendly green method. The isolated GAGs were characterized for structure and was found to be a mixture of chondroitin/dermatan sulfate (CS/DS) and heparansulfate in the ratio 80:20. The isolated GAGs were able to promote osteogenesis in MC3T3 cell and promote wound healing in HCAT cells. Studies on the mechanism of exogenous GAG-mediated osteogenesis is underway.

The availability and cost are the two major constraints in the formulation of fish feed. Furthermore, it is a challenge to replace fishmeal with non-conventional ingredients. Scientists at Univ. of Delhi, Dept of Zoology working on the evaluation of the effect of macrophytes-based feed have developed a user-friendly software, Interactive Fish Feed Designer (IFFD) version 2 for the formulation of cost-effective fish feed with non-conventional ingredients. Iso-nitrogenous and lipidic feeds are prepared with fresh water macrophytes *Lemna minor, Spirodelapolyrhizza*, and *Pistia stratiotes* using twin-screw extruder. The incorporation of freshwater macrophytes showed improvement in the growth and nutritional value of the cultured rohu without affecting the survival rate of fish.

In another study focused on live feed for aquaculture undertaken by researchers at AMET University, Chennai has identified a new approach using monoalgal diet and adopting selective breeding method for high density culture of *A. royi*and *P. serricaudatus* copepod species. Improved growth and survival of Asian seabass, *L. calcarifer* larvae and critical first feeding stage of silver pompano, *T. blochii* larvae was achieved with *A. royi* nauplii compared to the traditional rotifers live feed. Indigenous copepod live feed protocol has been developed for successful marine finfish larval seed production.

Monitoring variables such as dissolved oxygen, pH, tds and pond temperature is a key aspect of high-quality fish farming. An Intelligence forecasting approach is required to address the complexity of farmer's crop monitoring issues, scientists at Vel Tech Rangarajan R&D Institute of Science and Technology, Chennai have developed a hybrid intelligence mechanism for forecasting efficiently and handling a large amount of streaming data through Auto regressive long short-term memory integrated moving averages (ARLSTMIMA). The intelligent algorithm is embedded into Tiny ML an IoT device developed for getting real-time data. As a result of this procedure, the pond's water quality and environmental conditions can be continuously checked to guarantee a healthy prawn crop.

DBT funded National Repository of Fish cell lines established at C Abdul Hakeem College for conducting research on application of cell lines in

virological and biomedical research have reported development of novel cell lines from Asian seabass and *Osteobramabelangiri*. They have also isolated reported new viral pathogens (CyHV-3 and tilapia parvovirus) using cell lines for vaccine production. In addition to this, the center has sofar imparted fish cell culture training to 29 trainees and helped 11 PhD scholars for short term research using fish cell line.

Study supported on development of grow-out technology for mass culture of sand and muddy polychaete worms and assessment of their seasonal nutritional profiling for use in shell and fin fish hatcheries at ICAR- CIBA, Chennai have resulted in development of a simple small scale culture method for Mud worm Polychaete *Marphysa madrasi* and marien sand worm *Perineris nuntia* spp. The researchers have also identified a new mud worm *Marphysa madrasi* by using the Cytochrome c oxidase subunit I (COI) gene. The complete details have been registered in NCBI (Gene bank) https://www.ncbi.nlm.nih.gov/nuccore/ON068593.1. Furthermore, the bio-chemicals composition of the *M. madrasi* was also studied. Forty adults of *M. madrasi,* when reared in 100 L tanks, produced 2,016 juveniles in 4 month, with 90% survival. Around 500 juveniles were mass-reared in.

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3.B. BIOENERGY, BIORESOURCES, ENVIRONMENT AND FOREST (ADVANCED BIOFUELS, SUSTAINABILITY, AND BIORESOURCES)

3.B.1 Energy Bioscience, Biofuels and Waste to value

The programme promotes an enabling environment for research and innovation towards new-age technological developments in the area of clean energy, biofuels and waste to value. The programme is landscaping the clean energy innovations through centres of excellence, extramural and demonstration projects, and international collaboration through Mission Innovation to synergise and adapt to global needs and advancements while focusing on national priorities. The Energy Bioscience is envisioned to promote new-age innovations through research, development and demonstration in advanced Biofuel and bioenergy areas to support National Biofuel Policy, and to make available economic & sustainable biofuel for green industrial growth. The programme activities are focused on addressing the clean energy challenges in hard-to-abate sectors with a focus on research and translational activities on sustainable biofuel from agricultural residue & municipal waste, algal fuels, sustainable aviation fuels, integrated biorefineries, feedstock development, biohydrogen and biorefinery based technological demonstrations & coproduction.

New Initiatives: The Department has identified 7 targeted projects based on innovation pathways on advanced biofuels for aviation applications and eight new projects to promote translational activities on Sustainable fuel, waste management, and feedstock improvement. Department as the expansion of the programme has started working on research and innovation strategies to utilise Carbon dioxide as feedstock for producing fuels, chemicals and materials.

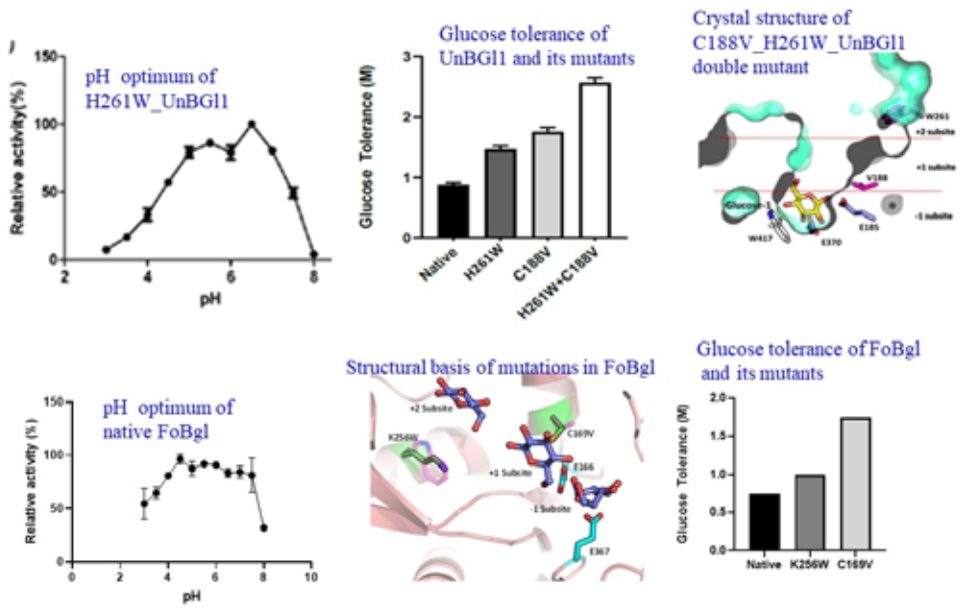


Figure 3.B.1: *Depicting tolerance level of engineered enzymes for improved biomass processing*

Significant Outcomes and Achievements:

Engineering enzymes for improved biomass processing: A group of scientists have been working on multiple β-glucosidases: (a) UnBGl1, (b) CtGH1 from *Clostridium thremocellum* and (c) FoBgl from *Fusarium oxysporum* to develop better enzymes with higher glucose tolerance and stability for efficient biomass processing, which is one of the important steps for bioenergy production. DBT PAN IIT Bioenergy Centre has developed: (1) Novel beta-glucosidase isolated, characterized and engineered for improved glucose and pH tolerance; (2) Chimeric enzymes with cellulose and endoglucanase are engineered with better specific activities; (3) A state-of-art technique for quantification of 13C enrichment of metabolites and fragments has been developed by the same team **(Figure 3.B.1).**

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	11
Number of Process/Product/ Technology Developed	01
Process/Product/Technology Transferred to User Agency/ Industry/ Stakeholders	02
No. of Research Publications	18
No. of Patents Applied	05
No. of Patents Obtained	03
No. of Human Resources Trained	158

Developing process for conversion of municipal solid waste into CTL oil: DBT ICT Bioenergy Centre has developed a CTL Process for conversion of municipal solid waste into CTL oil. A continuous CTL-reactor system for multiple feedstocks and an in-house process for catalyst synthesis were developed. The process intensification data showed the significant impact of operating parameters on the CTL outputs. MSW samples from multiple locations were collected and characterized to understand the physicochemical behaviour of different samples. The samples were subjected to CTL with in-detailed analysis.

Hydrogen production through agro-residue gasification and adsorptive separation: Investigators from the Indian Institute of Science, Bangalore have established that to realize the process, the main requirement is to maintain the reactor temperature under ash deformation temperature (900 °C) for an uninterrupted gasifier operation. This prerequisite is accomplished by optimizing CER (12.5 wt% of dry biomass), which enables the production of hydrogen-rich (42.2 ± 0.9 vol%) syngas with a lower heating value of 8.3 ± 0.2 MJ/Nm3 at a gross cold gas efficiency of 78.9%. The continuous production of pure hydrogen is realized using zeolite 13X in an in-house developed cyclic separation system. Overall, the integrated system converts about 73% of the hydrogen inherently present in the biomass to its pure form at an average overall efficiency and NER of 45% and 4.1, respectively.

National Repository for Microalgae and Cyanobacteria: Under efforts for Technical up gradations of the Department-established repository, investigators from Bhartidarshan University, added a total of 110 new isolates, encompassing 101 mesophilic strains and 09 psychrophilic strains, inclusive of both microalgae and cyanobacteria. These isolates were gathered in the plan period through a continuous survey conducted in the marine "hotspot" areas, precisely in the Palk Bay, Palk Strait, and Gulf of Mannar regions. This extensive survey covers over roughly 600 kilometers which encompasses the Bay of Bengal stretch, spanning from Kalpakam (12°30'57.1"N 80°09'18.7"E) to Tuticorin (8°41'35.1"N 78°06'14.5"E) in Tamil Nadu. Identified 13 morphologically different genera belonging to 82 Cyanobacteria & 19 Green Algae from different marine habitats namely ponds, puddles, stagnant waters, saltpans and brackish seashores. Researchers has also established that the Nitrate and phosphate uptake dynamics in

two halotolerant strains of Chlorella vulgaris is differentially influenced by carbon, nitrogen and phosphorus supply.

Developing organo-lime nanocomposites on graphene microstructures extracted from humic acids: Researchers at Kerala Forest Research Institute, Thrissur developed organo–lime nano forms which are found to have nearly 4 times higher efficiency than the conventional liming materials. Further, it has been developed on graphene structures from humic acids, hence combines the positive aspects of humic acid and reduces the quantity of lime required per unit area. The product has a sustained release property for longer periods thereby a potential to reduce repeated lime applications. The product shows potential to aid in soil acidity amelioration with smaller quantities and cost than the conventional materials

A new model to compare the performance of MET and DET: A first principles mathematical model comparing the performance of Ping Pong model (MET model) and Michaelis Menten model (DET model) has been developed by scientists at BITS Pilani, Hyderabad Campus. The concentration of hydrogen ions with parameters like temperature, pH and operating cell voltage are being studied for both the models.

Nanobased synthetic Photocatalyst for Microalgae Growth and Lipid for Improved Biodiesel: Scientists from Amity University, Noida and IIT-BHU Varanasi jointly synthesised two nanocomposites i.e. GO@g-C3N4and TiO2@g-C3N4 to provide photocatalytic platform for enhanced growth and lipids production from microalgae. The nanocomposites possess photocatalytic property enhancing the accumulation of pigments in microalgae that directly affects the rate of photosynthesis and its growth. Further, the mechanistic investigation was carried out to explore the effect of nanomaterials on lipid production. The synthesised nanocomposites support the increase in algal lipid productivity for the conversion of algal oil to improved FAME. **(Figure 3.B.2)**

Solar assisted hydroformylation/ carboxylation of olefins containing natural products with CO_2: A molecular hybrid consisting of copper bipyridine immobilized on reduced graphene oxide (Cu(bpy)2/ rGO) was synthesized and evaluated by scientists at CSIR-Indian Institute of Petroleum, Dehradun for carboxylation of cyclohexene, α-pinene, β-pinene and camphene with CO2 at room temperature for 24h. Allylic oxidation was observed in place of the expected carboxylation that indicated the role of CO_2 as soft oxidant. However, using the photocatalysts consisting of Rhodium and Nickel provided carboxylation of above olefins under identical conditions. The reaction products were confirmed by 1H and13C NMR spectral data.

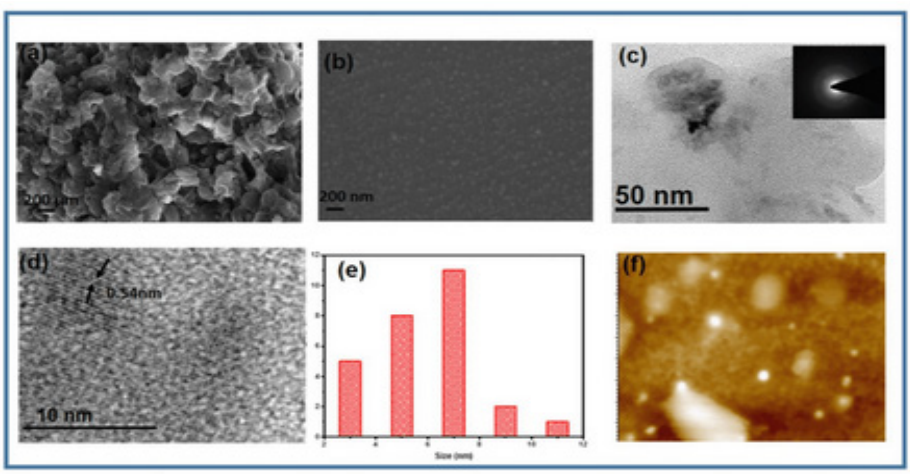


Figure 3.B.2: *(a)Surface topological illustration of defatted biomass of microalgae; (b) C-Dots (c) TEM and SAED pattern corresponding to the area (d) HRTEM (e) Particle Size distribution (f) AFM of C-dots*

Self-assembled electrodes for enhanced microbial electron transfer in bioelectrochemical systems: Modified electrodes resulted in substantially increased generation of microbial electricity. The findings may be helpful in boosting the power production from waste materials and increased production of valuable chemicals through microbial electro synthesis.

Mission Innovation- Multilateral Program to Accelerate Clean Energy Innovation:

Mission Innovation was announced on November 30, 2015 at COP21 in Paris to commit ambitious efforts to combat climate change. It 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 affordable. India has committed to actively participate in MI 2.0 through the launch of "Innovation for Sustainable Aviation Fuels" Clean Tech Exchange and "Mission Integrated Biorefinery" in MI6 at side event and COP 26. **Under MI 2.0, India through Department of Biotechnology is Co-leading the Mission Integrated Biorefineries with the Netherlands and Platform on Sustainable Aviation Fuels with USA and the Clean Tech Exchange Platform.**

National Consultation with Industries and Academia: Department has organized the National consultation with mainstream academia and industries to understand the actual issues to devise the path ahead on integrated biorefineries. The consultation emerged in recommendations on the feedstock expansion, and the needs and priorities on different biorefinery platforms i.e. algal, municipal waste and lignocellulosic.

The Integrated Biorefineries Mission held its third webinar in January 2024, hosted by Innovate UK KTN. 156 participants representing business and governments from 21 nations exchanged strategies to increase the economic sustainability of biorefineries by generating higher value products, with a focus on disseminating MI activities and international collaboration. To learn more about outcomes and next steps, read the report and watch the recording. Department of Biotechnology has actively participated and presented their activities before the global community.

India as co-lead, has supported and organized the webinars and six workshops throughout the year. During the CEM-14/IM-8 in Goa, India, Integrated Biorefineries Mission organised several events together with Biofuture Platform. All events were set up to give a broader outreach to the missions of Integrated Biorefineries Mission and Biofuture Platform. Department of biotechnology as co-lead for the MIB has actively contributed in organising the programme.

As part of the initiative, Department also showcased the low carbon polymers, and mitigation of plastic pollution. The R&D on plastic alternatives produced using the agri-waste through Bio refinery through webinars and workshops.

Societal Impact: The programmes and activities has resulted in outstanding publications and technological advancements in the area of clean energy. The advancements made through research, development and demonstration on waste to value, feedstock developmental has generated the new knowledge and tools for future that may have potential in changing the landscape of waste to value in the country. On the other side, the initiatives planned within the programme for co-utilizing the waste from agi, industrial and municipal establishments are intended to coproduce fuels, chemicals and materials to bring down the costs of production. These initiatives have potential to generate the new opportunities for entrepreneurship and employment, and to bring in the new ways to generate incomes for

the farmers and other communities in need. The multilateral programme on the mission innovation has resulted in the showcasing our efforts and scientific developments in the area of biobased clean energy before the global community, and resulted in generating new partnerships, collaborative programmes and in strengthening the global partnerships. This has resulted in strengthening the position of nation in global clean energy communities and platforms.

3.B.2 Environment Biotechnology

Programme aims to support biotechnology based Research, Development and Demonstration activities to address environmental issues (soil, air, water) & biotechnological intervention for bioresource conservation, utilization & climate change mitigation, to provide cost-effective and green solutions for the management of emerging climatic and environmental issues. Key activities include bio-based remediation of emerging pollutants like microplastics, xenobiotics, and degraded ecosystem restoration, Bioremediation technologies, Biodegradation of pesticide residues; conservation of biodiversity and to develop technologies for monitoring and mitigation of environmental pollutants and to develop the sustainable materials. The development of novel bio-based technologies using research-based insights from bioprocesses is the key to achieving the vision.

Programs under Environmental Biotechnology have been envisioned to provide biotechnology-based innovative clean and green solutions for environmental sustainability and management of environmental issues of National and global concern in the area of climate and environment.

New Initiatives: The department under the initiative on Alternatives to Single-Use Plastics has implemented research and innovation projects to develop sustainable alternatives to single-use Use Plastics and related innovations including the development of rapid biodegradability tests. The projects are being implemented through thirty different institutions in the country and are mainly focused on Corn-Based Bio-Polymers, sustainable films & coatings, nano-cellulose-based smart bio-degradable, PGGA blends, algae-based plastics, and the bio-conversion of the wastes to biodegradable plastics. These projects are part of the Innovation Road map to develop alternatives to SUPs entrusted to the department as part of recommendations of the National Task Force for taking measures to eliminate identified single use plastic items and effective implementation of Plastic Waste Management Rules, 2016.

Significant Outcomes and Achievements

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	09
Number of Process/Product/ Technology Developed	01
No. of Research Publications	07
No. of Patents Applied	04
No. of Human Resources Trained	115

Development of 'iSMAART' for effective treatment of textile industry effluent: A Ceramic membrane integrated anaerobic bioreactor (CMIAR) has been developed by scientists at IIT Delhi. The reactor showed ~90 % dye decolourization along with ~70 % COD reduction of 100 mg/L of reactive blue dye after 48 h operation under batch mode operation. **(Figure 3.B.3)**

DNA Aptasensor-Nanomaterial based product development and commercialization for application in Diagnostics and Environment Monitoring: DNA Aptamers were developed with high specificity and affinity towards E.coli bacteria

commonly found in polluted water. The evolved DNA Aptamers were stabilized on a polymeric surface (e.g.PDMS) coated with nanomaterials such as gold nano twins or nanorods with optoplasmonic responses and are developed into "Aptasensors". Subsequently, a point-of-care diagnostic device has been developed to detect the presence and CFU/ml of target bacteria in urine/water. The project was carried out by IIT, Guwahati.

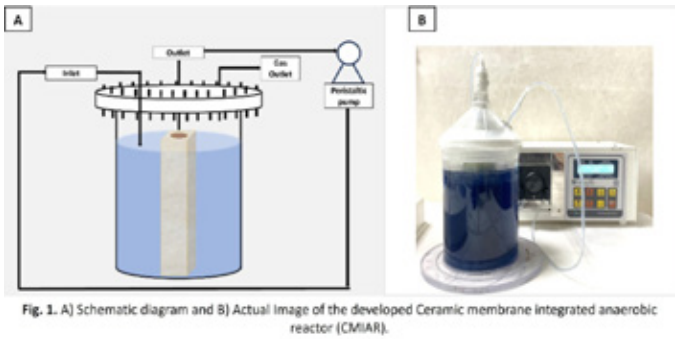


Fig. 1. A) Schematic diagram and B) Actual image of the developed Ceramic membrane integrated anaerobic reactor (CMIAR).

Figure 3.B.3: *A) Schematic and B) Actual Image of the developed Ceramic Membrane Integrated Anaerobic Reactor (CMIAR)*

Marine bacteria with novel marine biosurfactant: Low cost production, formulation and its use in oil removal: This study at NCL, Pune formulated a cost-effective media for enhancing biosurfactant production using different combinations of carbon and nitrogen source. Based on the process parameter analysis, biosurfactant production was found to be optimum at the standardized temperature of 25°C, pH 10, RPM 90, and 6% of inoculum. Based on the analysis, produced biosurfactant was applied and found to be the best candidate for recovering oils from water. This study will improve the quality of life forms inhabits in oil spillage water and play an important role in recovering oil from contaminating water bodies. **(Figure 3.B.4)**

Biosurfactant mediated enhanced oil recovery: The investigators from IIT Guwahati highlighted the potential of utilizing molasses as a sole substrate for enhanced biosurfactant (surfactin) production by Bacillus subtilisRSL2 in a semi-continuous bioreactor. The optimization of process parameters, such as molasses concentration, inoculum size, pH, temperature, and aeration rate, resulted in increased biosurfactant production. Significant reduction in surface tension and CMC values of rhamnolipid-salt systems were observed.

Demonstration of established biorestoration technology for ecological restoration of degraded mangrove ecosystem in Indian Sunderbans: The Bio-restoration Technology for ecological restoration of degraded mangrove ecosystem developed through department's funding, is being demonstrated for ~163 acres (~65 hectares) of degraded mangrove sites at Indian Sundarbans outside the protected area. The demonstration area comprises of 31 degraded mangrove sites at Indian Sundarbans outside the protected area. Out of these 31 selected sites, 16 degraded mangrove sites showed success of the applied bio-restoration technology with large-scale plantations as major component. The study is being implemented by Researchers from West Bengal State University, Barasat. **(Figure 3.B.5)**

Societal Impact: The programmes and activities have resulted in strengthening the eco-innovation roadmap in the country to leveraging the support to larger programmes. The innovation roadmap developed by the department on the sustainable alternatives to SUPs has resulted in implementation of more than 20 research and innovation oriented products to develop the low carbon alternatives to plastics. Department has also added value to the community strengths in the scheduled and interior areas through eco-restoration programme in Sunderbans that has not only enabled the communities to withstand the impact of cyclones in the coastal areas but also resulted in conserving the sustainable livelihood practices in fragile ecosystem

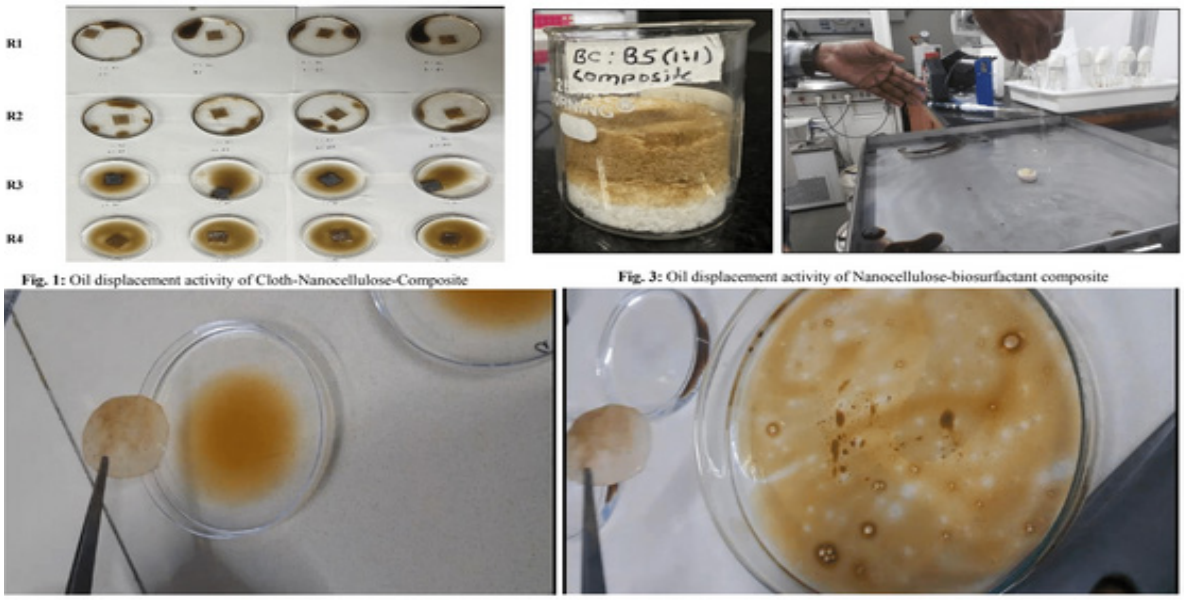


Figure 3.B.4: *Development of composite by immobilizing the biosurfactant on stabilizing matrix and evaluation for oil displacement activity to recover the oil after oil spillage in ponds.*

of the Sunderbans. Apart from this, the Department has undertaken the efforts on bioremediations of contaminated soils, wastewater, and river to address the emerging concerns relevant to public and environmental health.

The advancements made through research, development and demonstration on waste to value, feedstock developmental has generated the new knowledge and tools for future that may have potential in changing the landscape of waste to value in the country. On the other side, the initiatives planned within the programme for co-utilizing the waste from agi, industrial and municipal establishments are intended to coproduce fuels, chemicals and materials to bring down the costs of production. These initiatives have potential to generate the new opportunities for entrepreneurship and employment, and to bring in the new ways to generate incomes to the farmers and other communities in need. The multilateral programme on the mission innovation has resulted in the showcasing our efforts and scientific developments in the area of bio-based clean energy before the global community, and resulted in generating new partnerships, collaborative programmes and in strengthening the global partnerships. This has resulted in strengthen the position of nation in global clean energy communities and platforms.

3.B.3 Forest Biotechnology

The Department of Biotechnology has envisioned Forest Biotechnology programme to leverage biotechnological innovations for the conservation of forests, sustainable resource management, and mitigating the impacts of climate change. The focus of the programme is to develop biotechnological tools, technologies and approaches to accelerate the efforts for sustainable utilization, conservation and climate change mitigation of forest and associated ecosystems. The activities under the programme are being undertaken through mega network projects for holistic technological interventions for biodiversity management in protected forests and through individual generated projects for site-specific interventions. Few of the thematic sub-programmes are restoring degraded

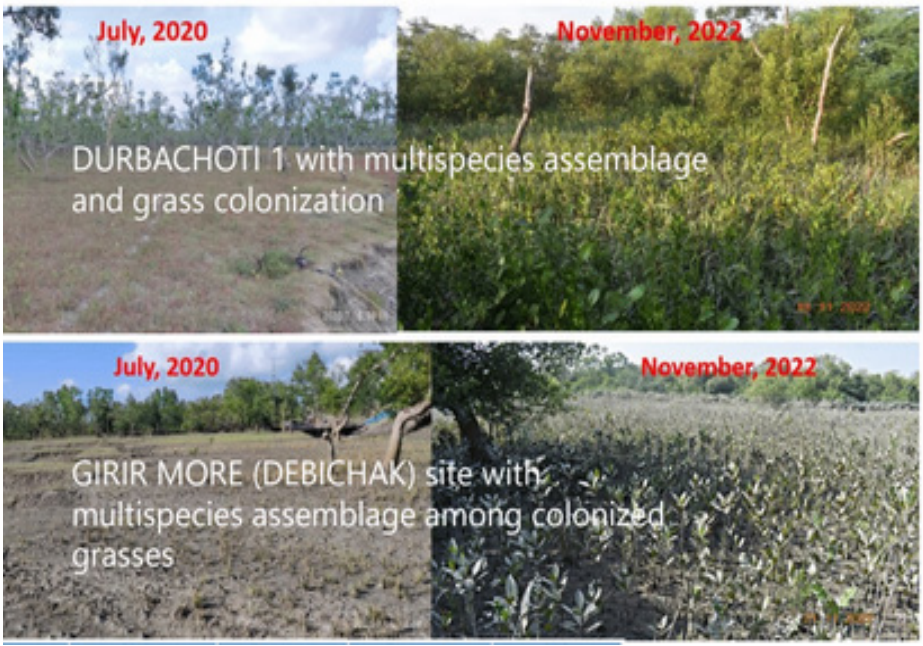


Figure 3.B.5: *Biorestoration of degraded mangrove ecosystem*

lands, advancing tree diagnostics, biodegrading pesticide residues, improving seed handling through molecular marker-based testing, and certifying technologies to ensure the production of high-quality seeds and planting materials for industrial forests.

Significant Outcomes and Achievements

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	22
Number of Process/Product/ Technology Developed	02
Process/Product/Technology Transferred to User Agency/ Industry/ Stakeholders	02
No. of Process/Product/Technology Commercialized	01
No. of Research Publications	11
No. of Human Resources Trained	101

Role of Himalayan Alder in recovery of degraded ecosystems in central Himalaya: Scientists from Jawaharlal Nehru Univeristy, New Delhi investigated the role of Alnus nepalensis (Alder) in the recovery of degraded ecosystems. Alder was identified as a model plant species to understand the Alder-soil-microbe interactions to hasten the process of stand development, leading to the recovery of degraded ecosystems and restoration of the lost ecosystem services and functions. For this purpose, different forest stands of Alder considering its age as a major gradient were selected in Western Himalaya, in the Rudraprayag District, Uttarakhand.

Development of multiplex-PCR based method for detection of important soil borne fungal pathogens of sandalwood and their management: Scientists from Dr. Y.S. Parmar University of Horticulture & Forestry, Solan tested twelve systemic and four non-systemic fungicides in vitro for their efficacy against pathogenic Fusarium sp. isolated from Sandalwood growing areas of Himachal Pradesh. Systemic fungicides viz.SA Glorius, Mainex, Amistar Top and Cabrio Top were found effective in inhibiting mycelial growth of Fusarium, while among non systemic ones Dhanuka M-45 gave good inhibition of the same. Also, two biocontrol agents viz. Trichoderma harzianum and T. viride along with newly isolated Trichoderma sp

were tested in vitro for their antagonistic properties to control Fusarium sp. All were found to more or less restrict the growth of Fusarium.

Understanding the invasiveness of Lantana camara: Lantana root exudates inhibit the growth of native plants (R. serpentine and O. sanctum) by decreasing soil nutrients availability because invasive plants litter extracts negatively impact soil condition and rhizospheric soil microbial carbon utilization and promote their own growth. Allelochemicals of Lantana decrease the diversity of microbes in the rhizospheric area of native plants and reduce their interactions with beneficial microorganism. Allelopathy impacts both native plant and their rhizospheric soil community which further facilitates the successful invasion. This study was performed by scientists at Institute of Science, BHU. **(Figure 3.B.6)**

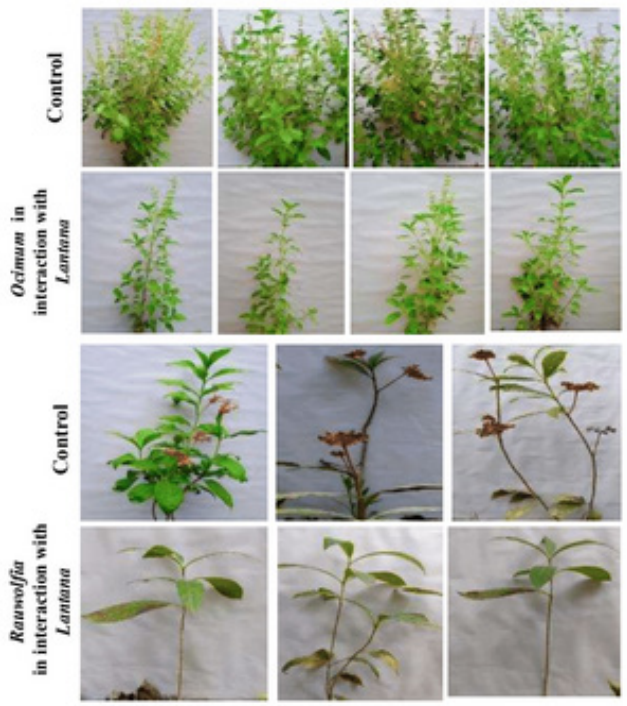


Figure 3.B.6: *Phenotypic effects of Lantana camara on plant growth*

The ecology and genetics of the living root bridges of Meghalaya: Scientists from IISc Bangalore, North East Hill University and NCBS successfully understood the biology, genetic diversity and population structure of the trees and pollinators within the mutualism between the rubber tree (living root bridge component) and its pollinating fig wasps, and used this knowledge to design long-term conservation strategies for this iconic relationship between trees, wasps and humans, within the riparian forest ecosystem of Meghalaya

Biotechnological approaches of plant-associated microbes for improved plant productivity and ecosystem functioning in the mangrove forest of Bhitarkanika, Odisha, India: Researchers from the National Institute of Technology Rourkela delved into the pivotal role of potential biofilm-forming bacteria and fungi with plant growth-promoting capabilities and their contribution for enhancing the health of mangrove plants and soil in this unique environment. Compatible plant growth-promoting bacterium (Pseudomonas aeruginosa GAT2212B) and fungus (Aspergillus niger KCRE2202F) isolates formed the dense mixed biofilm confirmed by both SEM and CLSM imaging. This consortium of bacteria and fungi contributed to the nutrient cycling in the soil microcosm experiment. They had a significant positive impact on the growth of the mangrove plants after attaching themselves on the mangrove root surface. Additionally, this mixed consortium had the ability to tolerate different abiotic stresses and also improved plant health in stress conditions. **(Figure 3.B.7)**

Conservation and restoration of insect biodiversity for livelihood security: Scientists from Sher-e- Kashmir University surveyed and analyzed the ecosystem health in northwest Himalayas. In terrestrial ecosystems, pollinators and detritivores play a crucial role in providing a variety of pollination services and aiding in nutrient recycling in favour of mankind. Insects were traped

and identified. Community mobilization for forest Bioresources management and Livelihood security by promotion of Sericulture and Ericulture, Beekeeping and Managed pollination was initiated in sampled areas followed by skill development for the value addition of forest Bioresources supporting livelihood.

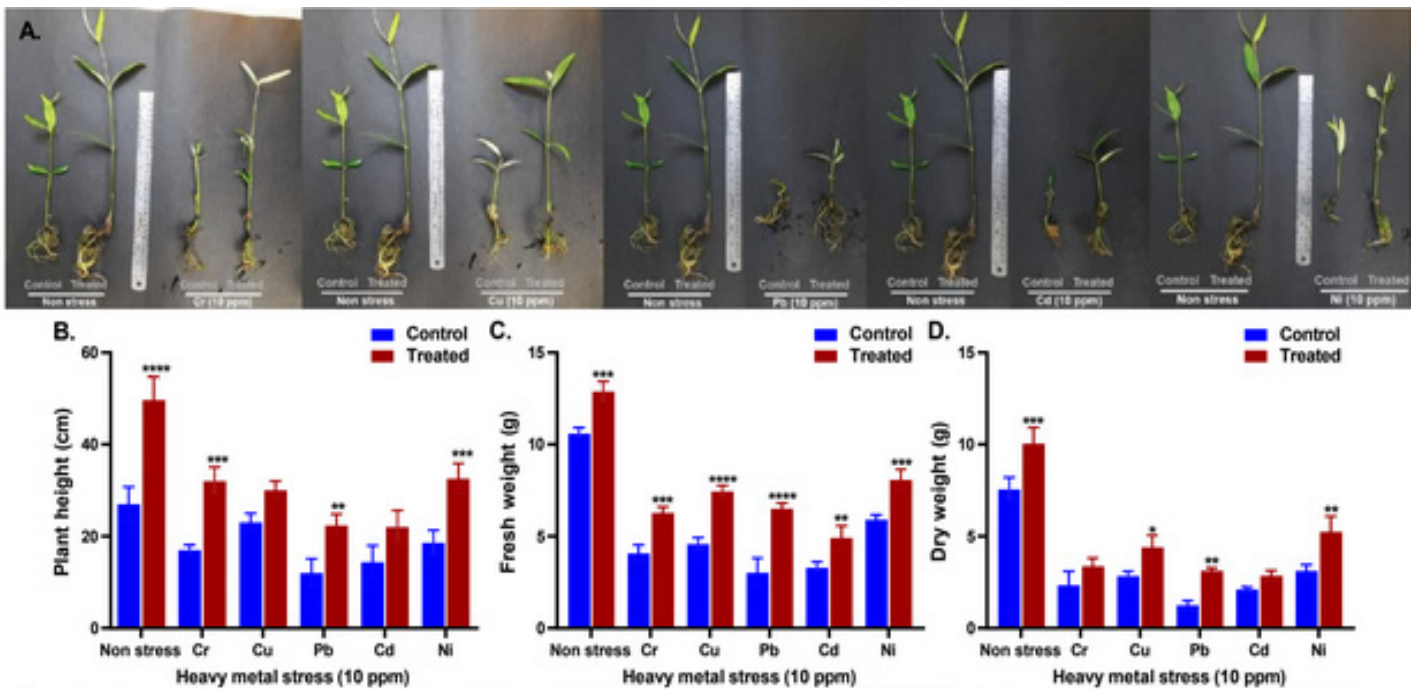


Figure 3.B.7: *Impact of mixed bacterial-fungal inoculation on (A) the growth of Avicennia officinalis L. seeds under diverse heavy metal stress conditions in hydroponics, (B) plant height, (C) fresh weight, and (D) dry weight.*

Conservation of Elephant corridor and demonstration of alternative livelihood in Dihira proposed reserve forest area: Investigators from Cotton University worked on the restoration of elephant corridor and regaining biodiversity through scientific and strategic plantation activities. Families who solely depend on forest resources in Dihira Forest Reserve were selected and provided with training, financial and technical support to take up alternative and sustainable livelihood options like poultry, piggery and dairy to decrease dependence on forest Solar lights were installed at strategic locations to deter outward movement of the wild animals and to enhance security. Construction of water reservoirs, cultivation of elephant deterrent crops and beehive fencing were some strategies used to reduce human wildlife conflict. **(Figure 3.B.8)**

Biotechnological applications for development of High Yielding Short Rotation (HYSR) clones for multifunctional industrial utility: Scientists from Tamil Nadu Agricultural University prioritized five species based on initial wood quality analysis. The wood quality parameters viz., Density, Hollocellulose, Acid insoluble lignin and veneer recovery were considered as quality parameters for screening the species amenable for multifarious industrial utility. Melia dubia, Toona ciliata, Chukrasia tabularis and Khaya senegalensis were identified for various purposes like paper, ply and energy. In these species, wide range of genetic resources were screened and advanced to both for quality characterization and clonal multiplication. Miniclonal technology was developed for four species Melia dubia, Toona ciliata, Khaya senegalensis and Acacia hybrid with

Figure 3.B.8: *Training the villagers to protect their environment and to sustain their livelihood*

varied degree of success. For all the species, clonal mother garden establishment has been progressing well for amplified multiplication towards clonal test to screen HYSR clones amenable for multifarious industrial utility.

Cloning and Characterization of Homeostasis from Salvadora Persical (Miswak): Investigators from Arid Forest Research Institute, Jodhpur collected seeds and raised seedlings of Miswak plant and perfomed RNA extraction followed by cDNA synthesis. The partial length sequence of Spcbl 10 gene was amplified, sequenced and aligned to confirm the gene and full length ORF was deciphered.

Societal Impact: The programmes and activities have resulted in decoding the few of the ecosystem services and their connect to the communities, which is one of the essential component for the climate resilient and sustainable practices to protect the ecosystems. Department, considering the diverse nature of ecosystems in the country has supported the research, development and demonstration projects from Kashmir to Kanyakumari to address the issue holistically. The programmes are being implemented in close collaboration with the state forest departments, and local communities wherever possible to give it greater impact and to translate the generated knowledge for awareness and benefits of the communities.

3.B.4 Microbial and Natural Resource

The resources of biological origin are non-fossil biogenic materials or processes that are renewable and biodegradable in a natural and sustainable manner. These resources meet our basic need for food, feed, bioactives, fuel, energy, shelter, fiber, bioremediation, and biomedicals, among others, and are vital to our current and future socioeconomic and ecological developments. However, exploitation of these bioresource is now challenged worldwide due to overpopulation and in the face of climate change risk; the need for further exploration, conservation, and sustainable utilization of resources of biological origin is undeniable for the sustainability of mankind.

Past decades have seen support to several conservations, mapping and inventorization studies led by modern biotechnology tools and technologies on microbes, plants, animals, insects, etc., Though continual support for conservation, mapping and inventorization of bioresource is imperative, the critical necessity is to develop processes and technologies for better and ecologically relevant utilisation of these bioresource through citizen participation. The Microbial and Natural Sciences programme of the Department promotes the sustainable utilization of such natural resources through development of technologies and products from it.

Significant Outcomes and Achievements

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	13
Number of Process/Product/ Technology Developed	01
No. of Research Publications	10
No. of Patents Applied	02
No. of Human Resources Trained	110

To develop lactose free and bioactive enrich milk-based functional products researchers at National Agri-food Biotechnology Institute, Mohali are exploring native microorganisms and biocatalysts from traditional fermented products of Sikkim. They have successfully standardized the production of bioactive peptides using mixed culture of selected lactic acid bacteria and yeasts. Mixed culture fermentation as co-starter with *Lactobacillus delbrueckii* LC04 and *Lactobacillus delbrueckii*LC03 was carried out. Lactose transformation up to 70% has been achieved in the controlled mixed culture fermentation.

In aspiration to develop novel high-performance materials, researchers at National Institute for Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram have successfully developed multifunctional benzoxazines and its polymer composites from agro residues. Formulation of the nanocomposites for coatings and adhesives and optimization of mechanical properties is in progress. The evaluation study of mechanical properties, viscoelastic properties and other properties is in progress **(Figure 3.B.9).**

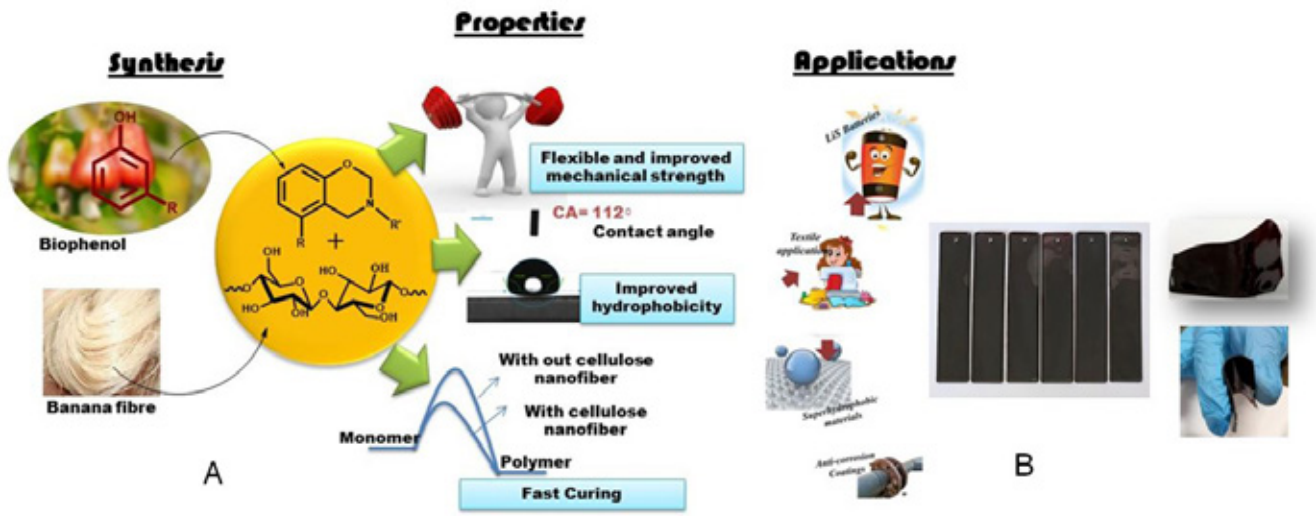


Figure 3.B.9: *Synthesis and development of multifunctional benzoxazines from agro residues and its polymer composites as high-performance materials. (A). Economically viable alternative for a high performance petroleum based. (B). Cardanol-Aniline Benzoxazine - Modified Cellulose Nanofiber Composites.*

Researchers at National Institute of Technology, Rourkela have successfully demonstrated that the aqueous fraction of the ethanolic extract of *Bacopa monnieri* (BM-AF) inhibited cell viability, colony formation, cell migration and induced apoptotic cell death in oral cancer cells. This BM-AF exhibited potent anticancer activity through apoptosis induction and mitophagy-dependent inhibition of NLRP3 inflammasome activation in both in vitro and in vivo oral cancer models.

In an attempt to enhance farmers income the Fragrance & Flavour Development Centre, Kannauj and Siksha 'O' Anusandhan, Bhubanesawar have jointly demonstrated the plantation of elite Kewra germplasm and intercropping of seasonal aromatic crops (i.e. Lemongrass &Palmarosa) along with it in 5 acre area.

Investigators at Institute for Stem Cell Science and Regenerative Medicine, Bangalore and National Centre for Biological Sciences, Bangalore have successfully established a suite of *in vitro* infection assays (qRT-PCR, Cell Viability and imaging based) with SARS-CoV-2 virus to test compounds and formulations for anti-viral activity as well as antibodies for neutralization. These assays were extended as services to private enterprises to test their compounds and formulations for anti-SARS-CoV-2 activity. They have also developed an organoid model for testing lead anti-SARS-CoV-2 molecules**.**

Scientists from GLA University under DBT funded project aimed to develop an herbal formulation for the therapeutic management of Mycobacterium avium subspecies paratuberculosis (MAP) infection in domestic livestock have developed a synergistic combination using *Moringa oleifera*and *Chenopodium album* which showed an MIC of 0.243 mg/mL. The synergistic combination has been formulated into pills (for domestic livestock) for the management of Johne's disease respectively. This study will provide a ray of hope for management of MAP-related autoimmunedisorders Johne's disease in domestic livestock.

At National Institute of Pharmaceutical Education and Research, Guwahati investigators have established the state of art pilot-scale extraction facility for standardization of phytopharmaceutical products from the medicinal plants. In an attempt to standardize plant extracts endemic to NE India *Curcuma longa, Zingiber sianginensis, Dolichandrone atrovirens, Zanthoxylum armatum, Mesua assamica and Phlogacanthusthyrsiformis*, were screened for various physico-chemical properties. They have also isolated nine reference compounds from *Curcuma longa* (Lakadong variety), *Zingiber siangensis* and *Dolichondrone.*

Investigators at University of Delhi (South Campus), New Delhi and Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai have performed mapping of seaweeds population in Chilika Lake through unmanned aerial vehicle (UAV) and Unmanned underwater vehicles (UUV) for capturing aerial and underwater images of aquatic vegetation, respectively. They have successfully demonstrated the cultivation of two different varieties of *Gracilaria verrucosa* in the Chilika Lake, Orissa. Agar extraction process from wild and cultivated varieties was also optimized.

In an attempt to understand the impact of climate change on the emergence of stress tolerant Symbiodinium clade and altered microbiome in reef building corals researchers at Pondicherry University, Puducherry and Zoological Survey of India, Port Blair have surveyed and recorded the coral health, diversity and diseases at coral reef sites of Andaman & Nicobar and Palk Bay. Coral diseases like white plague and *Porites* pink spot and *Terpios*invasion were recorded **(Figure 3.B.10)**.

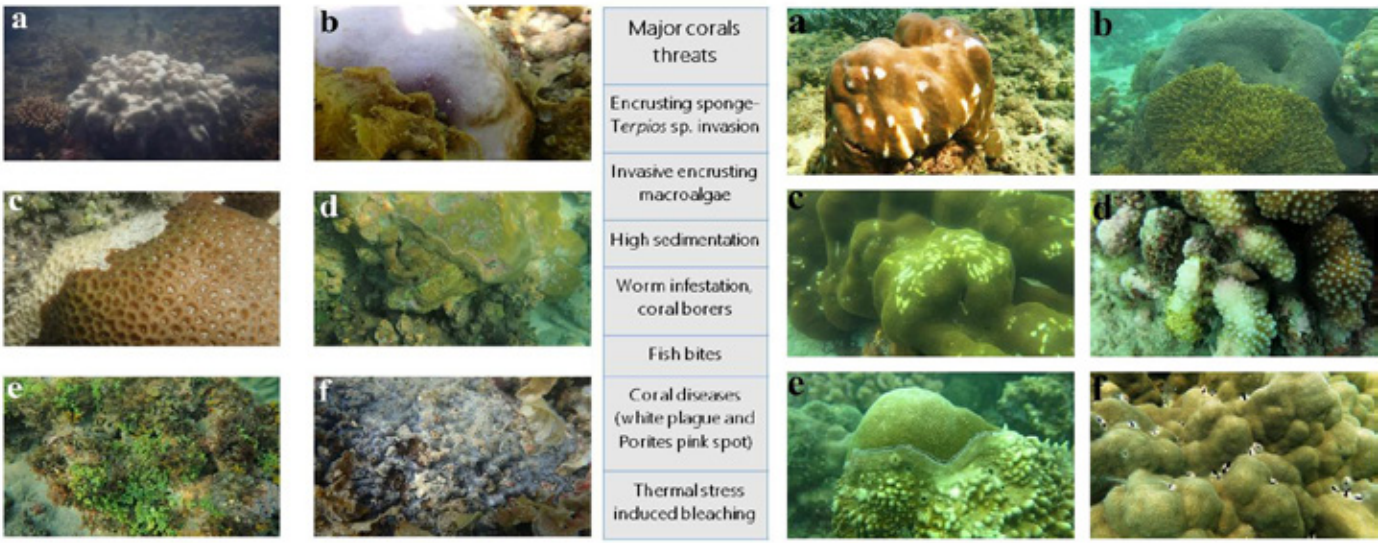


Figure 3.B. 10: *Major coral threats observed in Andaman & Nicobar Islands and Palk Bay Reef. (A) Threats on coral reefs of Palk Bay a-b) Bleached colonies; c) white plague coral disease d) pink spot Porites disease e) Macroalgae as space competitor f) Terpios sp. sponge as the invasive coral killer sponge. (B) Threats on coral reefs of A&N Islands a)-white plague coral disease ; b) Macroalgae as space competitor c) fish bites d) snail predation e) Coral competition f) invertebrate galls.*

Further analysis of the data revealed dominance of heat resistant *Durusdinium*, followed by *Cladodocopium*and S*ymbiodinium*.

Aiming to establish embryonic stem (ES) cells culturing from Orange-spotted grouper (*Epinepheluscoioides*), investigators are CUSAT, Kochi have established a recirculating Aquaculture System for the maintenance of Orange-Spotted Grouper, and trial runs are being carried out. Methodology for embryoic stem Cell development has been standardized with an alternative fish (*Anabas testudineus*). A complete genome editing platform for *Epinepheluscoioides* has also been developed for genetic improvement.

Investigators at BITS Pilani, KK Birla Goa Campus have attempted to comprehend the life cycle of Indo-Pacific horseshoe crab "*Tachypleus gigas*". The study tracked the animal's growth from fertilization (stage zero) till the juvenile stage (second instar). Study further revealed novel and first reports of the stages of development of the eggs, tracing from the blastula to the final molt. Detailed 'OMICS' analysis offered new insights into the molecular machinery at play during *T. gigas* development.

Some of the initial leads from various studies supported in recent past are also highlighted below:

At CDRI, Lucknow; investigators identified *Desmodiumgangeticum* extract as a potential osteogenic agent for facture healing in osteoporosis-related bone loss; ii) At ICGEB, New Delhi, investigators are attempting to biochemically characterize the anti-candida activity of *Allium tuberosum* herb; iii) At NIAB, Hyderabad investigators are screening various plant extracts for possible anti-theilerial activity; iv) Investigators at Kalasalingam Academy of Research and Education, Chennai are trying to improve the size of roots in planta by soil with microbiomes, elicitors and precursors for expanding the cultivation of Withaniasomnifera in Tamil Nadu.

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

The Department of Biotechnology (DBT) has

established the National Certification System for Tissue Culture Raised Plants (NCS-TCP) through a Gazette Notification of the Ministry of Agriculture dated March 10, 2006. This program promotes Agri-entrepreneurship and safeguards farmers' interestsby providing a certification system for virus-free and true-to-type tissue culture-raised plants of various crops.The DBT has established a well-defined operational structure for the successful implementation of NCS-TCP in India as shown in (**Figure 3.B.11)**.

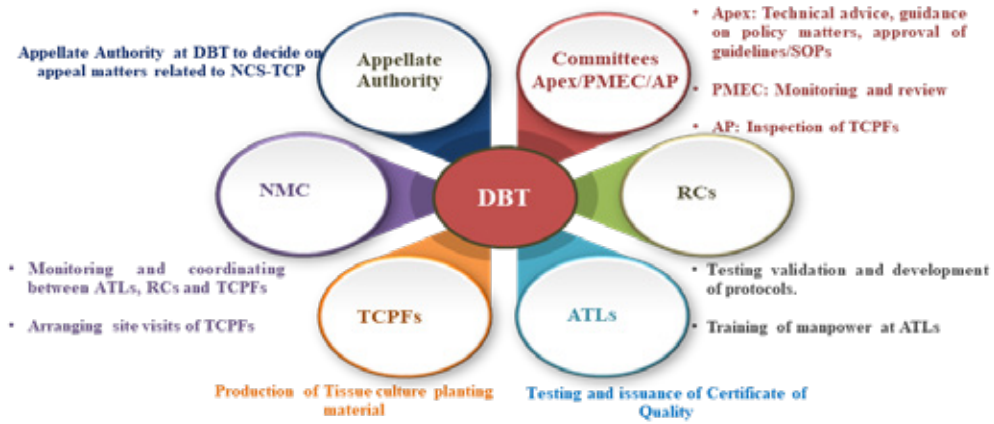


Figure 3.B.11: *Organizational Structure of the National Certification System for Tissue Culture Raised Plants (NCS-TCP). The function of each component is briefly mentioned.*

The major challenge for the success of the tissue culture industry is controlling the infection of plants by fastidious pathogens such as viruses, viroids, and phytoplasmas while maintaining the genetic uniformity of crops. The vision of this scientific program is to revolutionize the tissue culture industry by ensuring a stringent system for the propagation and distribution of virus-free and genetically uniform plants. The mission is to enhance agricultural productivity and sustainability by controlling plant infections caused by pathogens such as viruses, viroids, and phytoplasmas.The program's mandate is to enforce standard practices for tissue culture and certify the complying tissue culture plant facilities thereby minimizing the spread of pathogens and ensuring high-quality plant production. This involves rigorous research and development, quality control, and implementation of best practices in plant tissue culture.

The main objectives of the program include:

i. Develop and standardize protocols to control infections caused by fastidious pathogens, ensuring the production of healthy tissue culture plants.

ii. Maintain the genetic uniformity of tissue culture-raised crops to ensure consistency and reliability in agricultural production.

iii. Propagate and distribute virus-free, high-quality tissue culture plants to growers and farmers, enhancing agricultural productivity.

iv. Promote and support research and development activities in plant tissue culture to innovate and improve existing techniques and methodologies.

v. Facilitate the commercialization of the plant tissue culture industry in India, catering to local needs, and export demands, and contributing to the growth of the agricultural sector.

i. Recognized and new companies have been offered substantial support. In 2023, nine new companies were recognized, and 15

applications are under process for recognition in 2024. This initiative aims to expand and strengthen the tissue culture industry.

ii. Regular meetings with recognized companies are conducted to encourage testing and address any issues they face. This proactive engagement has resulted in a phenomenal 82% increase in plant testing over the last two years.

iii. The introduction of QR codes on certificate labels has enhanced traceability, providing all relevant information such as the source of the crop and the ATL where it was tested. This initiative ensures transparency and quality assurance in the tissue culture industry.

iv. The NCSTCP Management Cell closely monitors the disposal of virus-infected plants, ensuring that these plants do not reach farms and thereby maintaining the health and quality of agricultural produce.

v. Webinars have been introduced to raise awareness about the transformative potential of the tissue culture industry in Indian agriculture. These webinars serve as a platform for sharing knowledge, technology, and innovation, benefiting stakeholders.

vi. Targeted outreach awareness programs have been conducted to expand the program and improve awareness of stakeholders. These programs aim to educate and engage farmers, researchers, and industry professionals about the benefits and advancements in tissue culture.

vii. A new website and portal have been developed to enhance user experience and operational efficiency for the NCSTCP. This digital initiative aims to provide a user-friendly interface and improved functionality, facilitating better access to information and services.

Significant Outcomes and Achievements

The notable outcomes/achievements of the program during the reporting period include recognition of 100 Tissue Culture Propagation Facilities (TCPFs) out of which 9 were new companies joining the program, in 17 states showing its strong nationwide presence (**Figure 3.B.12)**. Through consistent monitoring and support, testing of plants has witnessed an impressive 82% increase from 2021 to 2023. A staggering 189,255 TCPs, representing over 176 million plants across various crops (apple, bamboo, banana, date palm, gerbera, potato, sugarcane), were tested for virus indexing and genetic fidelity. Comprehensive virus indexing was conducted on over 44,612 mother plants/stock cultures (MP/SC) across various crops. Certificates of Quality were issued for all tested plants, and 25,460 certificate labels were awarded to TCPs confirmed virus-free and genetically uniform. A critical outcome of these activities is the identification and exclusion of over 1.6 million virus-infected plants, preventing them from reaching farms. Further, nine informative webinars and two physical awareness programs were organized. These webinars covered a diverse range of crops, from fruits to ornamentals, while also addressing crucial topics like virus indexing and quarantine procedures. Two awareness programs were held specifically in the northeastern states of Sikkim and Assam, reaching over 100 participants each. Besides these, a new user-friendly website and portal were launched to streamline information access and functioning of the NCSTCP. These achievements demonstrate a strong commitment to safeguarding plant health and supporting the production of high-quality crops.

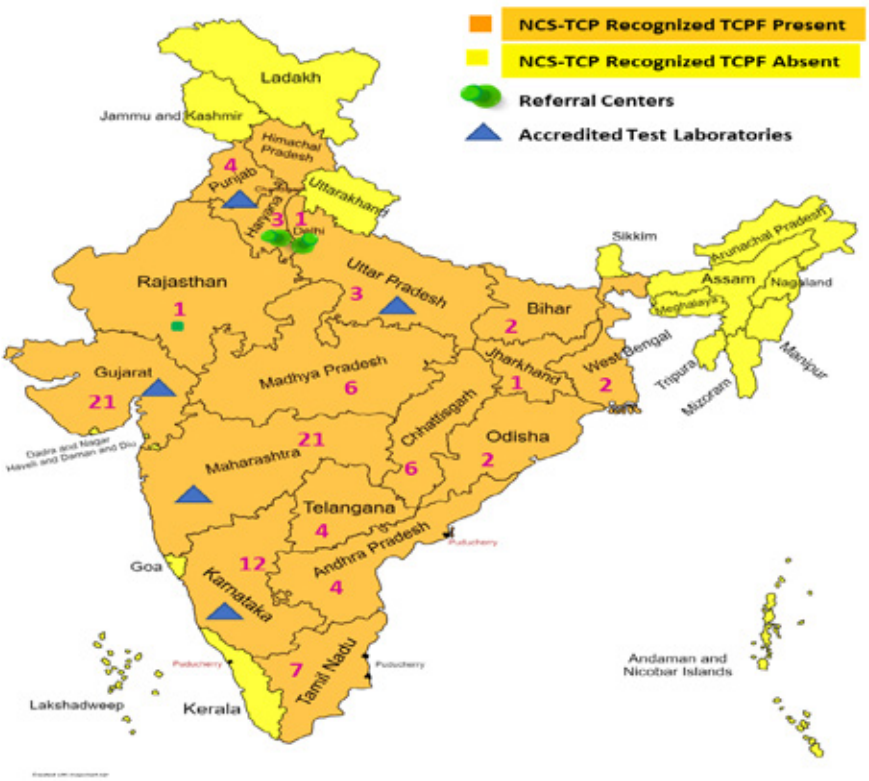


Figure 3.B. 12: *Nationwide Presence of TCPFs. The numbers in different states indicate the number of NCSTCP-recognized TCPFs in the respective states. The locations of all five Accredited Test Laboratories (ATLs) and both Referral Centers (RCs) are indicated state-wise. The RCs are located in New Delhi.*

The tissue culture program has had a profound impact on society, particularly in the agricultural sector. One of the major crops benefiting from this program is banana, which constitutes approximately 85% of all the crops under this initiative.Farmers using virus-free, healthy tissue culture plants experienced up to 30% increase in yield. This translates to higher incomes and improved livelihoods. Government of India data reveals a remarkable 8-fold increase in banana exports over the past decade. This robust export market creates opportunities for farmers to tap into global markets. The tissue culture industry has shown significant potential in rural areas by generating employment and opportunities. Many TCPFs are located in remote areas, employing the local rural population. It has been observed that more than 50% of the workforce in these facilities is women. This employment injects income into rural communities, leading to an improved standard of living. In summary, the tissue culture program is not only enhancing agricultural productivity and quality but is also playing a crucial role in socio-economic development. By increasing farmers' incomes, boosting exports, and generating rural employment, the program is contributing significantly to the overall betterment of society.

3.C Healthcare and Medical Biotechnology

Providing affordable quality healthcare for all in a large country like India is challenging. Towards this end, the Department of Biotechnology has prioritised research and development to actively support biomedical research and innovation aimed at understanding the causes of human diseases, including emerging infections, antimicrobial resistance, non-communicable diseases, genetic disorders, maternal and child health, and nutritional issues at the genetic and molecular levels. Efforts have been directed towards early detection, preventive measures, vaccine development, innovative tools and therapies, healthcare delivery systems, and developing biomedical devices and products. Over the years, the Department of Biotechnology has supported Research & Development projects across various thematic areas such as Bioengineering, Cancer Research, Chronic Diseases, Drug Development, Human Genetics, Infectious Diseases, Public Health & Nutrition, Stem Cells & Regenerative Medicine, Vaccine R&D, Women & Child Health, and 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. Around 80% of the needs for medical devices are met through imports. Thus, an initiative was taken to support indigenization of biomedical devices and resources through a call for proposals -"*Research on key components or resources for Biomedical Technologies*". 477 applications were received under the call. After a multi-step through evaluation, following projects were recommended for support:

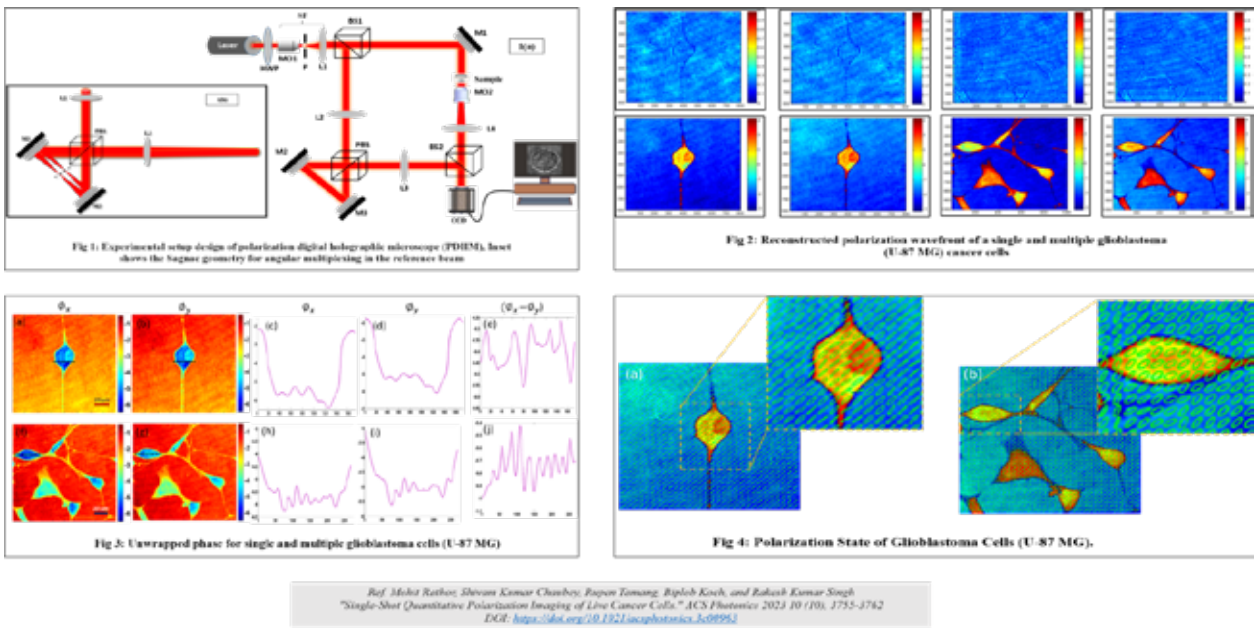
- Phase-I: Novel scientific ideas with sound rationale for establishing Proof of Concept: 67 projects for short duration (18-24 months)
- Phase-II: Research for advancing TRL, PoC to be available: 27 projects for 3 years.
- Center of excellence in Biomedical Engineering: Centre of Excellence for Minimally Invasive Cardiovascular Devices for duration of 5 years.

No. of research publications	27
No. of patent filed	2
Manpower trained	42

Major Achievements:

- In a project implemented at IIT-Madras and ICGEB New Delhi aiming to develop electrochemical biosensor using aptamers and metal binding peptides to detect chikungunya and dengue diagnosis, two gold binding peptides have been identified with good binding for future studies. CHIKV-E1 has been prepared for aptamer-based biosensor.
- In a DBT supported project, researchers at

IIT BHU are developing a Spatially Resolved Polarization Digital Holography Microscope (PDHM) for Diagnosis Applications. Unique features of this microscope are non-destructive, quantitative imaging, spatially resolved, full field of view imaging, 3D imaging, etc. (**Figure 3.C.1**). This can be used for non-invasive testing of biological samples and their structures. (https://pubs.acs.org/doi/10.1021/acsphotonics.3c00963). Various biological samples (blood cells, Hela cells, MCF-7 cells, etc), have been studied using PDHM.



Ref: Mohit Rathor, Shivam Kumar Chaubey, Rupon Tamang, Biplob Koch, and Rakesh Kumar Singh "Single-Shot Quantitative Polarization Imaging of Live Cancer Cells." ACS Photonics 2023 10 (10), 3755-3762 DOI: https://doi.org/10.1021/acsphotonics.3c00963

Figure 3.C.1: Single-Shot quantitative polarization imaging of live cancer cells using Polarization Digital Holography Microscope (PDHM)

- A project on design and development of cost-effective label-free detection of Alzheimer's biomarkers using liquid crystals has been supported at NIT Warangal. The researchers have been successful in sensing Alzheimer's disease biomarker using Aβ1-42 using Nematic liquid crystal (NLC) droplets at the laboratory scale. The NLC droplet immunoassay effectively detected Aβ1–42 antigen concentrations ranging from 45 to 112.5 μM.
- Another study supported at IIT Bombay, aims at scaffold-based *in situ* dendritic cell programming for cancer immunotherapy. The researchers have isolated and characterized bone marrow-derived dendritic cells (BMDCs). PEGDA-PLL (0.45 mg/mL) cryogels were prepared and characterized. These gels were found to be macroporous, cell-adherent and biocompatible. Mice melanoma model was developed, and vaccine administration trial was done (**Figure 3.C.2**). In vivo administration of scaffold loaded with vaccine components leads to significant reduction in tumor size as compared to bolus delivery and no treatment group. Administration of booster dose with injectable scaffold further led to reduction in tumor volume.
- In a project supported at Central Institute of Petrochemicals Engineering & Technology, a non-enzymatic sensor for the detection of cholesterol has been fabricated using polyaniline (PANI) and its nanocomposites (NCs) with ZnO nanoparticles (NPs). The zinc oxide (ZnO) reinforced composite of PANI was found to be capable of detecting cholesterol up to 0.3 mM detection limit. In addition, two different

Figure 3.C.2: Tumor size reduction via scaffold-mediated vaccine delivery in vivo.

doping agents, namely camphor sulfonic acid (CSA) and hydrochloric acid, have been used to prepare PANI and its NCs. Electrochemical studies have revealed that as the amount of ZnO NPs increased, the capacitive behavior of the composite also increased. A similar trend was observed in the case of HCl-doped polyaniline NCs. PANI/ZnO 8% NCs for both HCl and CSA dopant indicated good capacitive behavior for sensing cholesterol.

- A project supported at IIT-Ropar is developing antisense oligonucleotide-loaded, 3D printed, double-layered, and multifunctional wound healing matrix to target angiogenesis in chronic diabetic wounds. A major achievement on this project is development of antibiotic-free dressings, which not only provide protection against infection but also stimulates cells in wound area to proliferate and differentiate, leading to the tissue regeneration in the wound area. In the same project, the researchers have developed scaffolds, which stimulate bone regeneration even in osteoporotic conditions (**Figure 3.C.3**).

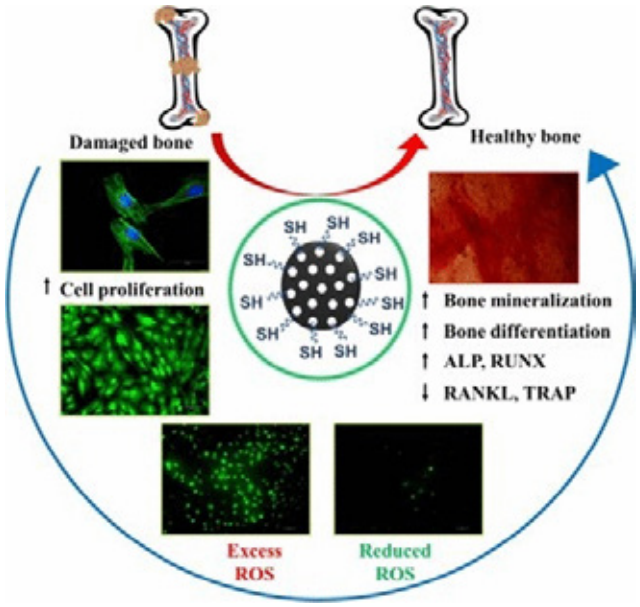


Figure 3.C.3: Bioactive dressings and scaffolds for bone regeneration

- A study supported at Jamia Hamdard University has developed a novel wearable electrochemical glove-based analytical device (eGAD) designed especially for detecting the club drug, methamphetamine (**Figure 3.C.4**). (https://doi.org/10.3390/bios13100934)

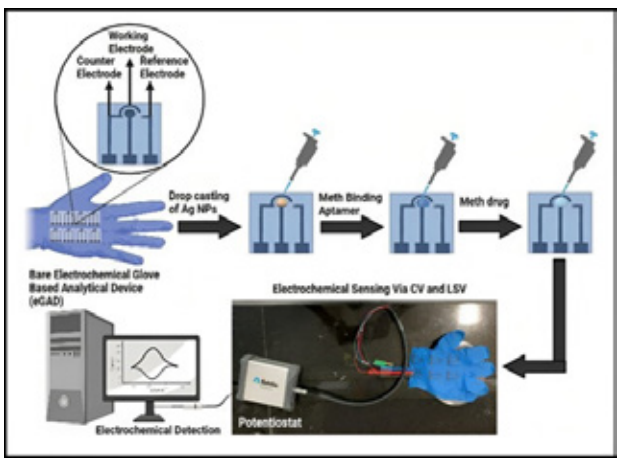


Figure 3.C.4: A novel wearable electrochemical glove-based analytical device (eGAD) designed especially for detecting the club drug, methamphetamine.

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.

Major Achievements:

No. of research publications	8
No. of patents	22 filed; 10 granted
Technologies transferred	3
Manpower trained	54

DBT-WIPO Partnership: World Intellectual Property Organization (WIPO) for the first time is partnering with a Department of Government of India, to fund and support Global Health Innovation Fellowship. A MoU was signed between WIPO, Department of Biotechnology, Biodesign centre at IIT-Delhi and IIT-Bombay, on 12th October 2023 in New Delhi. A total of 157 applications were received against the advertisement and after screening and selection, four international fellows, 2 each at IIT Delhi and IIT Bombay, have been finalized for duration of 24 months. The fellows have joined the programme.

DBT-Handbook on Biodesign for Med-Tech Innovations: The Department had constituted a Working Group to draft a report on "DBT Biodesign Guidelines". The Working Group constituted of subject matter experts, academicians, stakeholders, etc. The Hon'ble Minister of Science and Technology, Dr Jitendra Singh, launched the "DBT-Handbook on Biodesign for Med-Tech Innovations" on 5th February 2024 at India Habitat Centre, New Delhi. The document will serve as a handbook for undertaking Med-Tech entrepreneurship through the Biodesign process of Identify, Invent and Implement (**Figure 3.C.5**).

Figure 3.C.5: Launch of DBT-Handbook on Biodesign for Med-Tech Innovations

DBT-Biodesign Centres: During the reporting period, six Biodesign Centres have been supported (**Figure 3.C.6**). The major achievements of each of these are listed below:

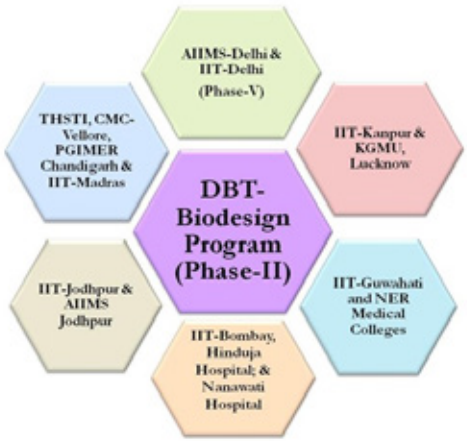


Figure 3.C.6: DBT-Biodesign Centres

A. School of International Biodesign (SiB) Programme (AIIMS New Delhi and IIT Delhi)

The Centre has completed Phase-IV of Biodesign Programme in 2023. During Phase-IV, 29 Indian and 02 international fellows were trained. The fellows completed 10 projects. The Centre has filed 10 patents. 04 startups were created and 01 product commercialized. 02 technologies developed during Phase-IV were transferred to spin-offs developed by the fellows. The products developed in Phase-IV included (**Figure 3.C.7**): Eturnal-An effective device to timely reposition the bedridden patients in order to prevent pressure injuries and minimize burden of care; Urovib- a device to prevent Catheter associated urinary tract infections; A device for non-invasive, continuous monitoring of vascular perfusion in transplanted tissues / flaps, in order to prevent tissue / flap loss; Cerva - A more accessible way to identify & treat cervical pre cancers in a single outpatient visit; Milagro - A better way to administer NIV that reduces leakage and incidence of pressure ulcers; MorphX1 – a device for cost effective and fast blood diagnostics; Physion – a device for ultrasound therapy at home for management of knee osteoarthritis; A safe and comfortable one-piece full-body protective suit with built-in ventilation support; AiroDam- An efficient and cost-effective way to protect the dentist from bio-aerosols during procedures; HipPro+ - a device to prevent hip fracture and injuries; ReMind - Home-based rehabilitation system for stroke and other neuromuscular diseases; Realtime needle tip and trajectory tracking solution for safer and accurate ultrasound guided interventional procedures such as nerve blocks. Phase-V has been implemented from January 2024.

Figure 3.C.7: A. HipPro+- a device to prevent hip fracture and injuries; B. ReMind - Home-based rehabilitation system for stroke and other neuromuscular diseases.

B. School of Innovations in Biomedical Devices and Systems and Inter-institutional Biodesign Center (SIBDS-IIBC): Biodesign Center at IIT Guwahati, NEIGRIHMS, Shillong & GMC, Assam

The focus area of the center includes - Biomedical Devices used in Musculoskeletal System; Surgical Devices, Testing Equipment as per ISO Standards; and AI enabled Diagnostic Devices and Tools. At present 08 fellows are working under the programme, including one industry sponsored fellow. There are 06 products under various stages of development; one of the products is at TRL-06. The products under development are: Impression 3D Digitization & Computer-Aided Manufacturing in Custom Foot Insole (I3DCAM) - an apparatus for impression mapping of foot structure; Hygiene management devices for bedridden people; Passive Knee Off-Unloader Exoskeleton System; Wearable IoT based Therapeutic and Preventive Device for Varicose Veins; Device for Harvesting Cancellous Bone Grafts During Orthopaedic Surgeries; and C1-C2 Implant Simulator. The Center has applied for patents for one of the products and 04 applications are under process.

C. 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: Biodesign Center at IIT Jodhpur & AIIMS Jodhpur

The Center is focusing on the development of medical devices, implants and diagnostics. At present, 08 fellows have been recruited who are working towards development of 06 technologies. The technologies under development are: SWASAM a device for reshaping the nasal septal cartilage via electromechanical reshaping (EMR); Single Hand and Operator Controlled Syringe for Ultrasound Guided Procedures; Root canal irrigation device; Bedridden Patient Care; Bioprinting for Drug Screening; and point of care device. The Center has applied for 03 patents. 05 Start-ups have been established.

D. Inter-institutional School of diagnostic Innovation in Biodesign: A fellowship program for building next generation pool of diagnostic innovators and entrepreneur: Biodesign Center at THSTI, New Delhi; IIT Madras; CMC Vellore; PGI, Chandigarh & Venture Center, Pune

The focus area of the center is in-vitro diagnostics and science-based product development. In the first batch 7 Biodesign Fellows were recruited. The fellows have finalized five needs for development including: Screening tool for Oral Cancer; Real time monitoring of drugs in critical care patients; Development of midstream urine collector for women; Non-invasive early detection tests for endometriosis; and Early diagnosis for acute kidney injury. Five patents have been filed.

E. School of International Biodesign (SIB)-Synergizing Healthcare, Innovation and Entrepreneurship (SHInE): Biodesign Center at KGMU Lucknow & IIT Kanpur

In the first cohort, 09 fellows have completed their fellowship. The first cohort has developed six products. These include: A Laparoscopic tool for surgery; Device for early detection of Breast cancer; Device for foot drop Syndrome; Device for detection of Arrhythmia; A device to break coronary calcium of the heart; and Assistive CPR device. The fellows have incorporated two Start-ups to expedite the commercialization of their medical devices. Three patents have been filed. The second cohort has joined the programme and is undergoing Clinical Immersion.

F. Medical Engineering, Design and Innovation Centre (MEDIC): Biodesign Center at IIT Bombay & Hinduja Hospital

10 fellows have joined the fellowship programme. Clinical immersions are going on.

Figure 3.C.8: KADAM - Device for foot drop syndrome

The fellows have identified 35+ unmet needs and shortlisted 11 for taking further.

Cancer Disease Biology

With advancement in scientific tools and technology, the mystery of cancer is unravelling, and the Department of Biotechnology continues to support and promote basic, translational and inter-disciplinary research through a program on Cancer Disease Biology. In the year 2023, a number of areas were supported such as developing PDX models that replicate human tumors with high fidelity and exhibit treatment responses, establishing cell lines with knockdown of gene of interest, designing and synthesizing peptides targeting telomeric length in cancer cells, mechanistic insights into tumor progression, migration and invasion, identifying potential therapeutic and prognostic biomarkers and identifying inhibitors against the lead molecule or target gene etc. The types of studies broadly supported under the program can be classified into Knowledge Research and Translational Research. The significant achievements emerging out of these programs is as follows:

Major Achievements:

No. of research publications	21
No. of patents	1

Knowledge Research:

One of the studies demonstrated a tight correlation between GSK3β activity and Six1 levels during cell

cycle progression and provided insights into the signaling mechanisms by which GSK3β exerts pro-tumorigenic effects by stabilizing Six1 and preventing its degradation. Both GSK3β and Six1 are reported to be overexpressed in various forms of cancers and high levels of Six1 are associated with overall tumor burden and disease prognosis.

In another study, the role of RAD51 paralogs in preventing R-loop accumulation during replication stress was examined and it was observed that mammalian RAD51 paralogs RAD51C and XRCC3 but not RAD51B, RAD51D and XRCC2 deficient cells exhibit R-loop accumulation spontaneously (**Figure 3.C.9**). The increase in accumulation of R-loops in RAD51C/XRCC3 depleted cells was also shown to be rescued by overexpression of R-loop cleaving enzyme RNaseH1.

In yet another study, the subcellular proteomic analysis identified differential behavior of the ER/PR+ and ER/PR- breast cancer cells in response to inflammatory condition. A different study explored the mechanism of viral infections induced epithelial-mesenchymal transition (EMT).

An ongoing study revealed the role of recombination activating genes (RAGs) in chromosomal rearrangements in human glioblastoma, demonstrating the ability of RAGs to bind and cleave at cryptic RSS substrates associated with breakpoints. Extrachromosomal recombination assays revealed lower efficiency in fragile regions associated with GBM, suggesting RAGs' involvement in chromosomal translocations and interstitial deletions suggesting a non-canonical RAG-mediated mechanism contributing to glioma-associated SVs. Interestingly, it was noted that tumorigenesis was significantly hampered when xenografts were generated using RAG1 KO GBM cell line. Overall, these findings suggest diverse and significant roles for RAG1 in brain function, glioma genesis, and maintenance of neural tissue integrity.

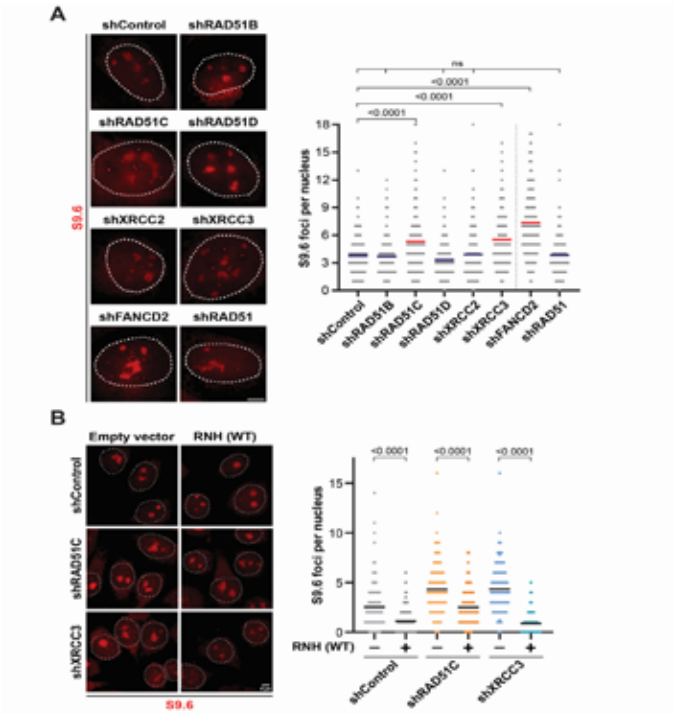


Figure 3.C.9 RAD51 paralogs participate in R-loop resolution in mammalian cells. (A) Representative S9.6 staining of RAD51, FANCD2 and RAD51 paralogs depleted HeLa cells. Quantification shows a significant increase in R-loop accumulation after RAD51C and XRCC3 depletion. FANCD2 acts as a positive control. (B) Representative S9.6 staining of control, RAD51C and XRCC3 depleted HeLa cells in presence or absence of RNH-Flag (WT) overexpression. Overexpression of RNH-Flag(WT) rescued the observed phenotype. Nuclear boundaries are marked with white dotted lines. (n=3, two-tailed Mann-Whitney U test)

Translational Research:

A study on Colon Cancer identified Lipocalin 2 (LCN2) as potential prognostic and therapeutic target in therapy-resistant late-stage colon cancer. Two potential mechanisms by which LCN2 promotes invasion and migration were also studied (**Figure 3.C.10**): One that LCN2 promotes invasion by inhibiting actin glutathionylation in an iron-dependent manner and another by promoting the formation of focal adhesions by stimulating the activation of Src kinase. The investigator's team in previously supported grant from the Department have developed a monoclonal antibody against LCN2 that could inhibit invasion & migration and

serve as the basis for a potential therapeutic. A patent has been filed for this antibody and the team is further working to license the antibody to companies for product development.

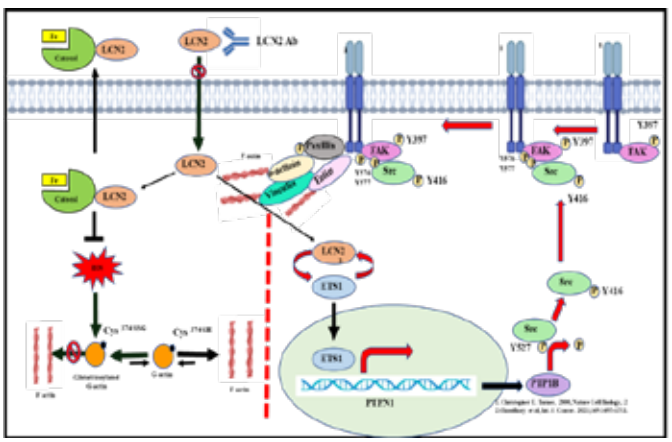


Figure 3.C.10. Model of the mechanism by which LCN2 promotes migration and invasion.

A collaborative project under Virtual National Cancer Institute (VNCI) initiative led by Tata Memorial Hospital, Mumbai on "Multi-Omics analysis to decipher mechanism of hormone Resistance in Breast Cancer" have standardized a process to establish Patient Derived Xenograft Models from minimum amount of tissue from cancer patient core biopsy has been established. These PDX models will serve as novel in-vivo pre-clinical models for development of novel therapeutics and will constitute a very valuable resource for the pharmaceutical industry in India giving an impetus to Make in India aligning with the nations goals of self sufficiency

A novel BCL2 inhibitor was designed, synthesized, and characterized with the potential to be used as an anticancer drug against leukemia, lymphoma, and many other cancers, such as head and neck, ovarian, triple-negative breast cancers from India. Preclinical toxicological studies showed that the novel BCL2 inhibitor, *Disarib*, does not affect the survival and function of normal cells (**Figure 3.C.11**). The evaluation of its toxicity in nonrodents is in progress before it can enter the clinical trials.

A promising NGS based Liquid Biopsy platform has been established where circulating tumour DNA from plasma of cancer patients progressed on endocrine hormone therapy, is subjected to next generation sequencing using a custom amplicon panel for 348 genes. This liquid biopsy platform will enable identification of point mutations in 348 full length genes with high sensitivity and specificity and will be one of the first assays to be developed indigenously which is validated on Indian patients. The plan is to scale up this assay to be able to identify copy number variations, methylation and eventually, translocations/fusions in cancer patients.

CD8 T cells, often called cytotoxic/killer T cells, are key players of our immune system in eliminating viruses and cancers. The efficient generation of antigen specific long-lived (memory) CD8 T cells following vaccination is critical to ensure the protection against the incoming infections. On the other hand, the CD8 T cells inside the tumour residing in a helpless condition are required to get activated to kill the cancer cells. Both issues pose challenges for scientists and clinicians. To address these challenges and come up with reasonable solution and affordable treatment, the immunology laboratory at the Institute of Science, Nirma University developed a Chimeric IL-15 using the tools of genetic engineering. The Indian patent filed for making this therapeutic biological drug was granted on March 19, 2024. Based on the experimental evidence, this molecule holds the potential to be developed as a drug to treat solid tumours and also in the vaccine formulation to promote the generation of memory CD8+ T cells against viruses and other intracellular pathogens. Based on in-silico prediction and SDS-PAGE analysis upon expressing the protein as a dimer, the chimeric IL-15 looks like an antibody without a light chain (**Figure 3.C.12**). Further structural study by crystallizing chimeric IL-15 or by Cryo-EM will be performed to elucidate its actual structure.

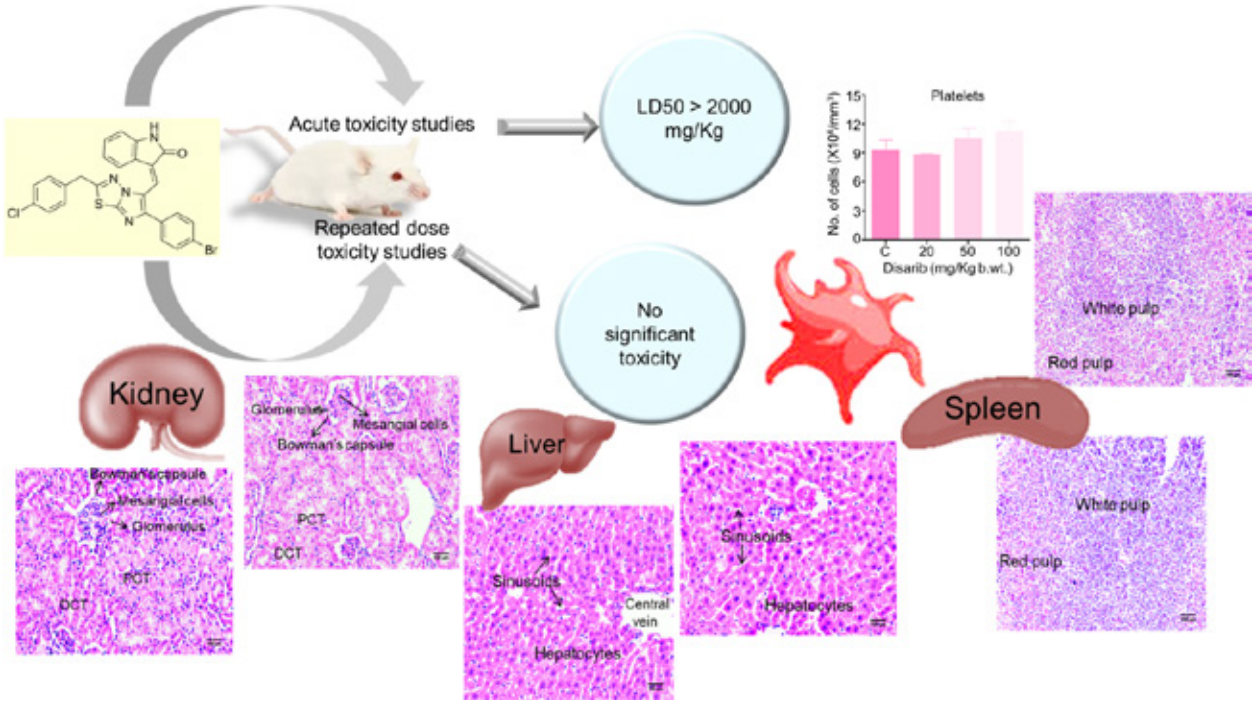


Figure 3.C.11: The figure depicts that Disarib exhibits a safety profile with no observed acute or chronic toxicity. The LD50 value, was determined to be >2000 mg/Kg, highlighting its substantial efficacy of safety. Moreover, Disarib treatment demonstrates the absence of platelet-related toxicity like thrombocytopenia, and it does not impart toxicity to any organs within the body.

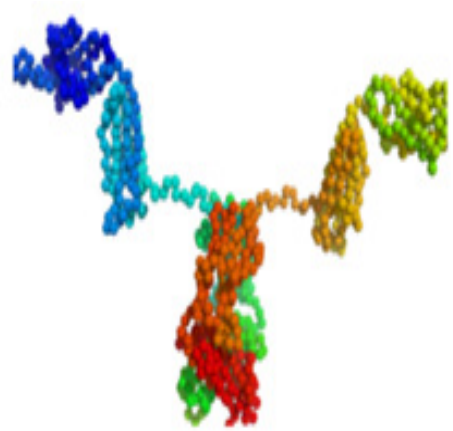


Figure 3.C.12. Predicted Structure of the Chimeric IL-15

Chronic/Lifestyle Diseases

The Department of Biotechnology under its 'Chronic Disease/Lifestyle 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 efforts so far have been to delineate the mechanistic insights of the underlying diseases and further underpin the physiological and pathological aspects of the diseases towards developing potential therapeutic strategies.

During the year, several studies have been supported in key areas of this diversified field of research. Some of the achievements emanating from the supported studies are as follows:

Major Achievements:

No. of research publications	21
No. of Manpower trained	118

Indian Chronic Kidney Disease (ICKD) Study-Second Phase:

The ICKD study is a well-established and globally renowned CKD cohort. It has enrolled >4300

patients across 11 centers across India and is the second largest CKD cohort worldwide. The ICKD study has produced original research articles in international peer-reviewed journals, received international recognition and is also part of iNET-CKD, an international consortium of CKD cohort studies of the International Society of Nephrology, Chronic Kidney Disease Prognosis Consortium (CKD-PC) and Global Kidney Patients Trials Network (GKPTN). Analysis of baseline subjects shows unique characteristics for Indian subjects which reinforce the need for and value of the data from this cohort. The study is aimed at understanding the clinical behaviour in terms of disease progression and disease complications during follow-up of chronic kidney patients enrolled in the first phase of study. The study has shown several findings around the association of quality of life with socioeconomic rather than medical factors, unmet treatment needs in our study of prescription patterns, gaps in the overall quality of care. One unique finding is the first-time strong and independent association demonstration of serum-free catalytic iron with composite major adverse kidney events in patients with CKD despite adjustment for gender, age, occupational exposure, hypertension, diabetes, tobacco, alcohol, history of acute kidney injury and eGFR. This finding has opened the door to a randomised clinical trial of iron chelation therapy. Another analysis shows that ACEI/ARB use is associated with a slower rate of decline in eGFR in those with CKD stages 1-3. ACEI/ARB users had a significantly lower risk of renal outcomes and cardiovascular mortality.

Multi-institutional Network Program on Systemic Lupus Erythematosus: Understanding the Diversity of SLE

First prospective inception cohort on Systemic lupus erythematosus for research (INSPIRE) has been developed from across India of 2503 patients The study has revealed phenotypic heterogeneity across different parts of the country. Autoantibody profile suggests high prevalence of Lupus specific antibodies: anti-Sm and anti Ribo-P antibodies in Indian population. Antibody clusters suggest co-occurrence of autoantibodies associated with specific phenotypes. Gastrointestinal involvement is associated with higher disease activity and mortality. A low-cost calculator has been developed comprising of age, CRP and total leucocyte count that is able to differentiate between infection and flare. The calculator has been validated and found to have good prediction. In a sub-study, it is found that about 2/3rd of patients with SLE have vitamin D deficiency/insufficiency which is much more in North India. High dose vitamin D (60,000 weekly X 5 dose and then monthly) improves vitamin D levels but has no impact on disease activity and nor does it prevent flares. Vitamin D levels do not show any association with disease activity or Type I IFN regulated proteins. The project has also established a biorepository as part of the study (blood and urine samples). This is a rare resource of longitudinal samples from patients with SLE which can be used for biomarker analysis. Further, DNA samples of 2028 patients are available for Genome studies.

Centre for Research in Low Back Pain and Degenerative Disc Disease

Research into infection-induced disc disease and its correlation with low back pain (LBP) holds significant societal and economic importance. In this project supported by the Department-it is aimed to pioneer novel clinical and radiological phenotypes for early diagnosis using advanced imaging techniques and

clinical procedures. Additionally, the study includes systematic transcript profiling to distinguish proteins and pathways relevant to aging and degeneration, and to explore the role of human intervertebral disc (IVD) microflora in maintaining IVD health and initiating degeneration. The study has introduced two innovative imaging sequences, magnetic resonance spectroscopy (MRS) and T2 relaxometry (T2R), which were adapted for MRI scanners to evaluate disc degeneration. T2R assesses disc hydration and collagen content, while MRS estimates molecular concentrations of various disc constituents. Preliminary findings suggest potential for early detection, highlighting molecular distribution discrepancies among age groups and between volunteers and patients. Moreover, a new classification system for changes in the disc-endplate-bone marrow complex has been proposed, aiming to enhance surgical intervention predictability. Lead molecules identified from label-free proteome analysis are undergoing validation using labelled (TMT 10-plex tags) proteome analysis. Identification of differentially expressed proteins (DEPs) in specific pathways aids in distinguishing mechanical-damage mediated inflammation from infection-based inflammation in intervertebral disc degeneration (IVDD). Notably, complement and coagulation cascades play significant roles, with upregulated proteins predominantly involved in these pathways. Furthermore, plasma profiling indicates inflammatory characteristics in the IVDD group, with significant upregulation of complement components crucial for immune defense and tissue homeostasis regulation, suggesting potential therapeutic targets. Analysis of the IVD microbiome through 16S V3V4 metagenome analysis reveals major phyla including Bacteroidetes, Proteobacteria, Actinobacteria, Chloroflexi, and Firmicutes in control and disease tissue samples. Disease conditions exhibit reduced Firmicutes, Actinobacteria, and Bacteroidetes, and increased Proteobacteria, indicating dysbiosis. QIIME2 analysis using the Greengenes database identifies approximately 27 genera, with top genera *including Pseudomonas, Prevotella, Ochrobactrum, Mycobacterium, Bacteroides, Sphingomonas, Clostridium, Acinetobacter, Faecalibacterium, and Leifsonia* in both control and disease tissue samples. Despite similar top genera, there are significant abundance differences that may elucidate disease phenotypes. Similarly, profiling of the gut microbiome through 16S metagenome analysis distinguishes major phyla such as Bacteroidota (Bacteroidetes), Proteobacteria, Firmicutes, and Actinobacteria in healthy volunteers and disease fecal samples, revealing significant abundance variations between the groups.

Functional Analysis of PHLPP1 in Myogenesis: Implications for skeletal muscle dystrophies

A study from Dr. Reddy's Institute of Life Sciences, Hyderabad was supported to delve deeper into the molecular mechanisms of myogenesis with implications for muscular dystrophies. The study investigates the functional significance of Ser/Thr Phosphatase (PHLPP1), in the control of myogenesis. It was observed that forced expression of PHLPP1 in myoblasts improves myogenesis (myotube formation) and PHLPP1 depletion led to remarkable changes in the differentiating myoblasts showing a compromised myogenesis gene expression program. PHLPP1 controls the homeostasis of mitochondria, which is dys-regulated in several diseases including muscular dystrophies.

New Initiatives undertaken:

During the year, Division has issued a Special Call for proposal on "Chronic Pain and its Management". Pain is a debilitating symptom of many diseases and is considered a disease itself when it persists beyond recovery from an injury or illness. It is a major unmet global public health challenge

that causes significant disability and debilitating features of long-term conditions including arthritis, cancer, diabetes and dementia. To address this challenge, the Call was issued, and the Department received a total of 135 EOIs and 25 were short-listed for full proposal submission. Six projects were recommended for financial support by the Department.

Genome Editing Applications in Healthcare

Recognizing the power of Genome Editing techniques to study and manipulate the genome, the Department has been engaged in promoting research and innovation in the area of genome engineering technologies and their applications in healthcare. Steps have been taken to encourage R&D programs in emerging genome engineering technologies and their applications in healthcare with the focus on the following niche areas: development of new cutting-edge tools and technologies for high-throughput, precise and efficient genome editing for healthcare applications; development of efficient and high throughput genome editing platforms in a wide range of laboratory animal models for catering to basic biomedical research and human disease modelling; and development of genome editing-based therapeutic solutions for the most prevalent genetic disorders in India.

No. of research publications	21
No. of Patents Applied/ Granted	02
No. of technologies developed/ commercialized	02
No. of Manpower trained	42

CRISPR based HIV -1 detection assay: In a DBT-supported project being undertaken at AIIMS, Delhi, a proof-of-concept Cas12a based qualitative cleavage assay has been successfully developed for detection of HIV-1 subtype C virus in infected children and adults. This detection assay was found to be specific for HIV-1 detection and successfully detected HIV-1 cDNA from all the subtype C infected donor blood samples tested in this study. (Indian Provisional Patent Application No.- 2022211059208)

In a separate study supported by the Department being undertaken at CMC, Vellore, CRISPR base editing has been used for the recreation of point mutations into the γ-Globin Gene (HBG) promoters and induce HbF to therapeutic levels. Precise base editing using adenosine or cytosine base editors has been found to be highly efficient in creating point mutations without inducing DSB breaks and the requirement of a donor template.

GenomeIndia Project

GenomeIndia is a flagship project funded by the Department of Biotechnology, Ministry of Science and Technology, Government of India. The project was launched in 2020, with the ambitious goal to identify and catalogue the genetic variations of diverse Indian populations by sequencing the whole genome of 10,000 healthy individuals from 99 communities, representing all major linguistic and social groups, across the country. The project is an exemplar of Nation-wide Scientific collaboration and innovation involving 20 national institutes which included 4 sequencing centres; 13 sample collection centres; and 8 method development centres (with some centres playing multiple roles) (**Figure 3.C.13**). The target of the project is to develop a reference genome for the population of India which will lead to a better understanding of the nature of diseases and specific interventions essential for various ethnic groups. The study will help in designing genome-wide and disease-specific genetic chips for low-cost diagnostics and research.

On 5th January 2024, the consortium completed the whole genome sequencing of 10,074 individuals

and same was announced by the Government on 27th January 2024 (**Figure 3.C.14**). The consortium of 20 institutions has established a national biobank of DNA and Plasma for approximately 20,000 individuals at the Centre for Brain Research located in the Indian Institute of Science campus, Bengaluru. More than 9800 sequence files of whole genome sequencing are already archived at the Indian Biological Data Centre (IBDC) set up by Department of Biotechnology, Government of India at the Regional Centre for Biotechnology (RCB), Faridabad. This digital public good will democratize data and become a valuable national resource, fostering large-scale human genetic studies and empowering nation-wide research efforts by the Indian and even the global research community.

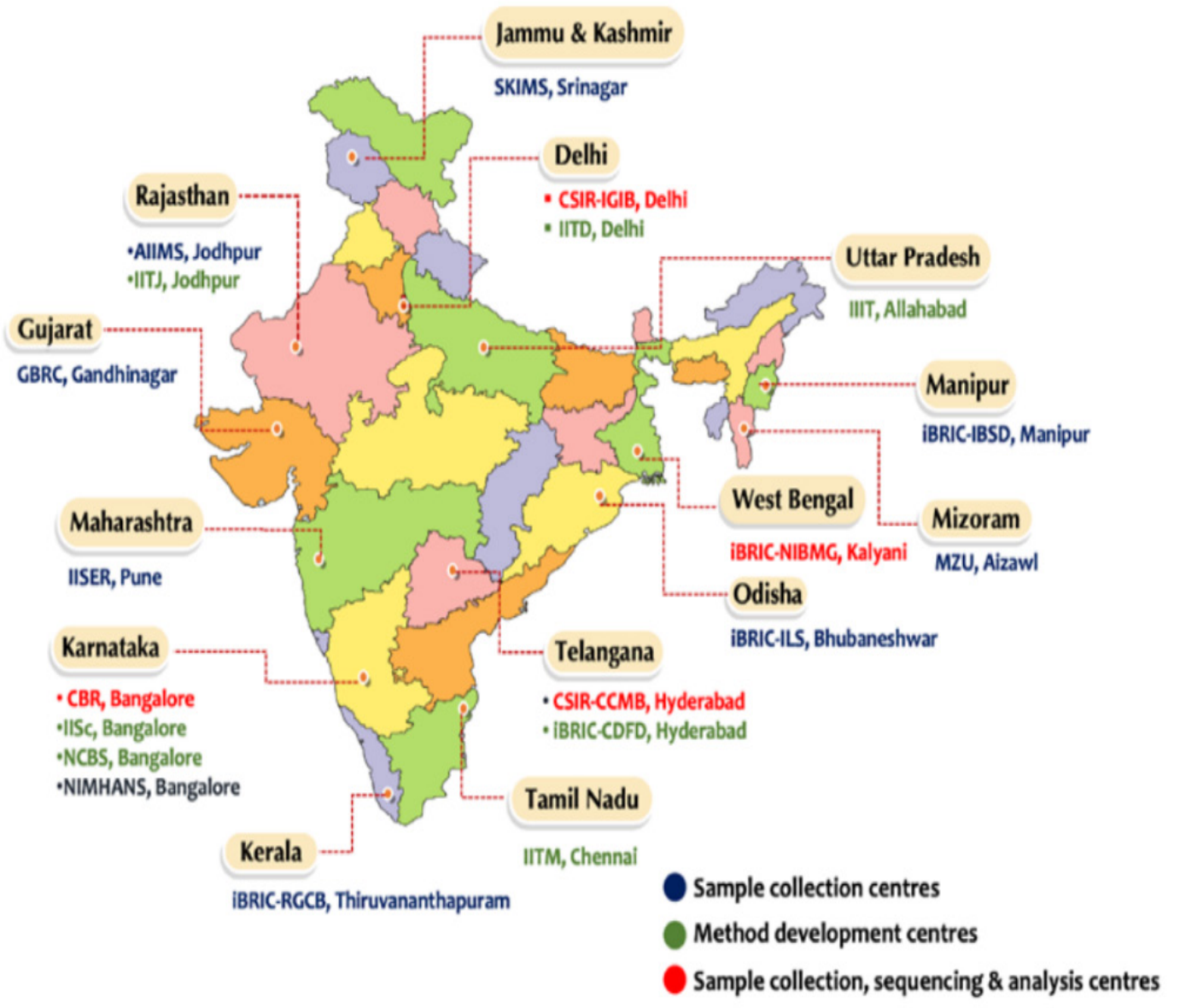


Figure 3.C.13: GenomeIndia comprises dedicated scientists and researchers from 20 partner institutions, with some of the institutions playing multiple roles.

Figure 3.C.14: Announcement of completion of 10000 whole genome sequencing on 27th January 2024 by Dr Jitendra Singh, the Hon'ble Minister of S & T

The preliminary analysis has resulted in the identification of 135.48 million variations. Among these, there are 117.8 million bi-allelic Single nucleotide variants (SNVs), 10.6 million Insertion-Deletion (INDEL) bi-allelic, and 6.97 million multi-allelic genetic variants. As expected, the majority of the variants (65% of SNVs and 64% of INDELs) belong to the ultra-rare category, with a minor allele frequency (MAF) of less than 0.1% in the overall population. A substantial number of common variants are rare or non-existent in the global databases that catalogue variants. This discovery will enable and enrich the set of innocuous variants and will facilitate studies of discovering genetic variants for rare diseases by eliminating innocuous variants from a list of candidate variants.

Human Microbiome Initiative (HMI) of select endogamous populations of India

This is a national flagship program of DBT implemented at the Biotechnology Research and Innovation Council-National Centre for Cell Sciences (BRIC-NCCS). It was initiated with the vision to map a reference microbiome of healthy individuals across the country. Special emphasis has been given on tribal microbiomes because it has been shown that rapid urbanization and rampant antibiotic usage are diminishing our microbiome which is important for our overall health. The project had the target of sampling more than 3400 individuals across the country from 17 endogamous communities. Comprehensive data on diet, demography, host genotype, Ayurvedic *Prakriti* phenotypes and correlation with bacterial, fungal, archaeal and microeukaryotic diversity have helped to identify community-specific microbial signatures. Microbiome profiling for 3878 individuals has been completed. It has been learnt from the study that tribal communities untouched by modern lifestyle and westernization harbour a higher microbial diversity which was found to confer health benefits. Microbes preserved from tribal communities may hold the key to the development of indigenous precision probiotics.

Some of the key conclusions from the project are as follows:

a. Clear grouping of communities based on dietary data from a food frequency questionnaire was observed using Bray-Curtis dissimilarity metrics with an NMDS (Non-metric multi-dimensional scaling) plot (**Figure 3.C.15**).

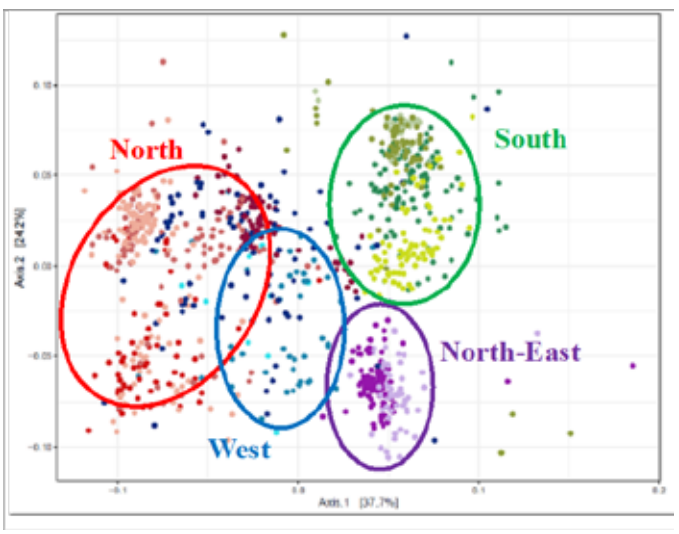


Figure 3.C.15: The HMI study assessed gut microbiome of 3878 healthy individual following traditional diet from tribal and non-tribal communities across India

b. This first comprehensive study worldwide found associations between diet, demography, and Ayurvedic Prakriti phenotypes with the

diversity of four kingdoms (bacterial, fungal, archaeal, and micro eukaryotic), identifying community-specific microbial signatures. Pitta Prakriti individuals had significantly different microbiomes.

c. The study identified five enterotypes in the Indian population, whereas other populations globally have shown only four.

d. In the Indian population, spices and condiments had the highest association with the gut microbiome, irrespective of biogeographical variation. Tribal communities showed higher alpha diversity compared to non-tribal communities.

e. This is the first reference human microbiome study from healthy Indian individuals, paving the way for future research on disease models and precision probiotics, and aiding dietary and probiotic recommendations through comparison with large-scale healthy microbiome data.

Human Genetics and Genome Analysis

The Human Genetics and Genome Analysis program of the Department of Biotechnology (DBT) supports research and development activities to uncover the role that genetics plays in human health. With a large population size, high birth rate, and consanguineous marriage being favoured in some population groups, there is a relatively high prevalence of genetic disorders in India. In this context, the Department's R&D program on Human Genetics and Genome Analysis seeks to address the burden of such diseases by understanding the mutation spectrum of diseases having a genetic basis, developing cost-effective diagnostic methods for genetic diseases, developing personalized medicines regimen and development of affordable therapies for these diseases.

No. of research publications	28
No. of Patents Applied/ Granted	01
No. of Manpower trained	142

Mission Program on Pediatric Rare Genetic Disorders (PRaGeD)

The Mission program on Pediatric Rare Genetic Disorder (PRaGeD) is a Pan-India initiative to develop methods for diagnosis of difficult-to-diagnose pediatric rare genetic diseases, discover and characterize new gene/variants, provide counselling and to develop new therapies for pediatric rare genetic diseases in India. The Centre for DNA Fingerprinting and Diagnostics (CDFD) in collaboration with 15 centres across India is recruiting patients and their families with rare genetic disorders. Under the program, so far, a total of 749 families with unexplained genetic conditions have been recruited by 16 collaborating centers after extensive conventional investigations such as karyotyping, MLPA, targeted Sanger sequencing and Chromosomal Array. Exome sequencing has been completed in 341 cases (**Figure 3.C.16**). Further, for 20 cases, Whole Genome Sequencing has been undertaken. Using this approach, 89 cases with difficult-to-diagnose rare genetic disorders could be diagnosed, so far. A total of 99 variants in 82 genes have been identified, out of which, 37 are pathogenic variants, 36 are likely pathogenic variants and 26 are VUS (Variants of Uncertain Significance). Another key aim of the study is to understand the pathophysiological mechanism of poorly-characterized rare genetic diseases, towards which, 17 cases have been investigated for segregation analysis by Sanger sequencing. Besides, splicing defects in four cases have been found. Further, pathogenicity of 6 variants has also been studied by structural modeling and molecular

dynamics simulation. In vivo characterization of two novel genes SERPINA11 and AIMP2 has been undertaken in mice and Drosophila, respectively and another three novel genes SKT38L, OGFOD1 and PATJ are being characterized using various in-silico, molecular, cellular and biochemical assays.

a) Number of cases recruited under PRaGeD

Code	Centre Name	Recruited	Exome Seq.	Under Process	Solved	Analysis ongoing	Genome Seq.
1	All India Institue of Medical Sciences	134	69	10	12	57	13
2	Baba Ghulam Shah Badshah University	31	5	12	0	2	0
3	Banaras Hindu University	0	0	0	0	0	0
4	Central University of Punjab	60	43	5	6	37	1
5	Centre for DNA Fingerprinting and Diagnostics	12	7	3	4	2	2
6	Centre for Human Genetics	0	0	0	0	0	0
7	ICMR-National Institute of Research in Tribal Health	32	6	5	1	5	0
8	Institue of Life Sciences	33	10	12	3	7	0
9	NIMHANS	50	38	6	15	23	6
10	ICMR-National Institute of Reproductive Research and Health	43	6	13	2	4	0
11	Nizam's Institute of Medical Sciences	49	18	10	4	14	5
12	Rajiv Gandhi Centre for Biotechnology	23	0	3	0	0	10
13	Sanjay Gandhi Postgraduate Institute of Medical Sciences	132	93	14	34	59	0
14	University of Jammu	0	0	0	0	0	0
15	University of Madras	30	0	10	0	0	0
16	Other Institutes	102	30	16	4	26	36
	TOTAL	749	341	119	89	236	73

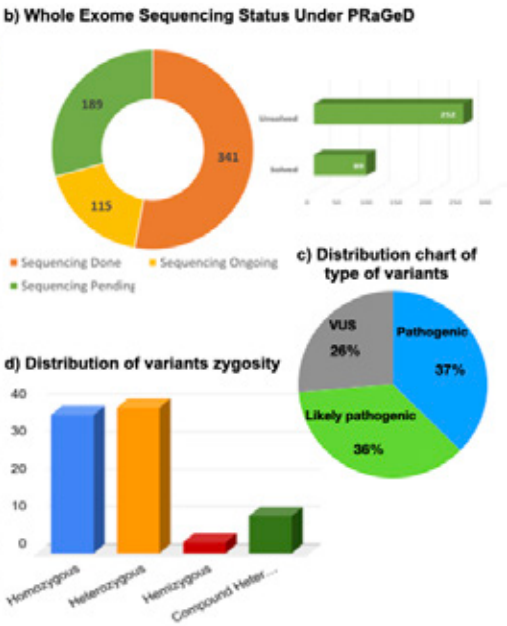


Figure 3.C.16: Mission Program on Pediatric Rare Genetic Disorders (PRaGeD) (a) Cases recruited under PRaGeD program. (b) Status of cases under exome sequencing. (c) Distribution of type of variants (d) Zygosity of variants identified under the project.

R&D Efforts in Human Genetics & Genome Analysis

Investigator driven R&D proposals have been supported by the Department in the areas of basic and applied research in human genetics. Some of the key findings emerging from these R&D efforts are summarized below.

A comprehensive diagnostic NGS panel for inherited bleeding disorders (IBD) to aid carrier screening and prenatal diagnosis has been developed in a study supported by the Department undertaken at PGIMER Chandigarh. A cohort of patients with inherited bleeding disorders was identified through coagulation studies and platelet function studies. Causal variants were identified and validated through Sanger sequencing (**Figure 3.C.17**). Genotype-phenotype correlation was done. Cost effective Next Generation Sequencing (NGS) panels – a common 6 gene panel and a larger rare inherited bleeding disorders panel have been developed based on the research outcomes.

High-resolution genomic architecture of congenital non-syndromic deafness in India has been studied in a multicentric study supported by the Department. A total of 414 families were collected at the participating centres. Among these, 106 (26%) were found to have positive histories for the disorder. Connexin 26 and Connexin 30 mutations have been found in 59 affected individuals (14%) out of 414 studied. An interesting pattern from the study of 414 families is that ~85% of the affected families do not carry mutations at the most common cause of hereditary hearing impairment identified in various populations of the world.

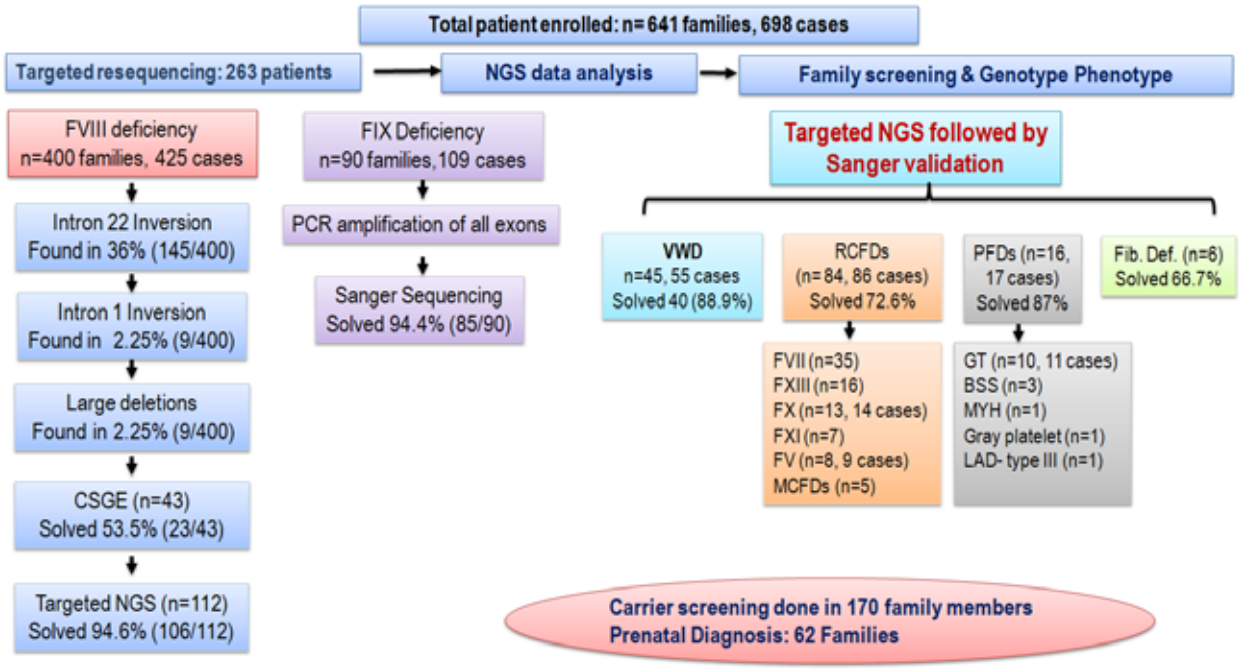


Figure 3.C.17: Studying the mutational spectrum of patients with inherited bleeding disorders.

In another study supported by the Department, a multi-centric investigation on identifying genetic variants causing or modifying tubular disorders in children with renal tubulopathy was undertaken. 250 children with renal tubulopathy including 166 trio samples (Proband, Father and Mother) were recruited across three cohorts and biospecimens were collected from patients including 166 trios for the biorepository. A total of 130 patients with varied renal tubular disorders were selected for clinical exome sequencing. Causal variants could be identified in 55.3% of those sequenced. It was found that the most common causative variant was the missense variant (**Figure 3.C.18**).

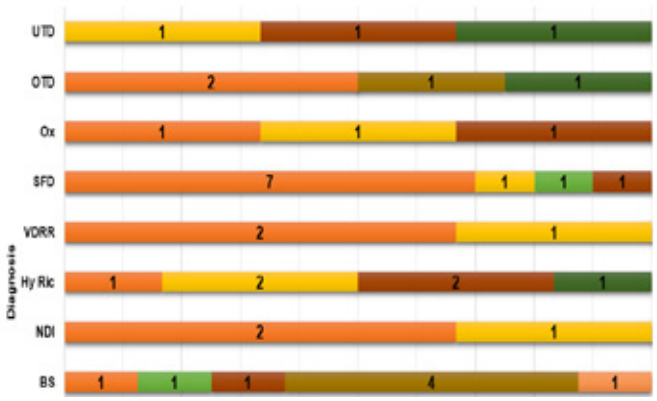


Figure 3.C.18. Types of variants causing or modifying tubular disorders in children with renal tubulopathy detected by Clinical Exome Sequencing. BS: Bartter syndrome, dRTA: Distal renal tubular acidosis, pRTA: proximal renal tubular acidosis, SFD: Stone Forming Disorders (Renal calculi, Nephrolithiasis), NDI: nephrogenic diabetes insipidus, HyRic: hypophosphatemic rickets, VDRR: Vitamin D Resistant Rickets, OTD: other tubular disorders: Renal glycosuria, hypercalciuria, liddle syndrome, etc, UTD: Unknown tubular disorders

Unique Methods of Management of Inherited Disorders (UMMID) initiative

The Department, in the year 2019, launched the Unique Methods of Management of Inherited Disorders (UMMID) initiative with the objectives: i) to establish Genetic Diagnostic Units in Government Hospitals wherein the influx of patients is greater; ii) to produce skilled clinicians in the area of Human Genetics; and iii) to do pilot scale screening of pregnant women and newborn babies for diagnostics of inherited genetic diseases in some aspirational districts to provide comprehensive clinical care (diagnosis, management, multidisciplinary care, counselling, prenatal testing).

UMMID programme was conceptualized with a vision to generate the volume of data, material resources, trained manpower and infrastructure to build the ecosystem for research in the area of rare and genetic disorders in the country. The need for UMMID has been emphasized in the National Policy for Rare Diseases 2021, issued by the Ministry of Health and Family Welfare. The programme has been viewed as an instrumental tool for the development of trained manpower, and resources and to establish a network in government setup.

In the initial pilot phase, 5 NIDAN Kendras, 7 Outreach centres and 6 training centres have been successfully established. In the last one year, these ongoing NIDAN Kendras and the Outreach centres have provided screening to more than 85000 pregnant women and 25000 newborn babies across 5 centres and 9 aspirational districts. In the past one year more than 20 faculties all over India have been trained. Mass awareness programmes regarding prevention, screening, and management of inherited disorders were routinely carried out by NIDAN Kendras at various levels including workshops, lectures, and distribution of pamphlets at high schools, nursing colleges, and primary health centres, as well as the display of public hoardings. UMMID is currently under pan-India expansion and will cover approximately 23 States/UTs through the establishment of around 70 UMMID components (**Figure 3.C.19**). 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. Prenatal screening for hemoglobinopathies includes screening for Thalassemia Major, which is a serious blood disorder requiring expensive lifelong treatment including frequent blood transfusions. Apart from a life of suffering for the affected, it places a significant financial burden on the family. Early screening at the time of pregnancy has enabled the prevention of 34 hemoglobinopathy-affected births, saving several families from the associated hardship.

Figure 3.C.19 Phase II of the UMMID initiative

Infectious Disease Biology

The Infectious Disease Biology Programme of the Department of Biotechnology aims to provide solutions to infectious diseases of global concern such as HIV/AIDS, tuberculosis (including MDR & XDR TB), vector-borne diseases; emerging or re-emerging threats such as influenza, Japanese Encephalitis and antibiotic-resistant microbes in terms of therapeutics, diagnostics and preventive measures. The programme has also supported the creation of clinical cohorts & bio-banks/ bio-repositories for COVID-19, TB, HIV & Liver diseases. The programme supported more than 100 projects in the year and also Centres of Excellence (CoE). Department of Biotechnology has also taken several initiatives to address AMR in alignment with the

National Action Plan on Antimicrobial Resistance (NAP-AMR).

No. of research publications	112
No. of Patents Applied/ Granted	08
No. of technologies developed/commer-cialized	09
No. of Manpower trained	202

Major Initiatives

Dare2eraD TB

The Department had launched an umbrella TB programme, Data Driven Research to Eradicate TB – "Dare2eraD TB". This includes setting up of the Indian Tuberculosis Genomic Surveillance (InTGS) Consortium; evidence-based regimen for treating Extra-Pulmonary Tuberculosis and Host Directed therapies as adjunct to anti-TB therapy (ATT) for shortening therapy.

Indian Tuberculosis Genomic Surveillance (InTGS) Consortium (**Figure 3.C.20**) under Dare2eraD TB initiative has been launched. This is a joint initiative of the Ministry of Science & Technology & Ministry of Health & Family Welfare led by DBT. DBT, ICMR and CSIR institutes are participating in this initiative with the aim to perform Whole Genome Sequencing of 32500 strains of TB, based on the Indian SARS-CoV-2 Genomics Consortium (INSACOG) model. This will be the first pan-India initiative at such scale to fully understand the biological characteristics of Mycobacterium tuberculosis (Mtb) and the effect of the mutations on transmission, treatment and disease severity. Data will also be useful in identifying the different Mtb lineages prevalent in different parts of India and patterns of transmission in the community as well as molecular signatures for rapid identification of drug-resistant TB. The data will aid in planning public health measures and appropriate control strategies for elimination of TB in alignment with vision of a TB Mukt Bharat by 2025. Work on the project has begun & Whole genome sequencing has been completed for >1300 strains of Mtb isolated from TB patients so far. Dedicated website has been set up to report the data (http://intgs.nii.ac.in)

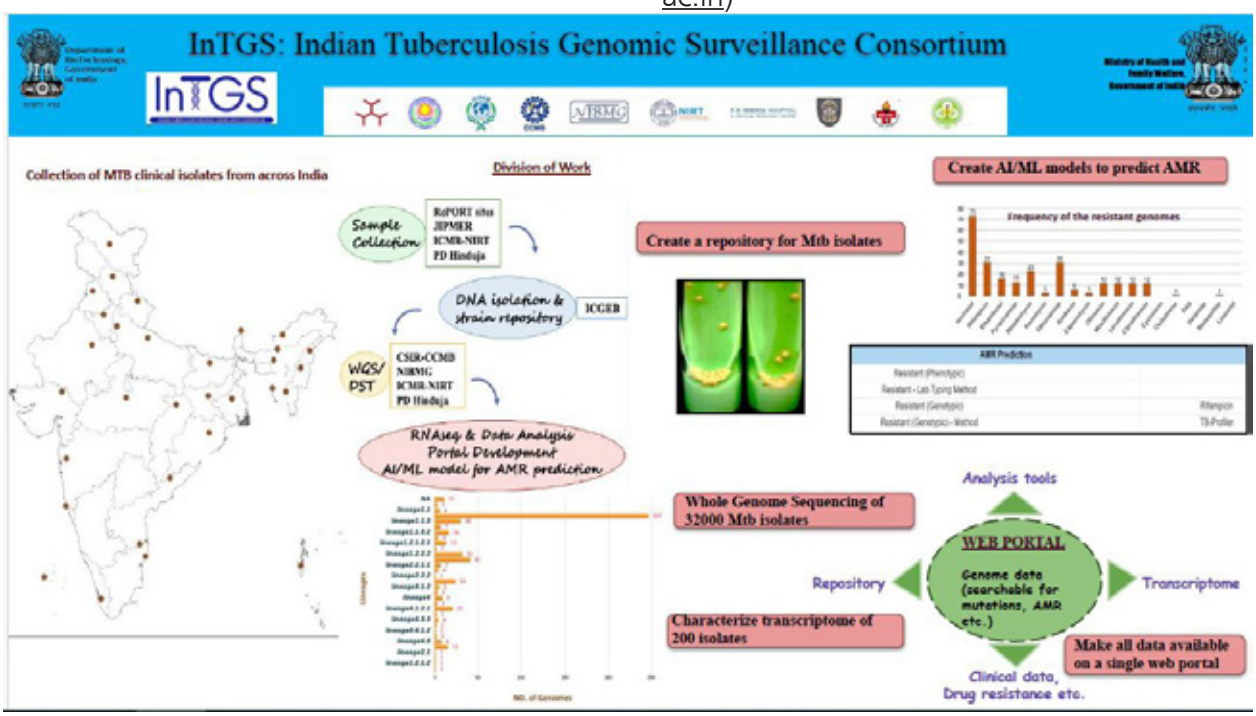


Figure 3.C.20 Indian Tuberculosis Genomic Surveillance (InTGS) Consortium

Antimicrobial Resistance (AMR)

In alignment with the National Action Plan- AMR (NAP AMR), Department of Biotechnology (DBT) has supported novel and cost-effective therapies against AMR and development of rapid cost-effective diagnostic kits to identify AMR-specific pathogens. National Centre for Microbial Resource (NCMR), NCCS, Pune has been notified to function as a Bio-repository for resistant microbes /infective agents (Bacteria and Fungi) with deposition of more than 1970 isolates so far. Indian Priority Pathogen List has been developed working along with WHO India Office to guide research, discovery and development of new antibiotics in India. The Department is also actively engaged in inter-ministerial consultations towards development of NAP AMR 2.0 being coordinated by NITI Aayog.

Research Resources: Cohorts & Bio repositories:

COVID-19 Bio repositories

The Department set up 5 COVID-19 Bio repositories at NCR Biotech Cluster- THSTI & RCB Faridabad; ILS, Bhubaneswar; InSTEM, Bangalore; ILBS, New Delhi and NCCS, Pune. More than 60000 clinical samples and 27 viral isolates have been collected and ~26000 biospecimens shared with industry and academia. THSTI's indigenous anti-SARS-CoV-2 IgG ELISA developed using the bioresource at the biorepository has been transferred to Xcyton Diagnostics, Bengaluru.

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 was 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 and ~50, 341 quality samples (Serum, Plasma and PBMCs) longitudinally collected from cohorts have been stored. This is the First National HIV Biorepository in India with a backup biorepository for split sample storage.

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

National Liver Disease Biobank (NLDB) is first liver biobank in India with storage capacity of 5.4 million biosamples established at ILBS, N. Delhi supported by DBT. 2.35 lakh aliquots of biosamples from 29,106 liver patients were collected, processed and stored centrally at NLDB via MOUs with 28 institutes throughout the nation and provided 10964 samples to 135 research projects to support the research, 33584 animal-pathology, 5769 assessment, 5383 cell sorting, 7213 mass-spectrometry, 9298 Next-generation Sequencing and research support services provided to researchers/scientists from 42 institutes. For quality assurance, NLDB became the first biobank in India accredited by ISO 20387:2018 and certified by Canadian Tissue Repository Network CTR.Net.

R&D Efforts in Infectious Disease Biology

Investigator-driven R& D proposals have been supported by the Department in areas of basic and applied research in infectious diseases caused by bacterial, fungal, viral & protozoan pathogens. Some of the key findings emerging from these R&D efforts are summarized below.

Indian HIV 1 Subtype C samples from early and chronic infection phases revealed new activation properties of viral LTR variants and host serum protein expression profile with implications for stronger viral latency and persistence under the Indo-Dutch Collaborative Program on HIV/AIDS Research supported by DBT. In a DBT-supported study at IIT Bombay, investigators show that several

proteins required for the completion of the DNA base excision repair (BER) pathway are packaged within the virions of Mimivirus as well as related viruses while they are absent from the virions of Marseillevirus and Kurlavirus that are NCLDVs with smaller genomes.

Structural, bioinformatics, and mutational studies in a DBT supported project at IISc, Bangalore suggest that UdgX diverged from F4-UDGs, and the emergence of the characteristic R-loop in UdgX is functionally assisted by A53/G53 to Q53 changes in motif A. This was published in Nucleic Acids Res.. In another DBT-supported project at IISc, Bangalore & BRIC-THSTI, Faridabad, investigators combine experiments and mathematical modelling to reveal a general design that prevents disproportionately large responses to weak signals, compromising bacterial fitness: phosphorylated histidine kinase (HK~Ps) can be sequestered by non-cognate response regulators (RR).

In a DBT-supported project at IISc, Bangalore investigators describe how pathogenic traits might evolve in bat-associated zoonotic viruses and reveal mechanisms that can be targeted to alleviate respiratory epithelial damage in respiratory virus infections. Investigators in a DBT-supported project at BRIC-CDFD, Hyderabad, discovered a novel mast cell inhibitor, PPE2 protein/peptide which has shown promising result in treating inflammation and tissue injury better and faster than the commercial drug Diclofenac. Lipid import-mediated replication checkpoint has been discovered for the first time in malaria parasites in a DBT-funded project at CSIR-IICB, Kolkata, which has opened a new avenue for novel anti-malaria therapeutics.

Nanotechnology Applications in Healthcare

The Department has been engaged in promoting research and development in the area of nanotechnology applications in healthcare to address the challenges of important human diseases. Major thrust areas include nanotechnology-based diagnostics for early disease detection; development of point-of-care sensors/detection systems based on nanotechnology; development of new therapeutics and targeted drug delivery vehicles based on nanotechnology; enhancement of efficacy of existing drugs using nanocarriers; and development of smart-nanomaterials for medical applications.

No. of research publications	28
No. of Patents Applied/ Granted	04
No. of technologies developed/ commercialized	04
No. of Manpower trained	65

Dual-sensitive fluorescent nanoprobes have been developed for the detection of matrix metalloproteinases and low pH in a 3D-tumour microenvironment (**Figure 3.C.21**). The overexpression of matrix metalloproteinases and low extracellular pH are two key physiological parameters involved in cancer initiation, progression, and metastasis. These have been the targets for several cancer detection and imaging modalities. In a study supported by the Department, undertaken at IIT, Delhi, dual-sensitive nanoprobes have been fabricated from carbon nanoparticles decorated with an MMP-9 sensitive peptide sequence. Carbon nanoparticles are known for their intrinsic fluorescence properties and are hence used as a pH-sensing moiety in the nanoprobes. In addition to this, selective cleavage of the peptide sequence by MMP-9 results in the generation of a fluorescence signal due to the separation of the quencher molecule from the fluorophore attached onto the MMP-9 sensitive peptide sequence, resulting in its detection. This protease-specific activation of the nanoprobes helps in precise tumour environment detection and imaging. The potential of these dual-sensitive nanoprobes to distinguish tumor-like

microenvironments, where pH is low and MMP-9 levels are high, from noncancerous ones was evaluated in vitro in 2D cell culture as well as in 3D microscaffolds. Such a detection platform could not only be useful in detecting tumors but can also provide valuable insights on growth, proliferation and local changes in the tumour microenvironment. Such a detection platform could not only be useful in detecting tumors but can also provide valuable insights on growth, proliferation and local changes in the tumor microenvironment.

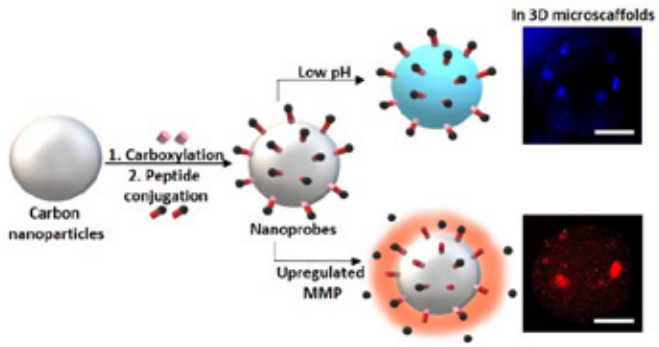


Figure 3.C.21: Drug eluting Nanowafers as a treatment modality for dry eye syndrome

In a separate study supported by the Department, undertaken at Manipal Academy of Higher Education, Cyclosporine A (CsA)-Cyclodextrins (CDs) inclusion complex-loaded nanowafers have been developed for the efficient and safe ocular delivery of CsA towards the treatment of Dry eye syndrome (DES) – a multifactorial disease related to tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability. DES has the potential to damage the ocular surface, accompanied by increased osmolarity of the tear film and inflammation of the ocular surface. The delivery system offers the convenience of lesser drug dose and reduced frequency of application for treatment of DES.

National Biopharma Mission

The **National Biopharma Mission (NBM)** is an Industry-academia Collaborative Mission aimed at accelerating discovery research to early development for biopharmaceuticals under the "Innovate in India for Inclusiveness (i3)" project. Approved by the Union Cabinet with a budget outlay of INR 1500 Cr, co-funded 50% by The World Bank (as a loan), NBM is implemented by the BIRAC Program Management Unit. The mission aligns with the national initiatives 'Make-in-India' and "AatmaNirbhar Bharat."

The mission aims to:

- Enable and nurture an ecosystem for advancing India's technological and product development capabilities in biopharmaceuticals.
- Transform health standards through affordable product development.

NBM focuses on two main components:

(i) Ecosystem Development: To create an enabling environment by:

- **Shared Facilities:** Establishing/strengthening research/manufacturing facilities.
- **Scientific Research:** Building a consortium for developing innovative technologies.
- **Clinical Trial Networks:** Linking clinical trial units with a network of experts and sites.
- **Skill Development/Training:** Developing skilled manpower with interdisciplinary competencies.
- **Technology Transfer Offices:** Enhancing technology transfer capabilities.

(ii) Development of Specific Products: Focusing on vaccines, biotherapeutics, medical devices, and diagnostics to address high disease burden/needs in the country.

Summary of Achievements

- **RFPs and Projects:** 39 Request for Proposals (RFPs) published; 143 projects supported, 65 completed, involving 214 grantees (134 private sector, 80 public sector).
- **Vaccines:** Supported the development of vaccines for Covid-19 (ZyCOV-D® and Corbevax®), pneumococcal vaccine (Pneuteger 15®), chikungunya, and dengue.
- **Biotherapeutics:** Supported products for diabetes, cancer, immune diseases, rabies, and COVID-19, including Pegylated Interferon for COVID-19 and biosimilar Liraglutide (Lirafit).
- **Medical Devices and Diagnostics:** Supported 18 medical devices and 11 diagnostics, including India's first indigenously developed MRI Scanner and various COVID-19 management products.
- **Facilities:** Established 22 high-end facilities, with 17 currently providing services to over 400 clients from academia, startups, MSMEs, and industries.

Major Outcomes by Category

- **Vaccines:** Achieved the mandate of bringing 2-3 vaccines closer to market, including COVID-19 vaccines and pneumococcal vaccine.
- **Biotherapeutics:** Achieved the mandate of bringing 2-3 biotherapeutics closer to market, with products for diabetes, cancer, and COVID-19 management.
- **Medical Devices and Diagnostics:** Launched various products for COVID-19 management and other health innovations, including MRI scanners and dental implants.

Translational Research Consortia

Supported the establishment of consortia for vaccines and monoclonal antibodies development for diseases such as dengue, chikungunya, Hepatitis E virus, and malaria.

Clinical Trial Networks

Enhanced clinical trial capacity by setting up GCP-compliant field sites and establishing disease registries across hospital sites.

Technology Transfer Offices

Established seven Technology Transfer Offices (TTOs), trained ~7000 participants, and transferred around 30 technologies, forging ~80 partnerships.

New Initiatives in 2023

- **Indo-US Bioethics Fellowship:** Screening and evaluation completed, with tripartite agreements to be signed by July 2024.
- **Antimicrobial Resistance:** Published a call for proposals, with 10 shortlisted for support and 5 granted aid.

Neurobiology

Under the Neurobiology program, the Department supports projects that aim to understand the nervous system and its disorders at a granular cellular and molecular level. This includes initiatives like advancing tools and techniques in neurology, supporting cohort studies focused on major neurological disorders, and establishing platforms to elevate technological competence in this dynamic field. During the year, a call for the submission of letters of intent (LoI) was initiated spanning diverse realms within neurobiology, including brain function and its disorders, the development of advanced neurological tools and techniques, platforms for technological innovation,

therapeutics, diagnostics, imaging technology, and biomarker discovery/validation for neurological disorders, learning, plasticity, and ageing. Through a rigorous screening process, 40 LoIs were shortlisted (out of 445 LoIs) for submission of full-length proposals. The proposals were evaluated and a total of 12 proposals have been recommended by the Committee for financial support.

No. of research publications	27
No. of Manpower trained	148

Dementia Science Programme

This programme aims to estimate the prevalence and incidence of Dementia in the country. The study involving 8 institutions/organization including 4 hospitals across the country adopts a multi-disciplinary (epidemiology, clinical sciences, genetics and basic biology) approach to characterize dementias and associated conditions in Indian population from different parts of the country. Under the programme an Illiterate ICMR-Neurocognitive Toolbox (ICMR-NCTB) has been developed. This illiterate ICMR-NCTB consists of tests from the domains of attention and executive function, episodic memory, language and the visuo-spatial test. The research team has recruited over 8000 participants for the population-based cohort and has effectively concluded the initial cognitive assessment test. These cohorts enable estimation of prevalence and incidence, categorization of dementia types, identification of risk factors, and understanding regional variations. The team has also conducted genetic analysis studies examining modifier genes linked to neurodegeneration leading to dementia, such as CDK5, GSK3β, BIN1, and PICALM. In a cohort comprising 20 patients and 20 controls, the results unveiled a significant association between the patient group and a specific PICALM variant, namely rs3851179.

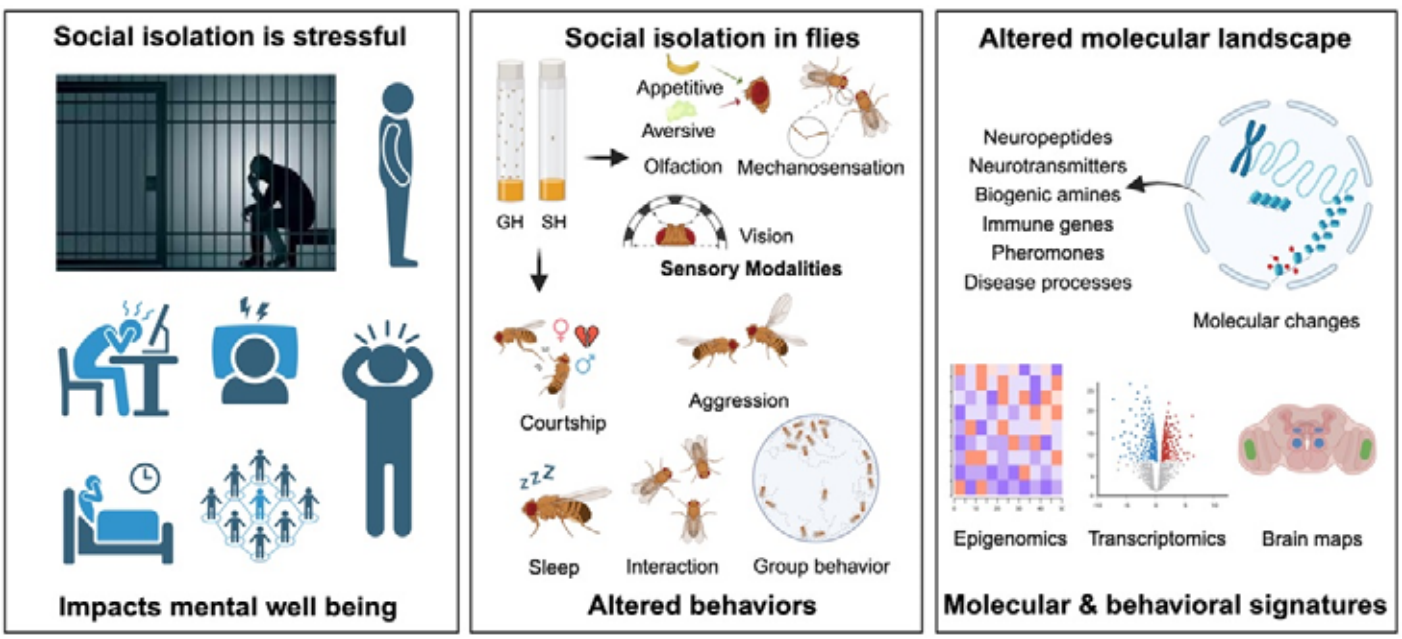


Figure 3.C.22: Lessons from lonely fly: Molecular and neuronal mechanisms underlying social isolation

Researchers in a different study examined how social isolation impacts mental health by investigating the underlying molecular and neural mechanisms in Drosophila. PIs uncovered insights into the molecular and neuronal processes behind isolation-driven behaviours in fruit flies. The team explored the recent progress in understanding how neuromodulators and neuropeptides influence

behavioural changes during social isolation and provided a comprehensive perspective on identified neuronal circuits and molecular mechanisms governing changes in aggression, courtship, group dynamics, and sleep resulting from social isolation. and provided a comprehensive perspective on identified neuronal circuits and molecular mechanisms governing changes in aggression, courtship, group dynamics, and sleep resulting from social isolation (**Figure 3.C.22**).

In the 'Collaborative Neuro-Engineering Platform for Excellence in Innovation and Translational Research' being supported by the Department, attempts are being made to supplement research and development of electro-mechanical physical simulators and computer-aided simulators for training of minimally invasive neurosurgery. Through this faculty, residents and trainee neurosurgeons can be trained using indigenously developed neuro-engineering training systems which in turn would help in reducing the number of live animals and cadavers currently being used for imparting training. The team has been working towards the development of an endoscopic third ventriculostomy simulator with the evaluation of surgical skills. The design of the Endoscopic Third Ventriculostomy Simulator involves the use of CT and MRI data of a patient to generate digital models of head anatomy, including the scalp, brain, dura, and ventricles. This is followed by the use of CAD modelling to create all the components of the simulator, ensuring the highest level of accuracy and realism in the design. This innovative design, combined with its high level of detail and functional components, makes the Simulator a valuable asset for neurosurgical training.

Public Health Nutrition

The major objective of the programme is addressal of micronutrient & macronutrient deficiencies, severe and acute malnutrition, stunting, agri-nutrition linkages, food fortification, overnutrition, probiotics for human health and well-being, food safety, molecular detection of GM traits in foods, development of low-cost foods/ supplements and utilization of agricultural residues for value-added products and capacity building in Food Science and Nutrition Biology. Recent research suggests that half of stunted or underweight children aged 5-19 years, had at least one biomarker of metabolic overfeeding – like high blood sugar or high blood lipids (cardio-metabolic risk factors that track into later life and are associated with non-communicable diseases). This is the classical intra-individual double burden of malnutrition, occurring within the same child, and occurring in childhood. The mechanisms associated with this phenomenon and the interventions for its mitigation are being pursued.

No. of research publications	17
No. of Patents Applied/ Granted	02
No. of technologies developed/commer-cialized	01

Micronutrient-fortified rice: To address anaemia, a school-based efficacy trial was undertaken in children in 9 schools in the Koppal district of Karnataka to test whether iron, B_{12} and folate-fortified rice improves iron stores. After one year of intervention, there was an improvement in body iron stores along with decreased soluble transferrin receptor (sTfR) concentrations, decreased vitamin B12 deficiency as well as Folate deficiency in the intervention arm compared with the control arm (**Figure 3.C.23**).

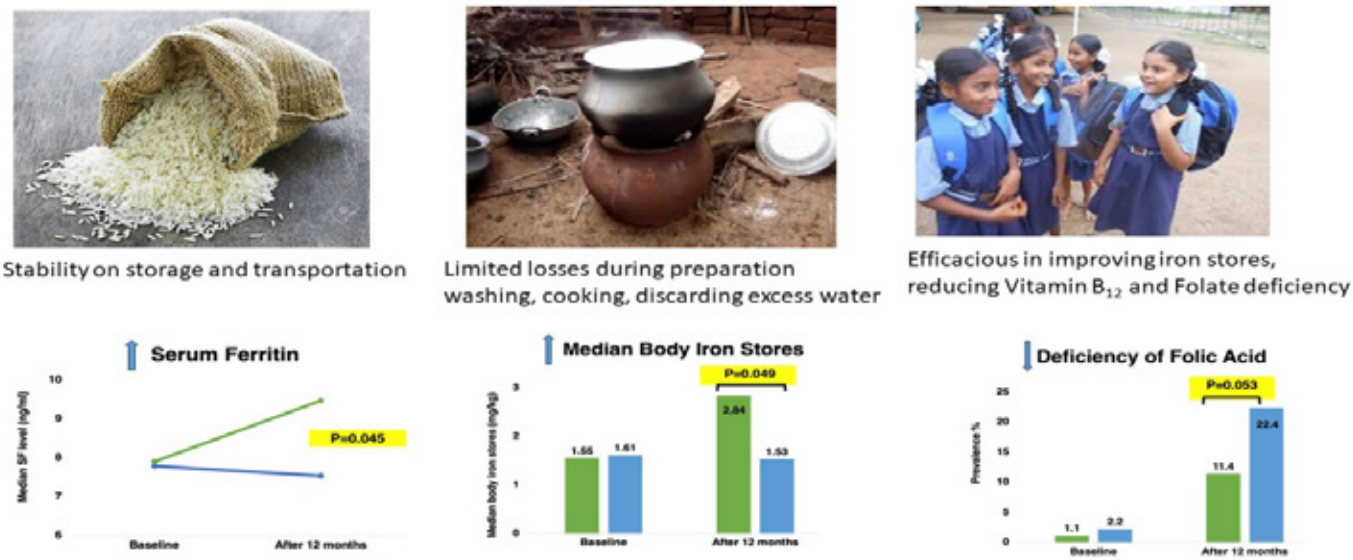


Figure 3.C.23: Efficacy of micronutrient-fortified rice

***In vivo* micronutrient bioavailability:** A process technology was developed for the improvement of *in vivo* micronutrient bioavailability. Vacuum impregnation of Fe and Zn inside the structure of the lentils was accomplished. This process simultaneously reduces phytate and has the potential to increase in vivo micronutrient bioavailability. Processed pulse (dal) after cooking reaches below 92-99.9% PA content with enhanced micronutrient bioavailability. A process machinery was also developed which is ready for transfer to industry.

Colonic B_{12} absorption: Vitamin B_{12} (cobalamin) is thought to be mainly absorbed in the terminal ileum of the small intestine through an intrinsic factor and receptor-mediated uptake. A novel 13C- cyanocobalamin molecule (^{13}C-B_{12}) was biosynthesised and, its intestinal absorption kinetics revealed that while the major absorption into the plasma occurred as expected, at about 6-8 hours after ingestion (about 50%), a smaller 'late phase' absorption peak occurred 10-12 hours after ingestion (about 10%). This was confirmed to be mainly due to colonic absorption. Unabsorbed dietary B_{12} can be absorbed in the colon is an important finding, as this was not thought to be possible before. This opens the potential of colonic microbial B12 as a potential contributor to daily B12 nutrition. The excretion kinetics of 13C-B_{12} from the body also showed that the daily loss was not as high as earlier thought, suggesting that the requirement in Indians could be lower.

Hydrogel-based technology for addressing anaemia: Iron Deficiency Anemia (IDA) stands as a prevailing global health concern, and in India alone, over 60% of women and children under the age of five suffer from anaemia, contributing significantly to morbidity and mortality during pre- and post-pregnancy periods. Scientists at the National Agri-Food Biotechnology Institute (NABI) developed a pH-responsive hydrogel drug delivery system, incorporating iron (Iron Dextran I-Dex) alongside probiotic bacteria (B) within alginate hydrogels, denoted as B + I-Dex (H). This formulation has exhibited reduced inflammatory responses and enhanced haemoglobin restoration levels *in vivo*

due to its ability to sustainably release its contents under intestinal conditions while safeguarding against premature release at acidic gastric pH levels. A patent has been granted to NABI for this product. (Patent no: 536107)

Role of Sirtuin1 (SIRT1) in Vitamin –D metabolism: Vitamin D deficiency and the rapid increase in the prevalence of obesity/metabolic syndrome are both considered important public health issues. A time-dependent inhibition of mitochondrial OCR (oxygen consumption rate) was observed at high concentrations of Vitamin D in mouse hepatocytes. The precursor form of the hormone, Cholecalciferol, which is the most abundant form of Vitamin-D available in the form of capsules and injection for humans with Vitamin-D deficiency, demonstrated a similar trend. Improved mitochondrial OCR and ATP production at lower concentrations and inhibition at higher concentrations indicate an interplay between Vitamin D levels and mitochondrial functions, which has the ability to impact organismal physiology. Understanding the mechanisms of Vitamin D deficiency caused by the inability of the liver to metabolize the precursor would address the origin of this deficiency, and improve therapeutic interventions in adolescents and adults, arising due to obesity, which is highly prevalent in our society.

Targeting Key Signaling Cascades Using D-Formin: According to recent statistics, globally, 1 billion individuals are deficient in vitamin D, especially in countries like India. Vitamin D and metformin have reportedly been found to reduce tumour cell proliferation, induce p53-mediated apoptosis and decrease blood vessel density. It was observed that the simultaneous addition of vitamin D (200μM) in combination with very low metformin (125μM) synergistically inhibited breast cancer cell viability. Vitamin D and metformin yielded an additively acting dosing mix. It has been identified that withdrawing vitamin D or metformin re-activated tumour cells, which caused tumour growth in mice. Hence, continuous administration of these agents is required to keep the tumour cells in a senescent state

Attempts to increase grain protein content (GPC) most often result in a reduction in yield in cereals. This trade-off between GPC and yield could arise mainly because of the shared source of reductants for carbon and nitrogen assimilation. A study was undertaken to investigate the influence of the availability of reductants for carbon and nitrogen assimilation in rice genotypes on this negative relationship Triose phosphate utilization was found to determine the YieldGrain protein trade-off in contrasting rice genotypes under varying light intensities. This study can aid in the development of rice cultivars with enhanced nitrogen use efficiency and improved protein quality.

Effect of early stunting on body cell mass and fat mass in term appropriate for gestational age (AGA) infants: Early growth faltering in infants, with a steep decline in linear growth from birth to 2 years of life, especially in low- and middle-income countries has created serious health concerns. A comparison of the body cell mass (BCM) accretion and body fat (BF) of term appropriate for gestational age (AGA) infants in both sexes, among those with and without growth faltering during first year of life to assess exposures, and the quality and quantity of complementary foods was made (**Figure 3.C.24**). Infants who faltered in growth exhibited shorter stature and lower weight while linear growth-faltered (LGF) infants showed a statistically significant lower % body fat at 1 year of age compared to non-linear growth-faltered (NLGF) infants. A significant increment in both weight and length from baseline to 1 y in both AGA and small for gestational age (SGA) infants

was also observed. The study observed accurate longitudinal trajectories of body composition, especially BCM from birth to 1 y of age in Indian infants using whole body potassium counter for the first time in India.

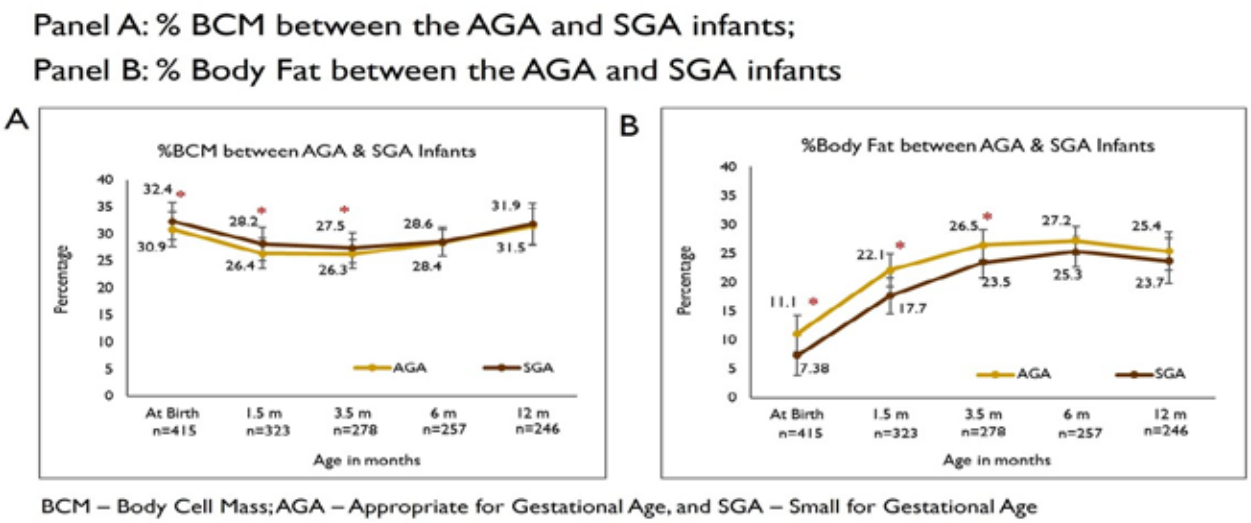


Figure 3.C.24: Comparison between AGA and SGA infants with respect to Body Cell Mass and Body Fat

Stem Cells & Regenerative Medicine

Stem cells and regenerative medicine has been identified as one of the thrust areas, by the Department of Biotechnology (DBT), keeping in view its potential in developing cell-based therapies, as well as, in gaining insights into developmental biology. Stem cell research was fostered in a comprehensive manner, over the past two decades, for promoting foundational research in developmental biology; development of animal models for studying disease biology; development of novel cell-based and gene therapies; creation of GMP grade manufacturing facilities; creating an enabling regulatory framework; capacity building for training and skilled workforce development.

Quantitative achievements

No. of Publications	25
No. of manpower trained	35
No. of patents applied/granted	5
Process/product/technology developed:	3

Major initiatives, outcomes and achievements of the programme

Major initiatives on accelerating stem cell technology for the development of gene and cell-based therapies for brain disorders and haematological conditions and community-based programmes on Sickle Cell Anemia and Thalassaemia have been implemented, which showed significant achievements, as enumerated below.

Development of gene therapies for haematological disorders

The Department has enabled the advancement of novel gene therapies for hereditary blood disorders such as haemophilia, thalassemia and sickle cell disease, by the Center for Stem Cell Research (CSCR), Vellore, a translational unit of the iBRIC-inStem, Bengaluru. Notable achievements in this arena include:

a. Approval for India's first gene therapy clinical trial for Hemophilia A, whereby, five pa-

tients with severe Hemophilia A have been infused with the gene therapy drug product (Lentiviral vector transduced haematopoietic stem cells).

b. Establishment of Proof-of-Concept for a novel AAV3 vector-mediated gene therapy for Hemophilia B.

c. Development of gene editing-based therapies for the treatment of Thalassemia and Sickle Cell Disease.

Community-based programme on Sickle Cell Anemia and Thalassemia

a. The '*Control & Management Programme for Sickle Cell Anemia and Thalassemia',* a community-based programme was implemented in the state of Odisha, by iBRIC-instem-CSCR.

b. Apart from increasing awareness of major haemoglobin disorders, this programme provides training to healthcare workers for improved diagnosis/treatment along with comprehensive testing and genetic counselling of the tribal population of the State. Phase-I of this program has been completed in 6 districts, namely: Balasore, Bargarh, Cuttack, Jharsuguda, Koraput, and Sambalpur. Under Phase II, the programme has been expanded to 15 districts of Odisha.

c. Over 2 lakh samples have been screened out of which, 470 subjects with Sickle Cell Disease and 8484 carriers for beta-thalassemia, have been detected and ~100 eligible couples have been counselled under Prenatal Diagnosis and Counseling.

Banking of induced Pluripotent Stem Cell (iPSC) lines

a. A cohort of large dense families with major psychiatric disorders, such as addiction, bipolar disorder, schizophrenia, obsessive-compulsive disorder and dementia, has been established by researchers from iBRIC-inStem, National Centre for Biological Sciences (NCBS) and the National Institute of Mental Health and Neuro-Sciences (NIMHANS).

b. More than 100 research-grade induced Pluripotent Stem Cell (iPSC) lines have been developed from PBMCs of individuals of selected high-value families, for future developmental and mechanistic studies.

c. Haplobanking of PBMCs from >200 individuals with homozygous HLA haplotypes and development of clinical grade iPSC lines from 15 donors representing top 20 haplotypes, has been achieved at iBRIC-inStem-CSCR.

Centre for Excellence on Stem Cell Research

A CoE for Stem Cell Research has been established at All India Institute of Medical Sciences (AIIMS), New Delhi. The focus of this programme is on: developing a pool of clinical grade Mesenchymal Stem Cells (MSCs) for basic and clinical research purposes; exploring the potential of keratinocyte and melanocyte transplantation for wound healing; treatment of Steven Johnson Syndrome, chemical burns, and limbal stem cell deficiency, using conjunctival, oral mucosa epithelial cell and limbal epithelial cell transplantation. As part of capacity building, ~9 workshops/seminars have been conducted wherein, 290+ participants have been trained. 96 publications and 3 patents have been generated, and one patent has been granted. The CoE served as a platform for attracting several national and international collaborations in tissue engineering and regenerative medicine.

Investigator-driven R&D projects in Stem Cell Research

Significant achievements of some of the investigator-driven R&D projects are provided below:

Differential expression of 57 exosomal miRNAs in

Bone Marrow (BM) MSCs from aplastic anemia patients; Development of humanized anti-GD-2 CAR constructs, using *in silico* mutagenesis studies and generation of GD-2 positive tumor mouse models for assessment of CART safety and efficacy; Delineation of the role of H2A deubiquitinases in the differentiation of human pluripotent stem cells into neuronal lineage, whereby, it was observed that stable expression of BAP1 in hESCs was essential for their neuronal differentiation.

Vaccine Research and Development

The mandate of the Vaccine Research and Development programme is to support basic and applied research for new and improved vaccines and related technologies; and build human and infrastructural capacities in 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; and strengthening vaccine development for epidemic preparedness.

Major initiatives

Major national mission programmes such as National Biopharma Mission, Ind-CEPI Mission and Mission COVID Suraksha, were implemented to strengthen industry-academia linkages and early translation and commercialization of the lead products. Efforts to foster international partnerships include: bilateral collaboration with the USA through the Indo-US VAP; cooperation with the European Union through the Horizon 2020 Programme; Grand Challenges India with the Bill & Melinda Gates Foundation; and partnership with CEPI under the Ind-CEPI Mission.

Outcomes and achievements of the program

Candidate vaccine development

These programmes have enabled the strengthening of clinical trial sites, setting up of immunoassay laboratories, animal challenge facilities, development of harmonized protocols and enhancing manufacturing capabilities. As an outcome of these efforts, vaccine candidates for diseases such as Dengue, TB, Chikungunya, Influenza, Pneumococcal Disease, Cholera, Malaria and COVID-19, are in various stages of development. Major achievements are the development of the low-cost indigenously developed Rotavirus vaccine (Rotavac), which became part of the UIP and development of India's 1st indigenously developed qHPV vaccine against cervical cancer (Cervavac) which received market authorization. The Ind-CEPI Mission, enabled support for development and generation of clinical trial material of an 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, and Panama. Development of a broadly protective beta coronavirus vaccine candidate by DBT-iBRIC-THSTI is being supported by CEPI. The Bioassay lab at DBT-iBRIC-THSTI has been recognized by global CEPI, as one of the sixteen laboratories globally, for centralized assessment of COVID-19 Vaccines.

Investigator-driven R&D projects in Vaccine Research and Development

Significant achievements of some of the investigator-driven R&D projects are provided below:

Researchers from IISc, Bengaluru, generated SARS-CoV-2 VLPs in a baculovirus expression system, for the wild-type (Wuhan), mutants (Spike + Nucleotide) and variants of concern (VOCs) like Delta and Omicron. They also demonstrated that mice immunized with wild-type and Spike+Nucleotide VLPs showed appreciable T-cell responses and viral neutralization. Delta and Omicron VLPs were able to heighten the cytokine response. An Indian Patent

Application No. 202141022412 "Coronavirus based Virus Like Particles (VLPs), methods and applications thereof", was filed by IISc.

Scientists from Centre for Stem Cell Research, a translational unit of DBT-iBRIC inStem, developed a novel *shikimoylated mannose receptor targeting lipid nanoparticle* system (SMART-LNP) for effective delivery of mRNA to the dendritic cells (**Figure 3.C.25**). Furthermore, they demonstrated that the SMART-LNP encapsulated SARS-CoV-2 Spike mRNA vaccine candidate produced strong Th1 predominant humoral and cellular responses.

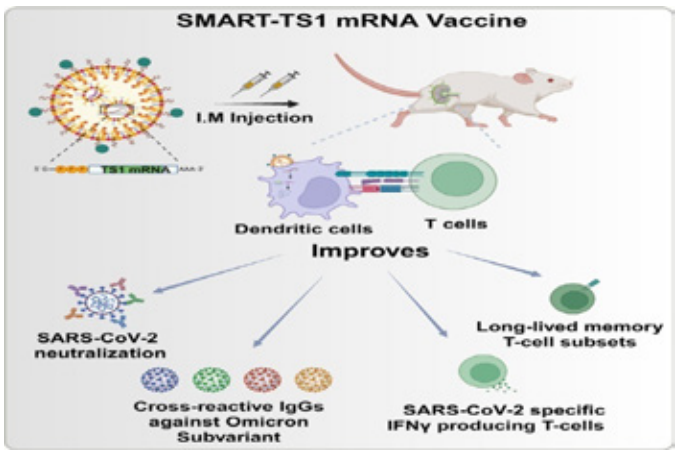


Figure 3.C.25: Dendritic Cell targeting SMART-LNP mRNA vaccine candidate

Achievements during the COVID-19 pandemic

In the wake of the COVID-19 pandemic, *'Mission COVID Suraksha –The Indian COVID-19 Vaccine Development Mission'*, was launched under Atmanirbhar Bharat 3.0 package. This Mission was led by DBT and implemented by BIRAC, a PSU of DBT. Five COVID-19 vaccines supported under this Mission received Emergency Use Authorization. These are the world's 1st and India's indigenously developed DNA Vaccine; India's first protein subunit vaccine; India's first intranasal COVID-19 vaccine; mRNA vaccine; and India's first Omicron booster mRNA vaccine. Furthermore, the clinical trial sites supported under Mission COVID Suraksha facilitated clinical trials of several major COVID-19 vaccines and therapeutics.

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 (**Figure 3.C.26**. 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.

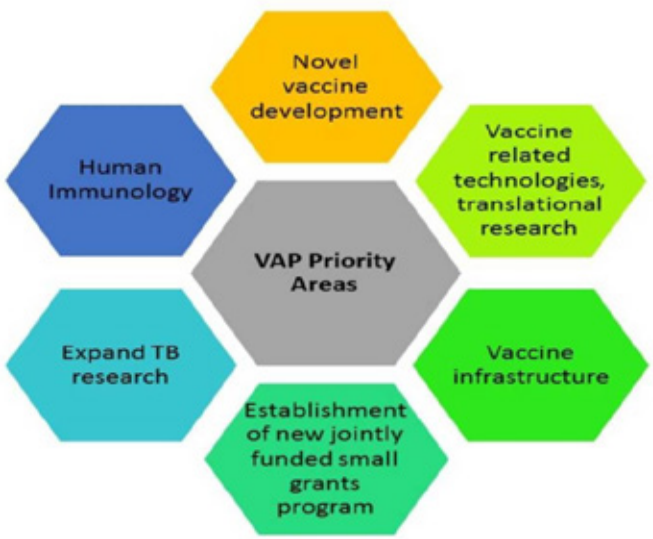


Figure 3.C.26: Vaccine Action Programme: Priority Areas

RePORT-India (Regional Prospective Observational Research on Tuberculosis)- 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 (**Figure 3.C.27**). In the diagnostic cohort- 44%, Cohort A (People living with TB) - 68% and Cohort- B (Household contacts of PLTB)- 45% of the target enrolments have been completed. Discovery and validation of new diagnostic and prognostic TB Biomarkers including: 2-gene transcriptomic signature for TB diagnosis in persons with advanced HIV; Six-cytokine biosignature discriminating active TB from latent infection; Molecular markers of drug resistance; New T-cell subsets involved in TB control is being carried out. RePORT India investigators contributed to the study design of VPM1002 TB Recurrence Trial which is the world's first clinical trial of TB Vaccine efficacy against preventing TB Recurrence & also RePORT sites enrolled 773/2001 (40%) of all enrolments.

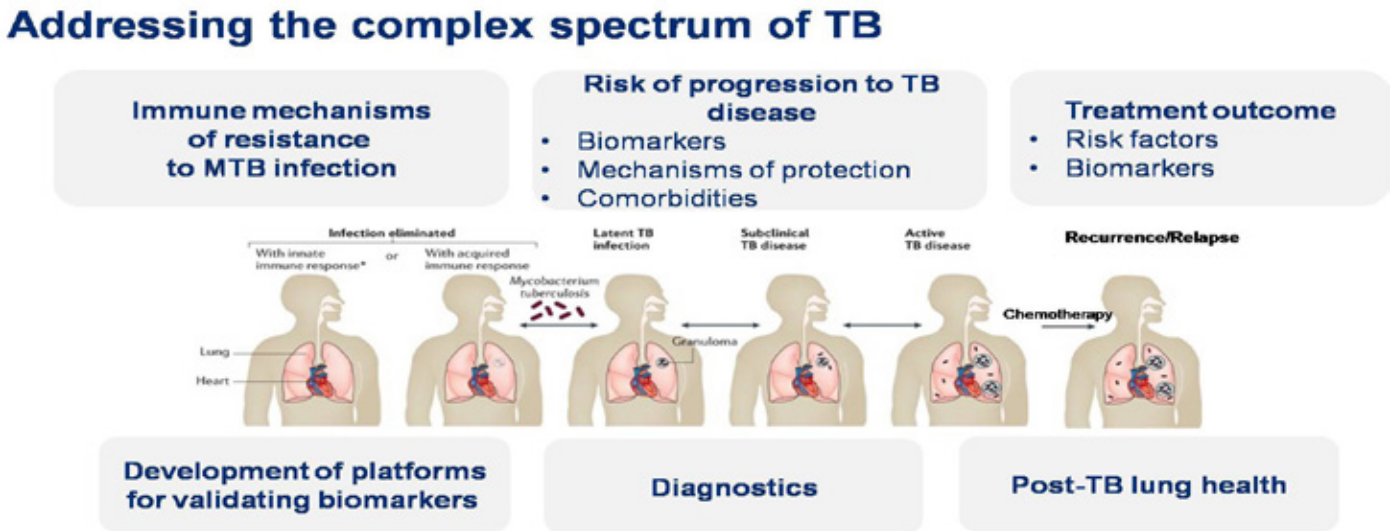


Figure 3.C.27: Scientific Focus of RePORT India

The 12th Annual RePORT India Joint Leadership meeting was held on 8th -10th Feb 2023 at ICGEB, New Delhi. This meeting has been acting as a platform to bring together TB researchers, clinicians, policymakers and collaborators to advance TB research in India & also review progress made by the Consortium. Critical areas of TB research including, vaccines, strengthening the Public-private partnerships in TB care and the less explored areas of sub-clinical TB, Paediatric TB and genomic studies were the focus areas of this year's meeting.

Vaccine Adjuvant Development Program - In August 2019, DBT issued a joint funding opportunity announcement with the National Institute of Allergy and Infectious Diseases (NIAID) for collaborative adjuvant research projects to bring together researchers in India and the U.S; DBT funded the Indian component and NIAID funded the U.S. component. Projects on development of

novel adjuvants for vaccines for Mycobacterium tuberculosis, Respiratory Syncytial Virus (RSV), Flaviviruses, and Foot-and-mouth disease are being supported under the Indo-US Adjuvant collaboration.

Initiative on Bioethics - The Department of Bioethics of the U.S. National Institutes of Health (NIH) Clinical Center and DBT have collaborated to strengthen Bioethics research in the country. In August 2023, DBT and NIH organized a one-day workshop on 'Ethics in Clinical Research' at the Translational Health Science and Technology Institute. The workshop was attended by over 40 scientists and policy makers and covered current ethical issues in biomedical research, including research on emerging biotechnologies and artificial intelligence, controlled human infection studies for vaccine research and development efforts. DBT and NIH have released a Request for Proposal (RFP) for the Indo-U.S. Clinical Research Ethics Fellowship Program under the National Biopharma Mission. The selected fellows will be co-mentored by faculty in the Indian host institutions and the NIH Department of Bioethics. The fellowship program will be important to the establishment of a National Center of Excellence in Bioethics in India.

Joint Working Group of Indo- US VAP - The 35th Joint Working Group Meeting of Indo- US VAP was convened in New Delhi on 26th and 27th October 2023. Discussions on pandemic preparedness focusing on KFD, Nipah, CCHF & Chikungunya were held during the meeting which was attended by regulators, policy makers and the scientific community from India & USA. DBT also organised the 'Rama-Robbins Lecture' delivered by Prof. K. Vijay Raghavan, former Secretary, DBT and former Principal Scientific Adviser to the Government of India on 'A global web for future pandemic preparedness' on 26th October 2023. Deputy Chief of Mission Ms. Patricia Lacina from the US embassy in India attended the Rama -Robbins lecture, organised by DBT.

Indian SARS-Cov-2 Genomics Consortium (INSACOG)

Indian SARS-Cov-2 Genomics Consortium (INSACOG) established in December 2020 has been conducting a national surveillance of SARS-CoV-2 genomic variants using next generation sequencing technologies to detect virus mutations and/or lineages that may pose a threat to public health. Such sustained country-wide genomic surveillance programs have enabled rapid public health interventions to control the spread of such potentially harmful virus variants. INSACOG has played an important role in the management of COVID-19 transmission and understanding the evolution of SARS-CoV-2 as well as resulted in the establishment of a sustained framework for managing future epidemics or pandemics of SARS-CoV-2 or similar pathogens.

The major initiatives taken in INSACOG are:

a) **Sentinel Surveillance:** Establishment of a network to 67 laboratories across 30 states and union territories in the country to undertake genomic surveillance, thereby increasing the overall sequencing capacity of the consortium to over 72,000 sequences/ month. This has resulted in the sequencing of SARS-CoV-2 genomes from about 3.4 lakh samples from across the country during the pandemic, along with centralised analysis pipelines and warehouse for sequence and metadata at IBDC as well as real time reporting of VOCs in Integrated Health Information Platform (IHIP).

b) **Sewage Surveillance Network:** Establishment of Sewage Surveillance network with 10 laboratories covering 13 cities across India, establishment of centralised reporting for

sewage surveillance in IHIP portal and raw data submission and real time unified analysis in IBDC.

c) **Hospital Network Study:** Continued Hospital network study with a network of 15 hospitals across the nation to analyse disease severity associated with SARS-CoV-2 variants in hospitalised patients.

Major Achievements

No. of Publications	11
No. of manpower trained	152

INSACOG has expanded to a network of 67 laboratories across the country with 30 states/ UTs having at least one IGSL. With continued surveillance, INSACOG has so far sequenced a cumulative of over 3.36 lakh viral SARS-CoV-2 genomes. The results have been shared with NCDC and respective state officials via IHIP and the raw sequences are deposited at IBDC for centralized analysis so that a common analysis methodology is followed across the sequencing laboratories. In the second phase, INSACOG established sewage surveillance network comprising of 10 laboratories which undertook sampling across 13 cities. The rationale for establishing sewage surveillance network was that with time decrease in availability of reported clinical cases of COVID-19 for sequencing would affect disease surveillance. Previous scientific publications have reported SARS-CoV-2 viral shedding in faces due to presence of ACE receptor along the gut lining, thereby providing an indication of increase in viral load in the locality generally 7-14 days ahead of actual disease surge. This advance indication would help immensely in public health management and preventing disease transmission. This network has tested over 6000 wastewater samples by RT-PCR across 13 cities of which 1116 samples eligible for NGS have been sequenced and uploaded to IBDC for centralized analysis. Centralized reporting of wastewater surveillance has also been created in IHIP.

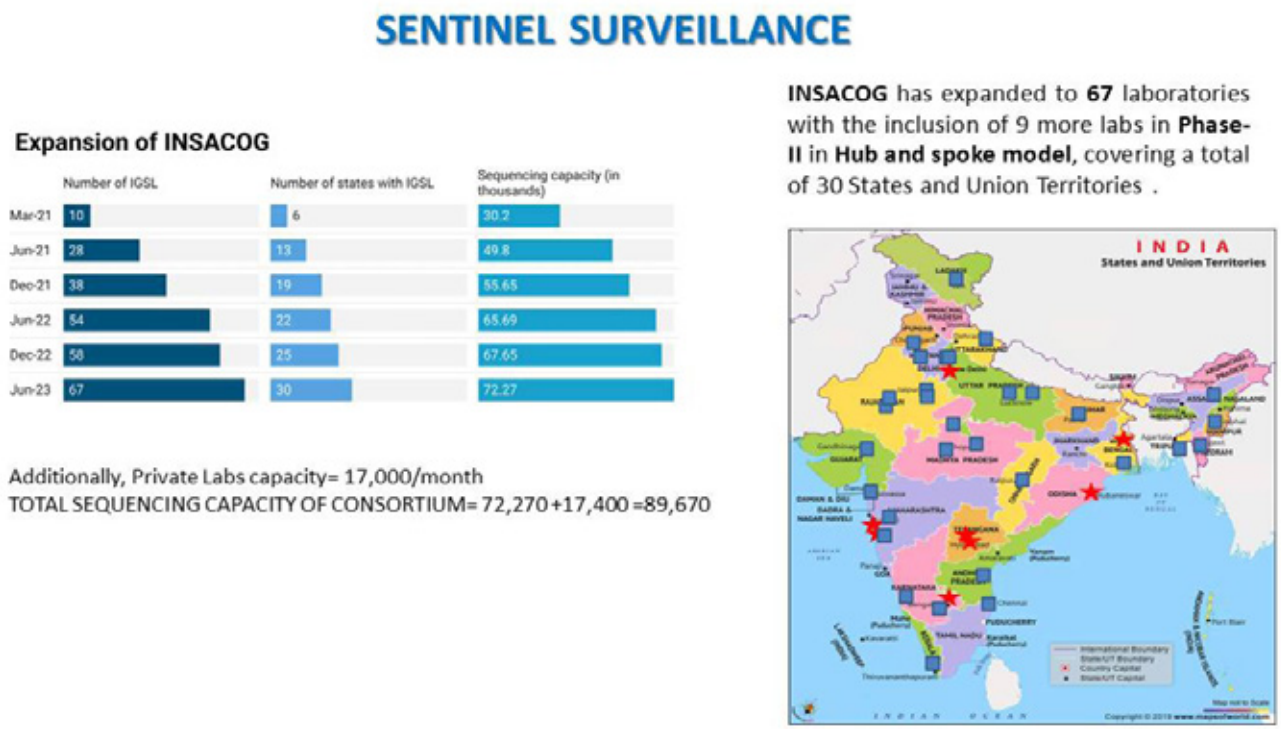


Figure 3.C.28: Expansion of INSACOG network

As part of the Hospital Network Study, 1185 patients have been enrolled from 15 Hospitals and are being followed up for clinical details. The HNS is also exploring long-term post-COVID complications, including long-term COVID-19 outcomes and fungal infections in an attempt to address crucial gaps in our understanding of the broader health implications of the disease. Regular updates and analysis have been shared with MoH&FW on a fortnightly basis in the form of SCAG approved INSACOG report and bulletin so as to guide the public health response against COVID-19 and related health complications.

Drug Development

The Drug Development programme was initiated to foster research & development for new and cost-effective therapies directed towards improved health outcomes. Support under this programme has been provided for: development of drugs from existing leads with established Proof-of-Concept; lead optimization, preclinical development and clinical therapeutic validation; discovery and development of novel therapeutic antibodies.

Considering the promise of antibodies as effective therapeutic interventions, efforts have been made to support discovery and development of novel therapeutic antibodies against HIV and AMR. Accordingly, development of novel therapeutic monoclonal antibodies against MDR and XDR *Klebsiella pneumonia,* broadly neutralizing monoclonal antibodies against circulating HIV strains, and development of specific single domain antibodies (sdAbs) against AMR Mastitis pathogens in dairy animals are being supported.

Achievements

A team of investigators from DBT-iBRIC-THSTI, AIIMS New Delhi, IISc and NIRT have identified elite/broad neutralizers for HIV-1 by estimating the neutralization potential of the plasma antibodies from the paediatric donors against HIV-1 pseudoviruses. Besides this the team has also optimized the assays for virus isolation, amplification, pseudovirus preparation and neutralization and performed initial PK PD studies for optimized antibody combinations in Non-Human Primates.

Researchers from AIIMS have successfully designed and generated stable recombinant HIIV envelope trimers derived from an elite neutralizer within the Indian pediatric population. In collaboration with IISc., biochemical and biophysical characterization of this envelope trimer, was carried out, and further studies on antigenicity and binding affinity to HIV-1 neutralizing antibodies are in progress.

Woman and Child Health Programme

Woman and Child Health programme addresses the unmet health needs of women and children and contributes to the global efforts to achieve Sustainable Development Goals of ensuring good health and well-being for all. The programme fosters interdisciplinary and collaborative research for better prevention, diagnosis, treatment, and management of various health conditions affecting women and children. Programmes are supported on complex and multifaceted 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 are supported in the area of congenital anomalies including congenital heart diseases (CHDs), diseases of neonatal period and early childhood as well as developmental disorders.

Major Achievements

No. of Publications	26
No. of Manpower Trained	298

The research projects supported under the programme have generated several new insights. Some of the notable accomplishments of the programme are:

Garbh-Ini (Inter disciplinary Group for Advanced Research on BirtH outcomes -DBT India Initiative)

Preterm birth is the leading cause of neonatal mortality in India, accounting for 25% of the global burden. It is associated with increased risk of adverse health and developmental outcomes. The Garbh-Ini program is a large-scale research initiative that aims to improve understanding of the biological and environmental factors that influence preterm birth and guide interventions using multi-omics biomarkers and AI-driven tools. The program also seeks to understand the impact of maternal, postnatal, and environmental factors on the growth and development of children born to the cohort participants.

The following are some of the interesting findings from the study:

a. The critical windows and thresholds of exposure to ambient air pollution that increase the risk of fetal growth restriction, preterm birth was investigated. At a threshold of 110 µg/mL of PM2.5 concentration, for every 50 µg/mm3 increase there was a reduction of gestation by one week.

b. A significant number of the Indian women often present to the clinics only during the second trimester of pregnancy with no memory of the LMP. With an aim to accurately determine the gestation period in such women for appropriate follow up and clinical decision making, pregnancy dating models have been developed for the first time in India. These are found to be more accurate than the Hadlock and Intergrowth 21 formula which are based on Caucasian population. Leads have been obtained in developing dynamic personalized risk prediction models for preterm birth. Models have also been developed for automated detection of fetal body parts, biometry measurement and gestational age estimation **(Figure 3.C.29)**. These models are being validated in external cohorts. The models hold promise for improving birth outcomes esp. in the rural settings with limited access to skilled physicians.

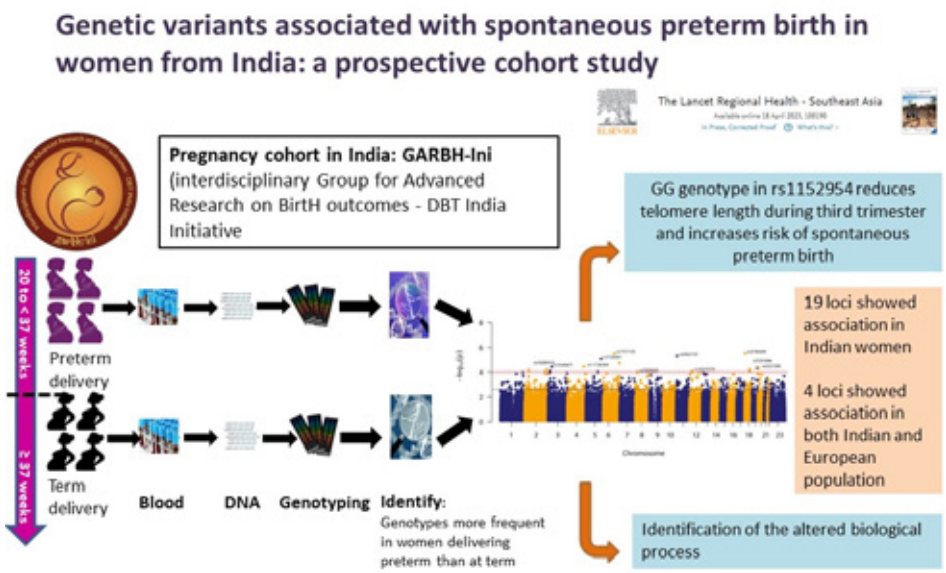


Figure 3.C.29: First study from South Asia on the genome-wide identification of maternal SNPs associated with sPTB

c. Efforts are also underway for identification of multi-omics biomarkers for predicting preterm birth:

- In the first Genome wide association study from South Asia carried out with an aim to aid stratification of women at risk for spontaneous preterm birth (sPTB), 512 maternal Single Nucleotide Polymorphisms (SNPs) were discovered, of which 19 SNPs showed increased genotype relative risk. These SNPs are known to alter the expression of genes associated with inflammation, apoptosis, cervical ripening, telomere maintenance, and other pathways, aiding in trans-ethnic risk stratification for sPTB.
- Differentially expressed proteins (29 proteins) have been identified that hold promise in predicting sPTB.
- Metabolomic studies revealed that elevated levels of steroids, glycerophospholipids, and fatty acids are associated with sPTB. Their increase can be attributed to dysregulation in primary bile acid synthesis and unsaturated fatty acid biosynthesis in cases of sPTB. To quantify these metabolites and develop prediction models, validation studies are being undertaken.
- Metabolic profiling of neonatal heel-prick and umbilical cord blood samples coupled with machine learning provided accurate gestational age estimation and preterm birth identification. These models can eventually aid the neonatologists with the use of interventions for PTB outcomes. These models could also be used as a surveillance tool to help determine the region-specific PTB rates in LMICs.
- Based on the distinct vaginal microbiome and associated protein profile in women who delivered pre-term, a dipstick assay has been developed to identify mothers at risk for pre-term birth.

Preeclampsia: Preeclampsia is a hypertensive disorder that affects 5-8% of pregnancies worldwide and can cause serious maternal and fetal complications. Placental dysfunction is a key feature of pre-eclampsia. One of the studies was aimed to compare the DNA methylation, miRNA expression, and protein abundance of placental exosomes from women with Early-Onset Preeclampsia (EOPE) and normal pregnancies. Proteomic analysis of circulating term placental exosomes derived from EOPE women identified total 208 proteins, out of which 20 were upregulated and 06 downregulated. 19 of these differentially abundant proteins were dysregulated in EOPE pregnant women's serum and placenta. The differentially abundant proteins primarily relate to complement cascade, hemostasis, oxygen homeostasis, lipid metabolism, and innate immune responses **(Figure 3.C.30)**. Transcriptomics of the circulating placental exosomes revealed 19 highly dysregulated miRNAs.

Genome wide methylation studies have shown a total of 355 Differentially Methylated CpGs (DMCs), of which, majority were of mitochondrial origin. The findings suggest that placental exosomes carry information that reflects the placental dysfunction and the maternal systemic response in preeclampsia and pave the way for possible identification of new prognostic and predictive biomarkers.

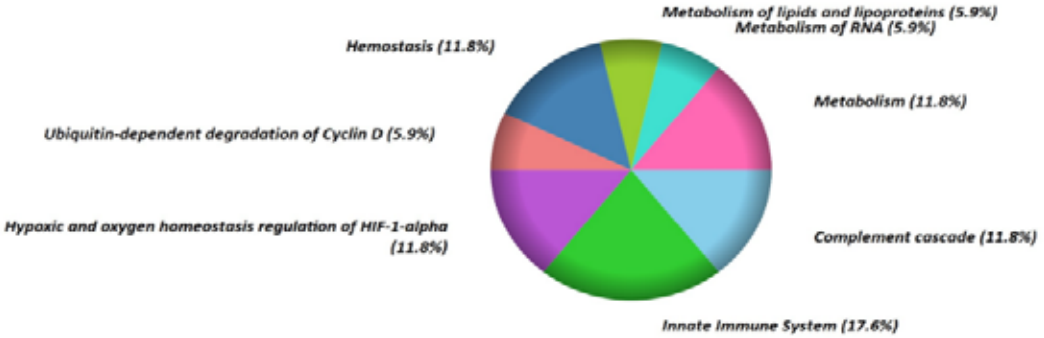


Figure 3.C.30: Gene Ontology enrichment analysis for the differential proteins observed in circulating term placental exosomes of EOPE women

Neonatal sepsis programme: Neonatal sepsis is one of the most common causes of mortality amongst neonates, with nearly 0.6 million neonatal deaths worldwide. One of the major challenges in the management of neonatal sepsis is the emergence and spread of Anti-Microbial Resistance (AMR), which reduces the effectiveness of available antibiotics and increases the risk of treatment failure and death. The aim of this inter-disciplinary network program is to understand the etiology, transmission, and severity of neonatal sepsis using various analytical platforms like genomics, metabolomics, metagenomics, microbiome studies, immune profiling etc. A total of 88,991 pregnant women have been screened, and 4269 mothers and 4775 neonates have been enrolled. The transmission dynamics study thus far indicates that most of the assessed hospital environments are reservoirs of bacterial pathogens that cause sepsis. Efforts are being made to decipher the severity of sepsis and the possible outcomes by characterization of the immune cell types, their gene expression as well as associated markers. Preliminary analysis indicates that the total T cells decrease at recovery, monocyte percentages increase during sepsis, while the Innate Lymphoid Cells (ILC) gradually increase from at suspicion to during sepsis to post recovery. Through immunophenotyping, some immune cell markers have been found to be consistently altered in most neonates suspected to have sepsis. Attempts are being made to see if these markers are expressed differently in healthy neonates, neonates suspected with sepsis and sepsis-recovered neonates. A parallel approach is being used to capture the circulating metabolic components that could explain the sepsis-associated organ dysfunction and help differentiate culture positive neonates from the healthy neonates based on identified metabolite signatures.

Developmental Biology: Generating specific cell types in the dish serves as a powerful tool to study the underlying mechanisms of various diseases and to develop new treatments. Of the three germ layers that emerge from the pluripotent cells, mesoderm layer gives rise to tissues and organs such as muscle, bones, blood, heart, kidneys, gonads etc. One of the key steps in the emergence of anterior mesoderm, which gives rise to cardiac progenitors, has been identified. Leveraging this knowledge, 3D-heart organoids have been generated (**Figure 3.C.31**). This lays the foundation for creating organoids that reflect the cellular and architectural complexity of heart, which will allow us to model congenital heart disease.

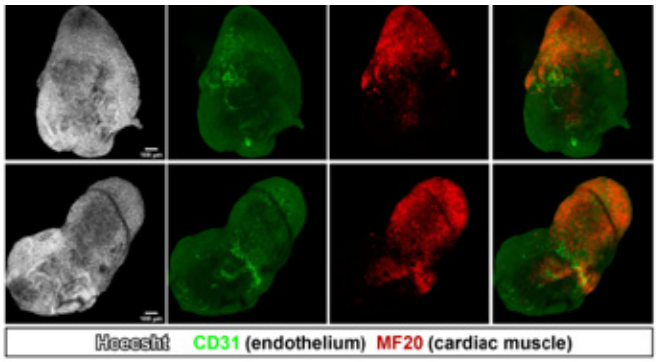


Figure 3.C.31: Heart organoids derived from embryo organoids harbouring anterior mesoderm

Micropeptides derived from a Wnt antagonist, SFR4 as promising candidates for targeting ovarian cancer: Ovarian cancer is one of the most lethal gynecological malignancies, with a high recurrence rate and poor prognosis. Ovarian Cancer Stem cells (CSCs) are a subpopulation of tumor cells that have the ability to self-renew, differentiate, and resist chemotherapy. In a study aimed at developing candidate molecules for targeting Ovarian Cancer Stem Cells, micropeptides derived from a Wnt antagonist, SFR4 (Secreted Frizzled Protein) have been found to be promising candidates. These are particularly encouraging as these also targeted EMT pathway and chemosensitized ovarian CSCs and can help overcome chemoresistance and recurrence.

Poly Cystic Ovary Syndrome (PCOS): It is a common endocrine disorder that affects women of reproductive age. In an animal study aimed at investigating the effect of polyamines in PCOS, it has been shown that putrescine and agmatine could ameliorate PCOS by modulating the polyamine pathway and its downstream effects on hormonal and metabolic pathways. The study suggests that polyamines may be potential therapeutic agents for PCOS by improving ovarian function and reducing inflammation and oxidative stress.

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3.D. THEORETICAL & COMPUTATIONAL BIOLOGY (BIOINFORMATICS, BTIS-NET, AI & BIG DATA)

Computational Biology and Bioinformatics constitute an interdisciplinary field that encompasses processing of biological information to unravel the underlying principles of biological phenomena. Deployment of machine intelligence for analyzing biological data has led to development of predictive and generative models using statistical, machine learning (ML) and artificial intelligence (AI) techniques. These models are not only capable of identifying signature patterns amongst attributes of biological processes but also have promising applications in various commercial sectors including medical, agriculture, food and energy. AI application in medical and agriculture sectors have expanded the horizon of biological studies to incorporation of socio-economic and environmental considerations. Department of Biotechnology supports projects under Theoretical and Computational Biology (Bioinformatics, AI and Big Data) for providing impetus to usage of biological data in industrial applications. During the year 2023-24, 15 publications in peer-reviewed journals ensued from DBT supported projects in the areas Bioinformatics, AI and Big Data. Amongst the DBT funded projects, 10 ongoing projects during 2023-24 carried out research work aimed at implementation of AI.

A project at Tripura University and Jadavpur University was supported for automated diagnosis of Arthritis and prediction of disease severity based on the non-invasive Image Analysis using Deep learning methods (**Figure 3.D.1).**

(a) **(b)** **(c)**

Figure 3.D.1: *Multimodality Image Dataset of Rheumatoid Arthritis Patient (a) Infrared Image; (b) MRI Image; (c) Ultrasonography Image*

In a DBT-supported project, researchers at Indian Institute of Information Technology, Hyderabad analyzed the adult-to-adult donor liver transplantation transcriptomic datasets to understand the clinical manifestations of liver regeneration. The differential gene co-expression analysis of samples from post-operative liver biopsies of normal and rejection patients showed a difference in the expression pattern of immune and cell cycle genes. The study may lead to understanding of the molecular mechanisms driving long-term stability (normal) or rejection of the transplanted graft.

For affordable screening and prediction of Diabetic Retinopathy (DR), Madras Diabetes Research Foundation, Chennai and Sankara Nethralaya Chennai have developed 'India Retinal Image database platform' using artificial intelligence based method. The database possesses 863 Retinal colour photograph images along with 863 OCT image video files with 1, 10,464 frames images. A large Optical Coherence Tomography image database of people with diabetes with corresponding retinal colour fundus photographs and clinical metadata has also been created.

Biotechnology Information Systems Network (BTIS-Net)

Department of Biotechnology is supporting Biotechnology Information Systems Network (BTIS-Net), a nation-wide network of Bioinformatics Centers, with a focus to bridge the interdisciplinary gap, build up information resources, and prepare biological databases and development of computational biology tools to address the research problems across all the disciplines of natural sciences. BTIS-Net programme intends to accelerate R&D in biotechnology sector through supporting Centres for conducting advanced research by 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.

The 47 centers supported all across the country **(Figure 3.D.2)** are involved in cutting edge Bio-medical research, synthetic biology and development of artificial intelligence based tools for healthcare and agriculture apart from developing human resource in computational Biology as well as Infrastructure development. The focus of these centers is to develop new bioinformatics approaches for improved genome analysis, transcriptome data analysis, deep learning algorithms to predict features from genomic data, develop high quality, manually curated, disease-specific online databases and customizable algorithms for data mining, drug design and development and also to develop high quality and efficient tools/ methods to increase the accuracy of analysis. Each of the bioinformatics centres supported, falls under one of the following unique domain areas Structural Bioinformatics/Drug discovery/ Drug development /Chemiinformatics, Database/ Tools/ML, Genome Informatics/ Metagenomics / Systems Bio/Microbial, Agriculture/Plants/Animal biotechnology, Marine/Aqua biotechnology, Human diseases/Disease informatics, Biodiversity and Proteomics/Metabolomics.

Figure 3.D.2: *Revamped BTIS-Network of DBT*

Thirty-five National Network Projects (NNPs) projects are being supported which are essentially multicentric projects to promote the collaboration between established bioinformatics centers and institutes and groups who are actually generating

biological data for computational analysis or complementary expertise to collaboratively workforce a bigger research objectives. Each network project in the above broad domain have different objectives, yet complementing research activities (**Figure 3.D.3**). Thus, these projects are expected to develop and use powerful computational methods which can answer various questions in different domains of biology and generate testable hypotheses for experimental validation.

The NNPs have been designed to inter-link different centres/institutions/research groups to bring them to a common platform. In any such projects major thrust is on computational methodology development/analysis and the data specific to this individual biological domain will be accessed from the available global databases. The DBT BTIC Apex center housed at ICGEB is tasked with centralized hosting of resources, public outreach, workshops, and training programs for BTIS-Net centres. It also carries out the activities like networking, website development, training in bioinformatics techniques, and promoting international collaborations. Regular activities include bioinformatics infrastructure development, evaluating BTIS-Net centers and maintaining virtual machines for hosting DBT funded resources.

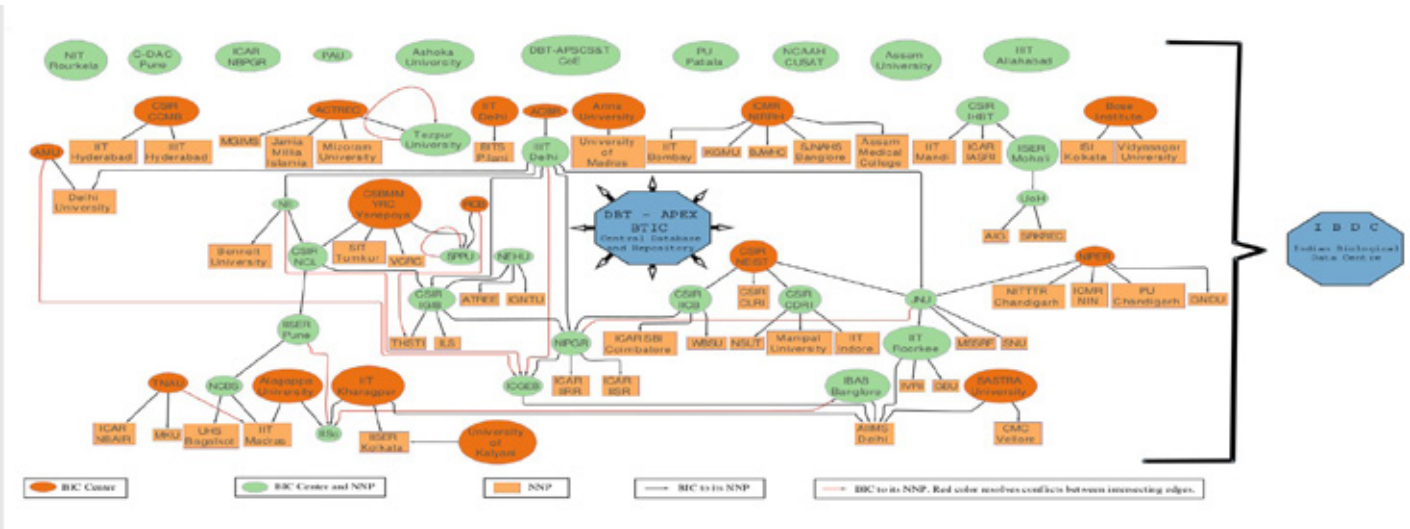

Figure 3.D.3: *Complementry associations of BIC and NNPs of revamped BTIS-Network of DBT*

Major achievements of the programme during 2023-24 are as follows:

Quantitative and Qualitative indicators for Major achievements	
No. of Research Publications	261
No. of Patents Applied	05
No. of Patents Obtained	01
No. of Database/Tools developed	68
No. of Human Resources Trained	3746

Some of the research highlights of these Bioinformatics center (BIC) and National Network Projects are as follows:

The DBT- Bioinformatics center (BIC) at IISc, Bangalore is focused on tackling biological challenges in human health and disease through the lens of systems biology and computational structural biology. Centre conducted various outreach activities like, a brainstorming session among faculty from and outside IISc on

"Integrating Bioinformatics with Biology", a two-day conference (SIRCON 2023) on "Autoimmunity and inflammation - a new epidemic" and a faculty training program on bioinformatics tools and analyses at the IISc Challakere campus. Research activities carried out at the center on different diseases like Tuberculosis, Diabetes, cancer etc., help to understand the underlying causes of diseases and explore new approaches to tackle the pathology of the disease. Personalized models of biological functions help in understanding patient prognosis and stratification. One such work from the BIC was developing personalized models of NAD metabolism in hepatocellular carcinoma patients. The studies carried out on the structural aspects of biomolecules like the protein-ligand interactions help in identifying off-target effects of drugs. The use of single-molecule techniques and multiplexed imaging to study enzymes that copy, protect, and compact the genome, is useful to understand the effects of antiviral and antibiotics on enzyme kinetics.

The Bioinformatics Center at ICGEB has made significant societal contributions through its diverse bioinformatics and computational studies in healthcare, agriculture, drug discovery, and COVID-19-related issues. Key impacts include the development of AI-based tools for predicting trabeculectomy outcomes in juvenile glaucoma and identifying angle dysgenesis, enhancing clinical decision-making and patient care (**Figure 3.D.4**). Notable cancer research outcomes include the identification of novel prognostic signatures in lung squamous cell carcinoma and prostate cancer, aiding early diagnosis and personalized treatment. The upgraded VirulentPred 2.0 web server aids in identifying virulent proteins, crucial for understanding pathogens and developing treatments. These efforts collectively enhance healthcare, reinforce agricultural sustainability, advance cancer research, and improve public health responses, significantly benefiting society.

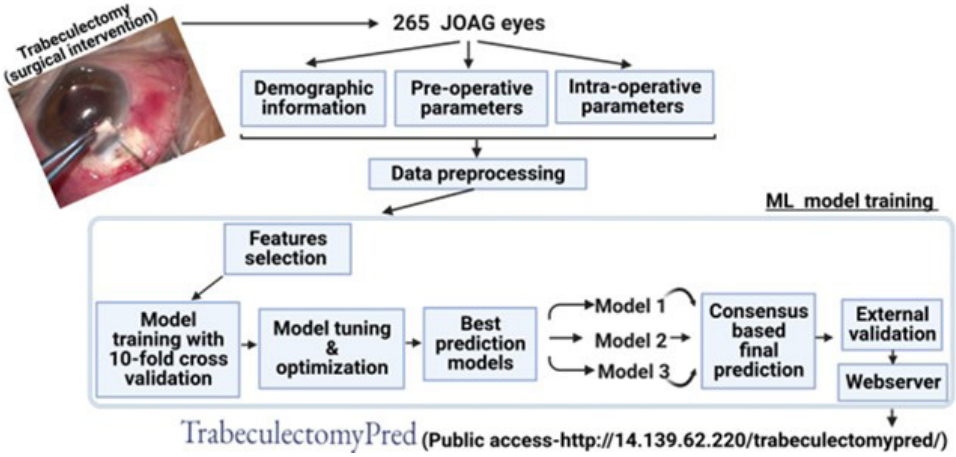

Figure 3.D.4: *TrabeculetomyPred Tool developed at DBT-BIC in ICGEB*

The Advanced BIC for Disease/Epigenetic/ Futuristic Genomics (ABCDEFG) at the CSIR – Centre for Cellular and Molecular Biology, Hyderabad is a state-of-the-art bioinformatics facility that can analyze large scale whole-genome data and extract biologically meaningful results and conclusions. Using a range of mutant *E. coli* strains and subsequent enzymatic treatments, they systematically benchmarked the existing deep neural network models to detect DNA methylation (5-methyl cytosine, 6-methyl adenine, and 4-methyl cytosine) from raw Oxford Nanopore data. They

have also developed neural network models, called NEMO (Nanopore Epigenetic Modification Output) models that accurately identify 6-methyl adenine from the Oxford Nanopore data generated on the R9.4.1 chemistry. They also created a new tool called Ribbit (Repeat identification by bit operations) that accurately identifies imperfect tandem repeats from assembled genomes, along with the motif and purity information. The tool is on par with existing tools in terms of accuracy while running twice as fast.

DBT-BIC at IISER, Mohali has designed and implemented an innovative exon descriptor framework Exon Nomenclature and Classification of Transcripts (ENACT), for enhanced annotation of transcript(s)/isoform(s) to enable systematic analyses of alternative splicing effects on protein function/structure. The transcript(s) of protein-coding genes from five model organisms viz. Caenorhabditis elegans, Drosophila melanogaster, Danio rerio, Mus musculus, and Homo sapiens are annotated and documented in ENACTdb database available at http://iscbglab.in/enactdb/. The web server provides exon-centric visualizations of annotated isoforms, facilitating the investigations of either exonic alterations impact on a single isoform or comparative analyses of changes in isoforms due to exon inclusion/deletion/changes in splice sites. Through multiple transcript alignment view, it is feasible to detect alternative splicing events such as exon skipping, intron retention, and most importantly identifying mutually exclusive events. Additionally, a protein mapping tool is provided to map a query protein sequence to their respective exons and delineate unmapped region.

DBT-BIC at CSIR – North East Institute of Science and Technology, Assam is developing indigenous software by integrating different open-source tools and algorithms. The group intends to develop an open-source Galaxy-based drug discovery platform, Molecular Property Diagnostic Suite (MPDS), with disease-specific information. MPDS is an ideal mixture of various data, small molecular drug discovery tools and algorithms, and advanced ML tools. The MPDS portal can be accessed at http://mpds.neist.res.in. The MPDSCOVID19 was recently published, and the current effort is to develop a single platform for docking, protein-protein interaction analysis. In addition they have developed the Indian Herbal Formulation database, where 522 unique herbal formulations have been incorporated. A computational drug repurposing approach was applied to identify drug molecules that can be repurposed against 24 different SARS-CoV2 protein targets.

The efforts of DBT-BIC Centre at IIT, Delhi is to build a computational ecosystem for addressing various biological research problems is very much on track through its indigenously developed Genome to Drug (Dhanvantari) pipeline. In Genomics, apart from the conventional physico-chemical approach, the group has incorporated the deep learning and signal processing based methods to strengthen the research outcomes (http://www.scfbio-iitd.res.in/bioinformatics/genefinding.htm). The quality assessment module in Proteomics has been enhanced for the evaluation of protein structures as a component of the Bhageerath initiative (http://www.scfbio-iitd.res.in/bhageerathH+/). In Drug Design, with the addition of the improved versions of in-house docking protocol (ParDock+), newer scoring algorithm (BAPPL+), machine learning based RASPD+ software which is a computationally fast protocol for identifying good candidates for any target protein. Sanjeevini, which is a culmination of all these modules, is very much in the contention to be among the best Drug Design software available globally (http://www.scfbio-iitd.res.in/Sanjeevini/index.php) (**Figure 3.D.5)**.

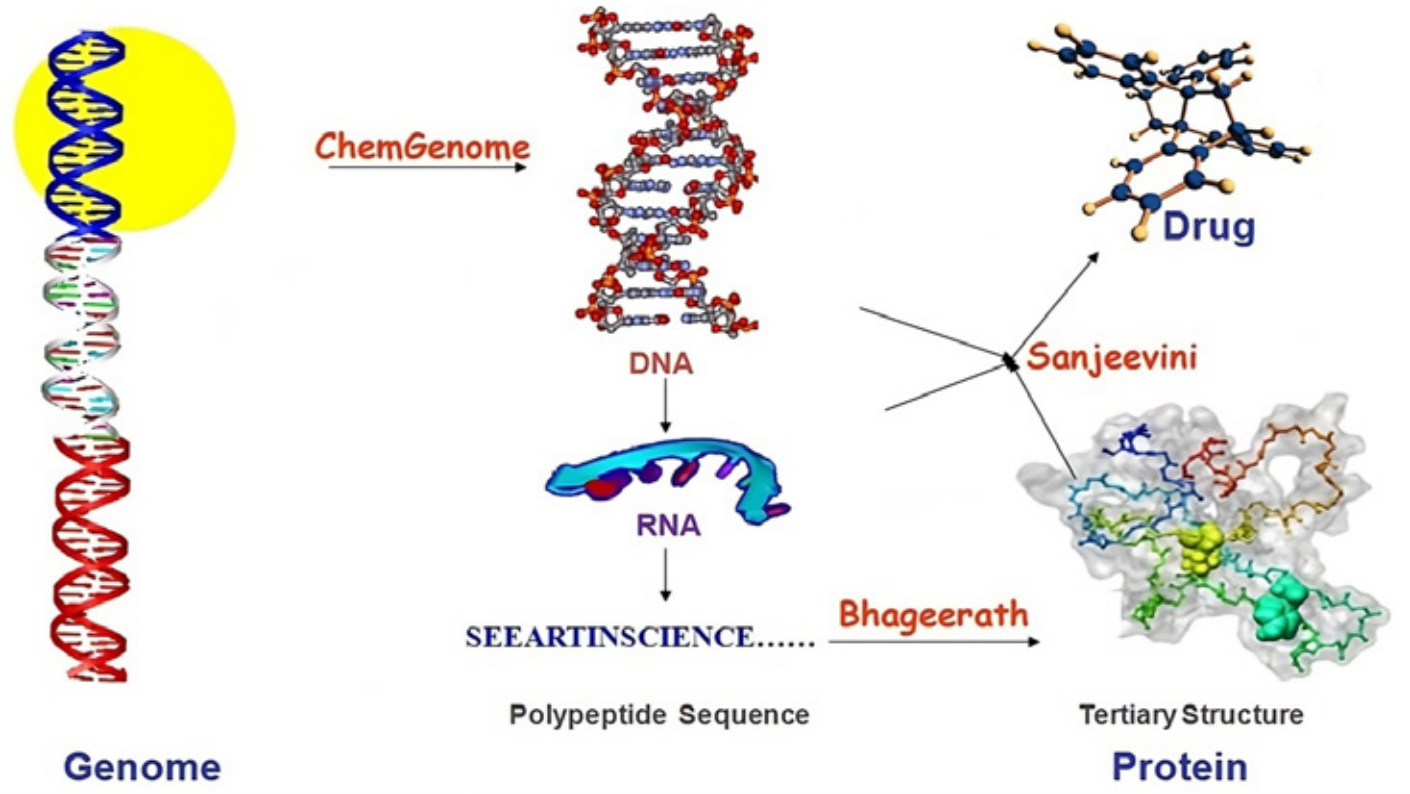

Figure 3.D.5: *Sanjeevini Module: A Complete Drug Design Software Suite*

DBT-BIC at CDRI Lucknow, the center has played a vital role in creating cutting-edge technologies like the development of ML-PDDT (ML-Powered Drug Discovery Tools) application suite, a web server utilizing machine learning algorithms with three integrated modules: OmegaX for predicting active compounds, AlphaX for screening molecules based on similarity, and BetaX for protein-protein interactions prediction. This suite is accessible at https://cdri.res.in/mlpddt/.

DBT-BIC at IIIT Allahabad has created a comprehensive database ABDB: the Structural and Functional Knowledgebase for Antibiotic Resistance, containing information on 5,967 clinically mutated β-lactamase enzyme sequences across different classes. This knowledgebase serves as a valuable resource in understanding antibiotic resistance mechanisms.

DBT-BIC at NEHU has done sequencing and publicly release of the complete genome and transcriptome of the largest human intestinal fluke for the first time. Similarly, it sequenced the organelles and the entire Indian pitcher plant's genome for the first time. The establishment of the web-based portal 'NEIHPID', showcasing taxonomical and NGS data on parasitic helminths, serves as a cornerstone resource benefiting the research community and society at large.

BIC at Aligarh Muslim University organized series of events across various institutions in India in line with the World Health Organization's "World Antimicrobial Awareness Week" has had a substantial societal impact by raising awareness about antimicrobial resistance (AMR), a pressing global health threat. Additionally, the publication of sixteen research articles in international peer-reviewed journals underscores the academic commitment to addressing AMR, contributing to global knowledge and potentially influencing policy and practice. These multifaceted efforts collectively

enhance public understanding, encourage responsible antibiotic use, and underscore the critical nature of AMR, fostering a more informed and proactive society.

The DBT-BIC at ACBR focuses on development of tools (including computational) for the discovery of novel drugs for target-based cancer therapy and to combat the threat of antimicrobial resistance in microbes. The web server for predicting target-based inhibitors has been completed and is ready for launch. The models built using ML and pharmacophore-based methods against HDAC, PARP1, CDK1, CDK4/6, telomerase, and BCR-Abl, will be made available soon for public use.

DBT- Computational Biology Centre at Assam University has developed and modified the database "DiaBank"(https://diabank.co.in). This database is the repository of the plants and their phytochemicals which have proven activity towards diabetes. Centre has also has taken initiative for Introduction of M.Sc. Bioinformatics Course to provide scope for pursuing two academic programme simultaneously as per National Education Policy 2020.

DBT-BIC at IHBT Palampur has also developed the DLNet model for a rice-specific network and introduced the A-HIOT framework for virtual screening of potential drug molecules and repurposing. Machine intelligence has guided the selection of optimized inhibitors for HIV from natural products. All these tools are freely available to the scientific community.

DBT-Centre for Microbial Informatics (DBT-CMI) was established with a main objective to create a stable and sustainable bioinformatics platform for storing, accessing, and analysing microbiological information found in diverse habitats of India along with skill and man-power development in this area of research. DBT-CMI I playing a crucial role in the analysis of the data generated by Anthropological Survey of India(AnSI) regarding the human gut metagenomes of Indian Particularly Vulnerable Tribal Groups (PVTGs).

The research activities of the Bioinformatics Center at the Bioscience and Biotechnology Department of IIT Kharagpur are focused on understanding the structure, function and evolution of regulatory networks with an emphasis on human diseases. Center has developed an efficient mapping of RNA-binding residues in RNA-binding proteins using local sequence features of binding site residues in protein-RNA complexes, classified and characterized the modular architecture and functional annotation of human RNA-binding proteins containing RNA recognition motif, and explored the correlation between increased heterogeneity in expression of genes with cancer progression and drug resistance. The database and webservers developed are available for academic use for free and can be accessed through our website (http://www.csb.iitkgp.ac.in/bioinformatics_centre/home.html).

In the National Network Project of JNU various institutes, has performed integrated multi-omics (transcriptomics, proteomics and metabolomics) analysis in two cultivars with contrasting response to drought to dissect molecular mechanism underlying drought stress response in rice and chickpea. This analysis is being extended further to multiple cultivars and other omics datasets to gain deeper insights into the mechanistic aspects of drought stress tolerance in crop plants. The pipelines have been optimized for genome and transcriptome analysis and integrated analysis of few omics datasets. A workshop on NGS based QC and transcriptome data analysis was organized in association with DBT-BIC.

Indian Biological Data Centre (IBDC)

The Indian Biological Data Centre (IBDC) is the national digital data repository mandated to archive all life science data generated from publicly funded research in India. It is supported by the Government of India (GOI) through the Department of Biotechnology (DBT). The IBDC enables the implementation of the "Biotech-PRIDE Guidelines" (Promotion of Research and Innovation through Data Exchange). The computational infrastructure, including a High-Performance Computing (HPC) facility and archival data storage, is hosted at RCB and NIC, Bhubaneswar. RCB houses a computing power of about 800 Tera Flops (AI mixed precision) along with a 4.5 PB (PetaByte) of storage, while NIC (Bhubaneswar) has a data storage capacity of about 1 PB. The biological data generated by researchers in India is being archived and curated at IBDC. The measures for routine and scheduled maintenance to ensure the proper functioning of the HPCC facility have been carried out on a timely basis. Owing to the magnitude and complexity of the expected data, IBDC is being developed in a modular nature. Currently, IBDC operates through five specialized data portals dedicated to the management of diverse biological data types (**Figure 3.D.6**).

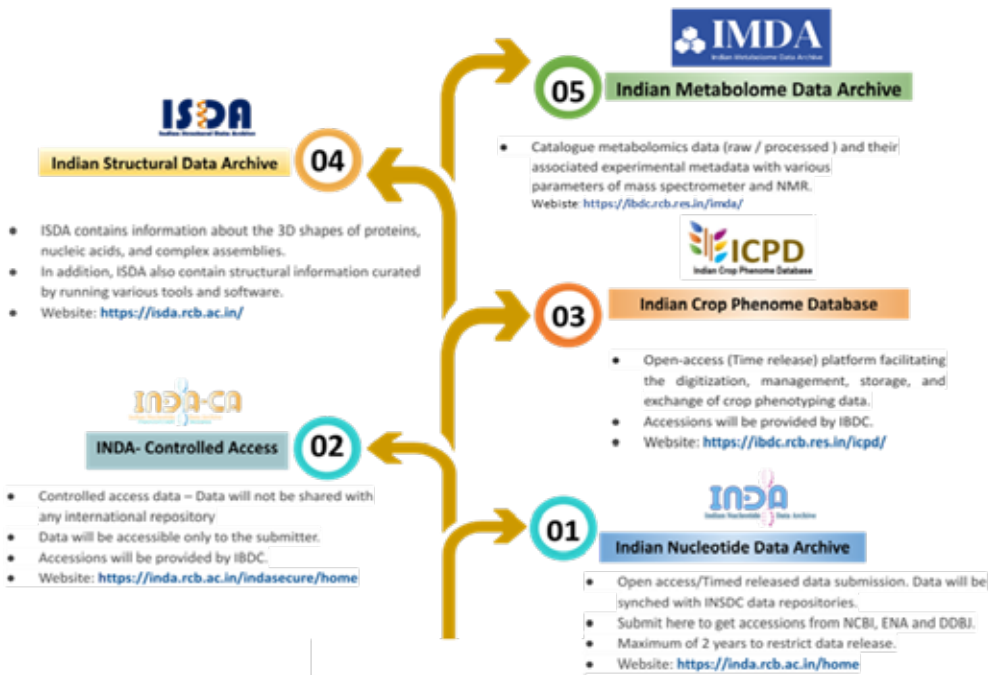

Figure 3.D.6: *Active data archival portals of Indian Biological Data Center (IBDC).*

Indian Nucleotide Data Archive: INDA is an open-access (Time-released) platform for archiving, managing, and sharing diverse types of nucleotide sequencing data generated across India. Data is synched with INSDC (The International Nucleotide Sequence Database Collaboration) repositories like GenBank-NCBI, ENA, and DDBJ. Submission to IBDC automatically generates both IBDC and INSDC (GenBank, ENA-EMBL, and DDBJ) accessions, and thus, there is no need to re-submit the data to international repositories (**Figure 3.D.7**). A Total of 4330 Raw Data submissions, 100 Assembly submissions, and 5 annotated sequences have been submitted to IBDC from 81 Different organisms, accounting for 41753533804542 bases and 26266457579070 bytes.

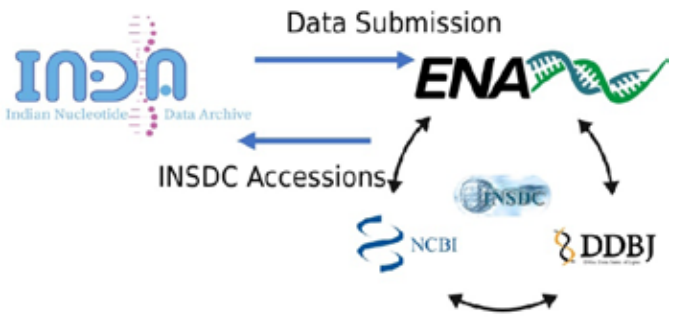

Figure 3.D.7: *Nucleotide data submission cycle at IBDC*

Indian Nucleotide Data Archive-Controlled Access: INDA-CA is a controlled access platform for archiving and managing diverse types of nucleotide sequencing data (similar to INDA) generated across India. In contrast to INDA, data submitted to INDA-CA is not shared with any international repository and resides securely on servers in India (IBDC) only. Data submitters can control the access of their data sets in consultation with the data center team. IBDC has also developed special submission tracks for projects of national relevance such as INSACOG, INSACOG Sewage Surveillance, and GenomeIndia. On the INDA-CA portal, 2269 submissions from 12 organisms have been received. A total of 229773 SARS-CoV-2 genomes from 60 different institutes have been submitted via the INSACOG portal, with a total of 1189 variants identified. The FASTA files from the INSACOG portal can be accessed by signing up to the portal. A total of 1145 SARS-CoV-2 sewage surveillance samples from five different institutes have been submitted via the INSACOG sewage surveillance portal. A total of GenomeIndia 9753 samples have been submitted to IBDC which include GVCF/UBAM and FASTQ files.

Indian Crop Phenome Database: ICPD is an open-access (Time-released) platform facilitating the digitization, management, storage, and exchange of crop phenotyping data following FAIR data guidelines. The portal provides universal data formats for the submission of phenotyping datasets from 30 different crops. Data from 6571 different plant traits using over 7000 different experimental techniques can be submitted. All submissions are provided permanent accessions by IBDC. Currently, 16 datasets belonging to one crop involving 21 traits, 17 tissues, 19 developmental stages, 1 gene, and 12 treatments have been submitted by 4 users of three different organizations. The data portal also provides personalized desktops for the users where they can view and analyze their submitted data sets. Tools for graphical visualization and statistical analysis of the submitted data are also provided on the web dashboard.

Indian Metabolome Data Achieve (IMDA) is an open-access platform for archiving, managing, and sharing metabolomics data and associated experimental metadata generated through analytical techniques such as Mass Spectrometer (MS) and Nuclear Magnetic Resonance (NMR). IMDA accepts targeted and un-targeted data and metabolite structures identified in metabolomics experiments. The raw data can be uploaded in the form of binary files and processed data in the form of quantitated metabolite concentrations, MS peak height/area values, LC retention time, NMR binned areas, etc. A unique and persistent IBDC accession will be assigned on data submission to IMDA. A total of 64 samples with their raw data files of NMR based metabolomics study have been submitted by one to IMDA-IBDC.

Indian Structural Data Archive: ISDA contains information about the three-dimensional structures of biological macromolecules and their functional complexes with natural or synthetic molecules. It also contains structural information curated by various tools and software. At present, ISDA has list of 218196 experimental structures (MX, NMR, and Cryo-EM) and 626895 theoretical models. The archive mirrors the information present in the wwPDB and is updated on a weekly basis.

Integration with DBT-CDAC integrated computing environment (ICE):

DBT-CDAC has developed an integrated platform for online software development and analysis called ICE, which is hosted by IBDC. Through this platform, researchers can directly access the installed computing environment, open access data in IBDC, and other applications available under IBDC computing resources. At present, users of ICE use a separate entry point, and it has been proposed that ICE users may also have access to IBDC data sets through a seamless mount point. In this regard, ICE and IBDC will aim to come up with an authorization protocol that will avoid multiple levels of entry and usage of IBDC datasets and aim to unify the licensing conditions wherever possible. Users of these platforms will be provided an API-based access through ICE with the same conditions as other IBDC users.

BRAHM HPC Access

In addition to data archiving services, IBDC also provides bioinformatics data analysis and access to 'BRAHM-HPC' to the research community upon request. A total of 49 principal investigators from 35 different organizations are using the HPCC. On average, about 1900 jobs per month have been executed on BRAHM HPC by the users. To further provide seamless services to our users, a dedicated web portal for managing the HPC access and data analysis requests has been developed and implemented on the IBDC web page (https://ibdc.rcb.res.in/hpcrequest). The screenshot of the portal is shown in **Figure 3.D.8.**

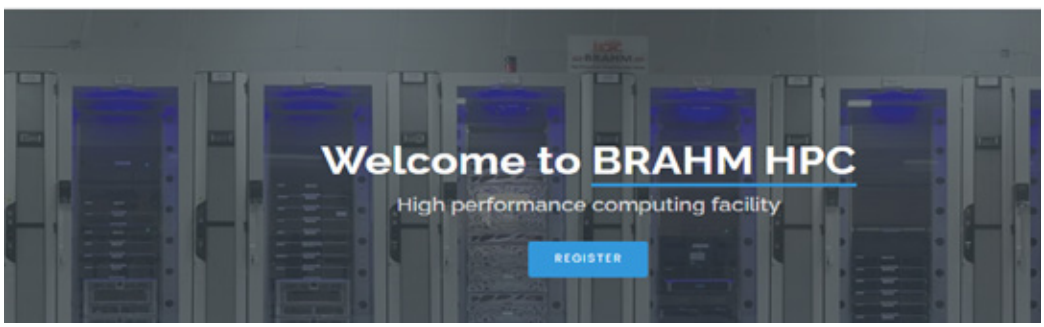

Fig. 3.D.8: *A Screenshot of HPC portal*

Data Analysis Service

In addition to data archiving services, IBDC also provides bioinformatics data analysis and access to 'BRAHM-HPC' to the research community upon request. Several research groups are already availing of the HPC storage service and analysis support from IBDC. IBDC also provides data analysis services (In-depth Whole Genome Variant call and phylogenetic analysis, RNA-seq analysis, *de novo* genome assembly, MiRNA microarray data analysis, SARS-CoV-2 variant analysis, etc.) to 11 different research groups affiliated with 8 institutions.

Outreach activities

To spread the word about the activities of IBDC, outreach activities are conducted on a regular basis for data submission (nucleotide data, phenome data, INSACOG data, and GenomeIndia data); IBDC BRAHM HPC Usage and data analysis discussions **(Figure 3.D.9).** As of now, 100 workshops with more than 1000 participants associated with 67 institutions, have been successfully conducted.

Figure 3.D.9: *Summary of various outreach activities of IBDC*

The 17th Annual International Biocuration Conference (AIBC-2024) was jointly organized from 6th -8th March, 2024 by the Indian Biological Data Centre (IBDC), set up by Department of Biotechnology, Government of India at NCR Biotech cluster, Faridabad and Department of Plant Molecular Biology, University of Delhi South Campus for the first time in India at the auditorium complex of the 'National Capital Region (NCR) Biotech Science Cluster' in Faridabad, India.

On the occasion, Dr. Jitendra Singh, the then Hon'ble Minister of State (IC) for Science & Technology launched 'ICE'-Integrated Computing Environment, a cloud-based computational facility for life science researchers (**Figure 3.D.10**). IBDC Capsule and three biological data Submission portals-1. Indian Nucleotide Data Archive –Controlled Access (INDA-CA) portal 2. Indian Crop Phenome Database Portal, & 3. Indian Metabolome Data Archive Portal were also launched. The conference was attended by 218 participants from 16 countries.

Figure 3.D.10: *Dr. Jitendra Singh, the then Hon'ble Minister of State (IC) for Science & Technology launching ICE'-Integrated Computing Environment, a cloud-based computational facility in 17th Annual International Biocuration Conference (AIBC-2024), organized from 6th -8th March, 2024 in IBDC*

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4. BUILDING INTERNATIONAL COLLABORATIONS AND PARTNERSHIP

4 BUILDING INTERNATIONAL COLLABORATIONS AND PARTNERSHIP

Department of Biotechnology (DBT) is supporting projects and programmes through Global Innovations Directorate in mutually agreed areas of cutting edge research and innovations in Biotechnology and Life Science sector to strengthen science diplomacy. Department has been supporting various R&D bilateral programmes with Switzerland, Sweden, Australia, Netherlands, Belgium, Germany, Canada, South Korea, UK and USA and Multilateral Partnerships with European Union, BRICS, Globalstars (EUREKA), QUAD, G20, HFSPO and EMBO. Under the scheme Department also partnered with Philanthropic Organizations Bill & Melinda Gates Foundation (BMGF)-the USA and other NGOs.

The International cooperation programme of DBT aims at bridging the technology and capacity gap in emerging areas of biotechnology and life sciences by bilateral and multilateral sharing of knowledge, resources, and expertise. The programme supports Research and Innovation in various areas of biotechnology including Maternal and Child Health, Vaccine Development, Diagnostic devices, Fundamental and Basic research, One-Health and AMR, Waste to Value, Bio-fuels, Animal Health, Aquaculture, and Climate Smart Agriculture.

The programme has facilitated the creation of new knowledge, development of technologies, and fostered capacity building, training and mentorship of human resources. Through its continuous efforts, the department has managed to place India as a preferred international cooperation partner for several countries. Partners include Government S&T organizations, research/academic institutions, councils, philanthropic organizations and NGO's.

Major initiatives:

Bilateral Cooperation:

a) **DBT-NSF Research Collaboration Programme:** Department of Biotechnology (DBT) Ministry of Science & Technology, Republic of India and National Science Foundation (NSF), Republic of United States of America have signed an Implementation Arrangement (IA) on Research Collaboration on 22nd August, 2023 in New Delhi in the august presence of Dr. Jitendra Singh, Hon'ble Minister of State (Independent Charge), Ministry of Science & Technology (**Figure 4.1**). In pursuant to the DBT-NSF-IA, a Dear Colleague Letter [DCL]: Special Guidelines for submitting Collaborative proposals under Department of Biotechnology (DBT), India and U.S. National Science Foundation (NSF) was issued for inviting the proposals for consideration. Under this DBT-NSF call department has received 91 proposals and these proposals are being examined for further consideration.

b) **Indo-Sweden (DBT-VINNOVA):** Department has announced a Joint Call for Proposals under the indo-Sweden Innovation Partnership 'Cooperation within Health focusing on AI-based Digitalization, Bio-design or Circular Economy'. The aim of this call is to enable

innovative, sustainable, scalable, and cost-effective health solutions in both countries. The department has received 38 proposals and these proposals are being examined for further consideration.

Figure 4.1: Signing of an Implementation Arrangement (IA) on Research Collaboration between DBT and NSF.

c) **Indo-UK (FADH):** Department announced an Indo-UK (DBT-BBSRC) Joint Call to address Farmed Animal Diseases and Health **(**FADH) focusing on enhancing mechanistic understanding of host-pathogen interactions and tackling veterinary antimicrobial resistance (Vet-AMR) including bacterial, parasitic and viral pathogens for the purpose of improving animal health. Under this call 34 proposals were received and these proposals were reviewed in the Expert Committee and 7 proposals have been recommended through mutual consent for funding support.

d) **India-U.S. Collaborative (Vision Research Program):** Department announced a joint Collaboration Call Funding Opportunity Announcement (FOA)-2023 under Vision Research Programme. This Funding Opportunity Announcement encourages Multiple Principal Investigators applications from United States (U.S.) and Indian institutions as bilateral collaborations that will advance science and technology important to understanding, preventing, and treating blinding eye diseases, visual disorders and their complications. The department has received 5 proposals and these proposals are being examined for further consideration.

e) **Indo-Australian Biotechnology Fund (IABF) Collaborative Research Project - Round 15:** Department announced a call for proposals under the Innovations partnership between India and Australia to support research and innovation projects that are highly relevant for scientific solution for AMR and RNA Vaccines. The priority areas of research under this call were Antimicrobial Resistance (AMR), RNA Vaccine and Therapies. Out of the 22 proposals submitted, only 20 were deemed suitable for review by the Expert Committee, with 2 ultimately being approved for funding support.

Multilateral Partnership:

a) European Union:

- A call under EU HORIZON 2023 Framework on New detection methods on products derived from new genomic techniques for traceability, transparency and innovation in the food system. Proposals were expected to contribute to the development and validation of detection methods of products obtained through new genomic techniques.
- A call on Pandemic preparedness and response: Broad spectrum antiviral therapeutics for infectious diseases with epidemic potential was announced. Aim of the call was on preclinical work and proof-of-concept/first-in-human studies and early safety and efficacy trials for testing new or improved anti-viral therapeutics, with a clear regulatory and clinical pathway, Innovative delivery systems and suitable safety profiles for broad use, application of novel approaches and widely applicable workflows (e.g. artificial intelligence) for rapid and reliable identification of broad-spectrum anti-viral therapeutics.
- A call was announced on Validation of fluid-derived biomarkers for the prediction and prevention of brain disorders. Aim of the call was to validate biomarkers that can reliably confirm early stages of the human brain disorder and guide treatment/ intervention selection, to provide evidence supporting the regulatory acceptance of the biomarkers, exploitation of existing data, bio-banks, registries and cohorts is expected, together with the generation of new key data.
- DBT and EU launched a call on Pandemic preparedness and response: Host-pathogen interactions of infectious diseases with epidemic potential. Focus of the call was on identification and characterisation of receptors on the host cell and viral surface proteins that enable the docking and internalisation of a virus with a particular emphasis on the diversity of cellular entry receptors and tissue specificity, characterisation of the mechanism of viral uptake in the host cell with regard to the topology and the dynamics of the host receptor – virus-ligand interaction.

b) BRICS: 6th coordinated call for BRICS multilateral projects 2023 under thematic areas "Systematic response–Using WEF (water, energy, food) nexus approach for a cross-sectoral management of climate change" was announced. Under this call, 7 proposals are received and 2 proposals found eligible for the scientific evaluation.

c) DBT-BMGF:

- **Cachexia Tuberculosis (TB):** Grand Challenges India (GCI) announced an open Call for Proposals on 'Fundamental and Innovative Research in Cachexia TB to address the needs and gaps in India. 50 proposals were received in response to the request for proposals (RFA) that solicited consortia-based research interests with a strong rationale aiming to explore and address the unresolved questions surrounding cachexia TB.
- **Climate Change and Health:** GCI had announced a Call for Proposals on 'Accelerating Catalyzing Solutions for Climate Change's Impact on Health to encourage locally led, system-level research and ideas that are scalable and sustainable, and support the studies and innovations that utilize transdisciplinary approaches to adapt and mitigate or reverse the combined, deleterious effects of climate change on human health. 93 applications received in response to the RFA launched.

- **Accelerating Catalyzing Solutions for Climate Change's Impact on Agriculture in India:** GCI launched an open call for proposals on Accelerating Catalyzing Solutions for Climate Change's Impact on Agriculture. This program that has been strategically designed to address the challenges within the agri-food system amidst the backdrop of climate variability and change, received 160 applications.

No. of research publications	30
No. of projects completed	17
No. of technologies developed	08
No. of technologies commercialized	01
No. of Manpower trained	180

Major Achievements:

Bilateral Cooperation

A. INDO-SWISS:

- A project on structure, dynamics, and function of CCR5-arrestin interactions is being implemented at Indian Institute of Technology Kanpur has determined the structure of β-arrestin1 in complex with the phosphorylated carboxyl-terminus of CCR5 and revealed the interaction interface and activation-dependent conformational changes in β-arrestin1. These findings have implications for better therapeutic targeting of this receptor using novel chemical molecules with unique pharmacological profiles.

- A project on direct 3D Bioprinting strategies to study articular cartilage development and regenerative therapy for osteoarthritis is being implemented at IIT, Delhi addressed problem of osteoarthritis by using rats' BMSCs encapsulated in a silk-fibroin-based scaffold with different modulators of BMP and WNT signaling. The full cartilage defect model optimized with the desired size and the scaffold containing differentiated BMSCs has been implanted successfully. With this study, researchers has manipulated Wnt and BMP signaling pathways to target the mesenchymal stem cells to guide their differentiation to chondrocytic lineage which can produce a healthy collagen matrix and regenerate the fully functional cartilage in an OA patient (**Figure 4.2**).

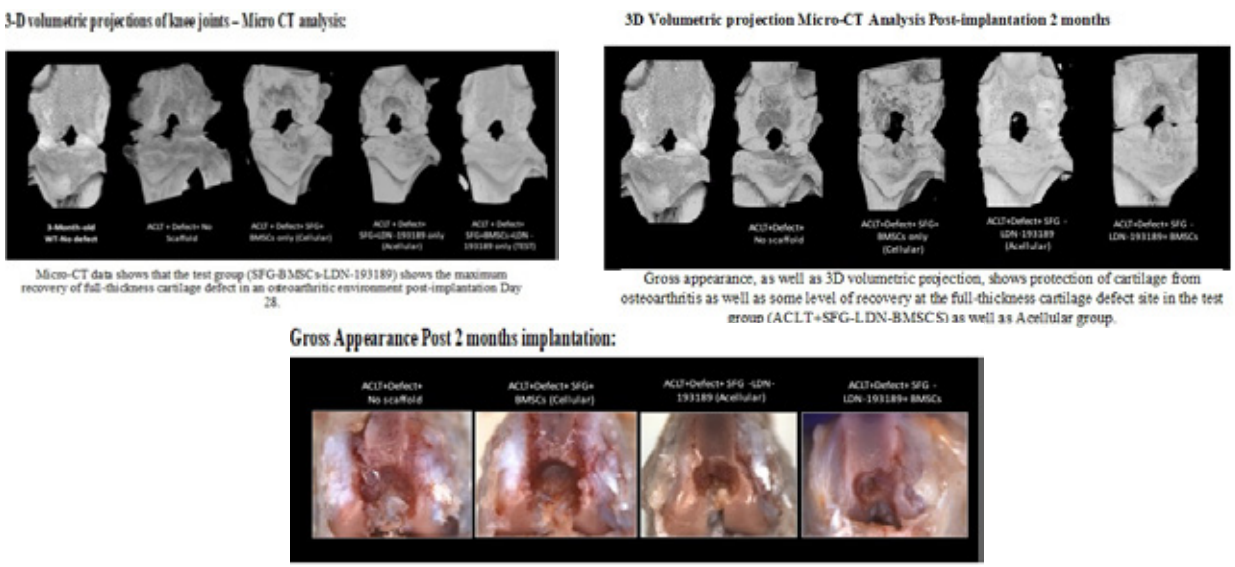


Figure 4.2: 3D Bioprinting strategies to study articular cartilage development and regenerative therapy for osteoarthritis

- A project entitled the genetic control of morphological and ionomic adaptation during the colonisation of India by grain amaranth is being implemented at Vivekananda Institute of Hill Agriculture, Uttarakhand has conducted phenotyping of diverse indigenous and global amaranth genotypes (476 accessions). The heritability estimates for most of the biochemical traits suggests complex genetic architecture and greater influence of environment in the inheritance of the traits.
- A project on unravelling the interaction of mineral nutrition (N and K) and vitamin B6 metabolism for sustainable agricultural practices is being implemented at National Institute of Plant Genome Research, New Delhi has reported that the different nutrient regimes (of nitrate and ammonium nutrition or combination) plays a role in causing differential growth effects in Desi and kabuli chickpea.
- A project on deciphering the functions of the conserved fat storage-inducing transmembrane (FITM2) protein in lipodystrophy and insulin resistance through systems approaches is being implemented at AIIMS, New Delhi demonstrated that in the absence of FITM2, yeast cells become auxotrophic for inositol and revealed precise role of FITM2 in lipid metabolism. (**Figure 4.3**).

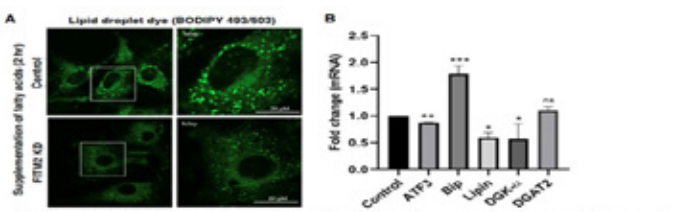
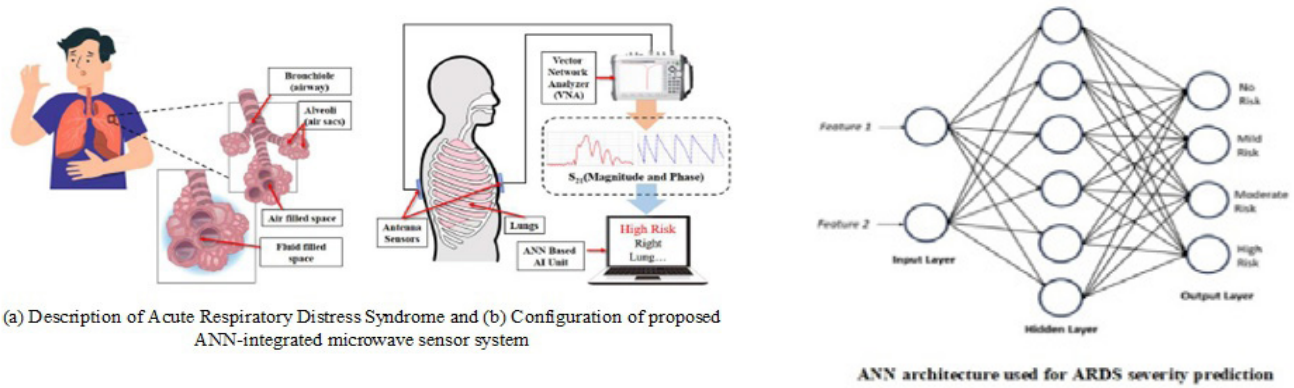


Figure 4.3: Deciphering the functions of the conserved fat storage-inducing transmembrane (FITM2) protein in lipodystrophy and insulin resistance through systems approaches

B. INDO-SWEDEN:

- A project on Assessment of Bone Age using Artificial Intelligence in children and adolescents across different ethnicities implemented at Hirabai Cowasji Jehangir Medical Research Institute Jehangir Hospital, Pune has developed a novel methodology for rating bone age from hand X- rays. This method segments hand into three groups of bones and base. This project has also developed bone age assessment (BAA) software to implement their new segmental Greulich Pyle method and demonstrated high quality BAA using their software trained on the RSNA (Caucasian) dataset.

- A project on AI based Detection of Acute Respiratory Distress Syndrome (AI-DARDS): An artificial intelligence aided non-contact framework for detecting acute respiratory distress syndrome using microwave sensors is being implemented at Indian Institute of Engineering Science and Technology Shibpur, West Bengal has developed a two-antenna-based microwave system integrated with an ANN-based AI system for the severity detection of ARDS. This study integrates four key components: portable microwave-based system design, simulation on human body model, phantom trials and AI based classification methodology for detection of ARDS. These findings serve as a proof-of-concept for the system's diagnostic and monitoring capabilities (**Figure 4.4**).



(a) Description of Acute Respiratory Distress Syndrome and (b) Configuration of proposed ANN-integrated microwave sensor system

ANN architecture used for ARDS severity prediction

Figure 4.4: AI based Detection of Acute Respiratory Distress Syndrome (AI-DARDS): An artificial intelligence aided non-contact framework for detecting acute respiratory distress syndrome using microwave sensors

C. INDO-UK:

- A project on AMRWATCH: Defining the AMR Burden of Antimicrobial Manufacturing Waste in Puducherry and Chennai is being jointly implemented at Pondicherry University and Indian Institute of Technology, BHU has standardized the method for Metagenomic DNA extraction from Animal faecal, Human Faecal, Water and Sediment samples, standardized the method for identifying 196 resistant genes from metagenomic DNA samples, completed with pilot study and analysis of all biological samples. These findings underscore the importance of assessing drug resistance dynamics within different environmental compartments, highlighting the potential impact of pharmaceutical effluents on the emergence and persistence of multi-drug resistant bacterial strains.

- A project on AMRflows: Antimicrobials and resistance from manufacturing flows to people: joined up experiments, mathematical modeling and risk analysis being jointly implemented at IIT, Hyderabad, IIT, Madras and IIT, Gandhinagar revealed a significant concentration of antibiotics in both the Musi and Adyar Rivers, potentially leading to the emergence of antibiotic-resistant microbial populations. An infection-risk assessment study was carried out to understand developmental changes in a fish embryo model. This work highlights the likelihood of low survival rates and developmental disorders in fish populations.

D. INDO-GERMAN:

- A project on Effects of Urbanisation on Value Chains and Livelihoods of Farmers and other Stakeholders (Poultry and Sheep / Goat Value Chains) being implemented at UAS, GKVK, Bengaluru reported that the major production constraints faced by contract broiler farmers are disease outbreak, inadequate availability of labour and high wages; whereas, sourcing of quality inputs, disease outbreak and high feed cost are the major production constraints faced by noncontract broiler farmer (**Figure 4.5**).

Figure 4.5: Effects of Urbanisation on Value Chains and Livelihoods of Farmers and other Stakeholders

- A project on investigation of drug polymer interactions by coarse grained molecular dynamics simulations for stable drug formulations is being implemented at NIPER, SAS Nagar demonstrated the limitations of current methods of selection of polymers/ surfactants and highlights the advantages of in-silico methods like coarse grained (CG) models. The project attempted numerous amorphous solid dispersion (ASD) formulations of celecoxib (CEL) for enhancing the solubility, dissolution rate, and in vivo pharmacokinetics via high drug loading, polymer combination, or by surfactant addition.
- A project on Impact of urban consumption on peri-urban agroecology and livelihoods being implemented at School of Development, Azim Premji University, Bengaluru has reported that consumers' income, lifestyles and occupation influence their consumption preferences towards local and exotic produce.

Multilateral Partnership

A. DBT-EUROPEAN UNION:

Water Cooperation:

- Strategic Planning for Water Resources, Development and Implementation of Novel Biotechnical Treatment Solutions and Good Practices (SPRING) project at IIT, Guwahati is focusing on mitigating adverse scenarios in the water quality of the Godavari Delta and river Ganga near Varanasi encompassing canals and drains. This project has developed microbial sensory platform integrated automated smart technology for river environmental analysis, underground pipe blockage detection and clean-up (**Figure 4.6**).

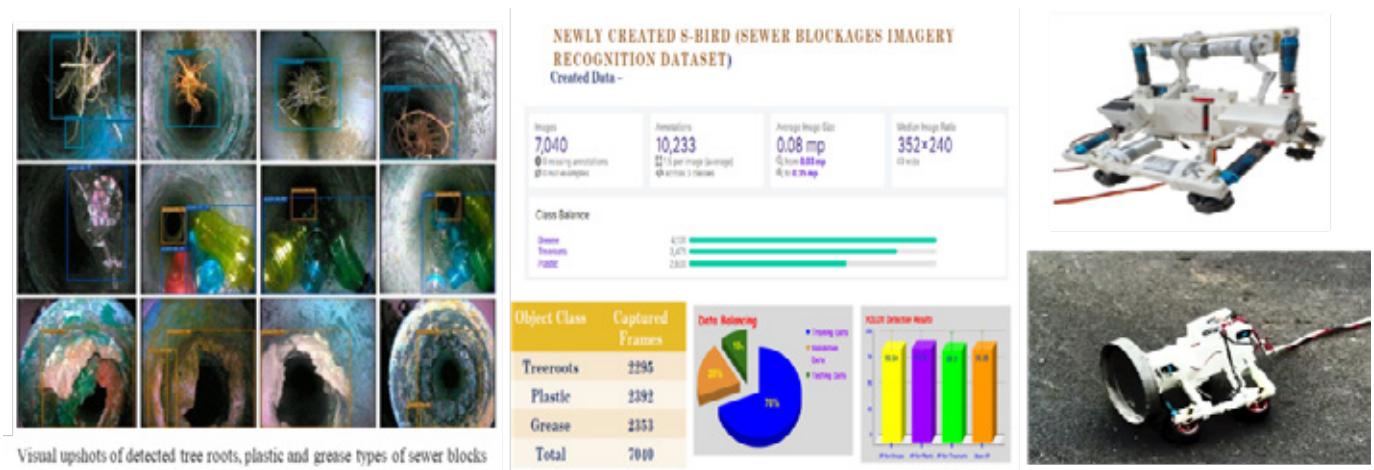


Figure 4.6: Sewer Robotic System for Detecting Underground Water Blockages

- bIo-mimetic and phyto-techNologies DesIgned for low-cost purification and recycling of water (INDIA-H2O) project at Pandit Deendayal Energy University (PDEU), Gandhinagar has demonstrated technology to fulfil need for freshwater in the coastal region of Gujarat and showcase zero liquid discharge by installing Integrated Batch RO-FO system in Nilkanth Varni School, Lodhva village, Tehsil – Sutrapada, District - Gir Somnath (**Figure 4.7)**.

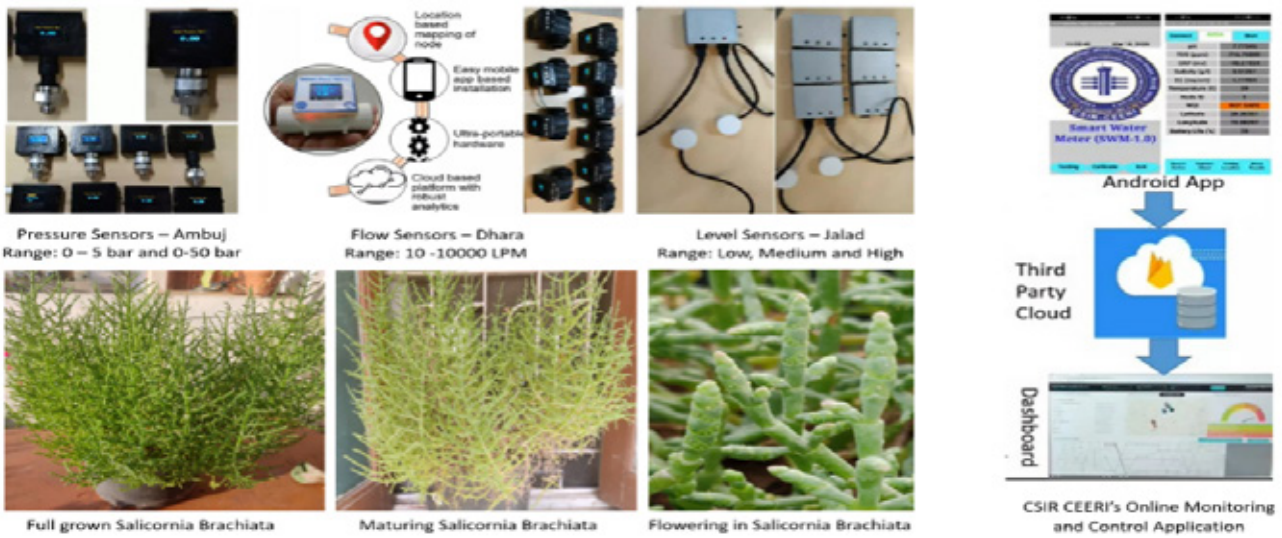


Figure 4.7: Demonstration of low-cost purification and recycling of water in INDIA-H2O project

Cervical Cancer:

- Prevention and Screening Innovation Project Toward Elimination of Cervical Cancer (PRESCRIP-TEC) study at MAHE, Manipal has developed an Innovative cervical cancer screening protocol, in which hrHPV self-test is done as a primary test and VIA-AI as a triage test.

Maternal and Child Health:

- Connecting European cohorts to increase common and effective response to SARS-COV-2 pandemic (ORCHESTRA) project at THSTI, Faridabad is evaluating risk of adverse maternal and neonatal outcomes associated with SARS-CoV-2 infection.

Human Influenza Vaccine:

- Indo- European Consortium for Next Generation Influenza Vaccine Innovation (INCENTIVE) study at NII, New Delhi has down-selected Pentavalent COBRA mix formulation for GMP manufacturing in India for the clinical trials.
- Evaluation of Rationally Designed Influenza Vaccines (ENDFLU) study at IISc, Bengaluru has tested several novel subunit vaccine designs in mouse immunizations and shown to protect against high-dose viral challenge for next generation influenza vaccine candidate(s) with broader and longer-lasting protection up to and including a Phase I clinical trial and Controlled Human Infection Model (CHIM) study.

- Effective and Affordable Flu Vaccine for the World (INDIGO) at THSTI, Faridabad has reported that the tetravalent Flu vaccine, Fluarix Tetra, is immunogenic in an Indian population. Study design enables assessment of vaccine response rate, persistence/ phases; provides detailed immunogenicity along with mechanisms that may limit vaccine immunogenicity.

Tuberculosis Vaccine:

- In Silico Trial for Tuberculosis Vaccine Development (STriTuVaD) project at AIIMS, New Delhi has enrolled 120 (90 DS+50 DR) TB patients for RUTI TB vaccine clinical trial, Safety and efficacy of RUTI vaccine is being monitored in pulmonary tuberculosis patients.

B. DBT-EUREKA Cooperation: A breakthrough bio-coating technology to improve shelf-life, contamination resistance, and the quality of eggs (EggsTEND) project at Venkateshwara Hatcheries Ltd, Pune is in process to make the facility of egg coating as per the need of market like coating of eggs with or without washing.

C. DBT-BRICS Cooperation: SARS-CoV-2 Network for Genomic Surveillance in Brazil, Russia, India, China and South Africa (NGS-BRICS) project at NIBMG, Kalyani has standardized the Droplet Digital PCR (ddPCR) method to quantify the SARS-CoV-2 viral copies in specimens. Additionally, Phylodynamic analysis of SARS-CoV-2 genomes has revealed a unique sub-cluster bearing 6 co-appearing non-Spike mutations and their plausible emergence in India.

D. G20 Research and Innovation Initiative Gathering (RIIG): Under India's Presidency of G20, the Department of Biotechnology led G20 Research and Innovation Initiative Gathering (RIIG) conference was held in Dibrugarh and Itanagar on 24th-25th March 2023. More than 100 delegates from G20 member countries, guest countries and international organisations, as well as the scientific community, gathered to discuss and explore ways to build a sustainable and circular bio-economy. The interactive event facilitated active engagement among all key stakeholders, including people, policies and places to promote an inclusive policy-making approach that provides a conceptual framework to mainstream circular bio-economy models across different sectors **(Figure 4.8)**.

Figure 4.8: Department of Biotechnology led G20 Research and Innovation Initiative Gathering (RIIG) conference at Dibrugarh/Itanagar on 24th -25th March 2023 on Circular Bio-economy

E. QUAD: Department is leading Horizon Scanning subgroup on next steps regarding collaboration in the synthetic biology and biomanufacturing area. Currently, discussion regarding establishment of principles for collaboration on synthetic biology as a first step and prior to consider specific areas of possible joint partnerships is underway.

International Non-Governmental Organizations (NGOs):

DBT-BMGF Partnership (Grand Challenges India): The Grand Challenges India since its inception has become a catalyst for transformative

societal impact by focusing on healthcare, education, and technology. In healthcare, the initiatives have addressed critical issues related to maternal and child health, infectious diseases, and healthcare delivery systems, leading to improved health outcomes and sustainable healthcare models. Grand Challenges India has also significantly influenced capacity building by supporting STEM programs, empowering marginalized communities, and enhancing overall education quality. Additionally, in the technology sector, the initiative has fostered breakthroughs in data sciences and artificial intelligence, contributing to inclusive technological development.

The Grand Challenges of India under DBT-BMGF collaboration has supported Women and Infants Integrated Growth Study (WINGS). This study was designed as an individually randomized factorial design trial. The study enrolled 13,500 married women aged 18-30 years residing in the low-income - to lower-middle-income neighbourhoods of Delhi, with no or one child and with fertility intentions. The findings indicate that a package of interventions in multiple domains when delivered concurrently had a significant impact on the.

CERVAVAC vaccine: India's 1st indigenously developed quadrivalent Human Papilloma Virus (qHPV) vaccine against cervical cancer supported under DBT and BMGF cooperation received market authorization from DCGI in 2022 to be rolled out in seven states of India for immunization of girls aged 9-14 years age, as announce in the Interim budget of GoI 2024.

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5. SOCIETAL PROGRAM

5 SOCIETAL PROGRAM

The Department of Biotechnology has been supporting projects for disseminating benefits of biotechnological knowledge, processes and technologies to the marginalized sections of the society especially farmers and unemployed youth in Aspirational districts and rural areas through Biotechnology Based program for Societal Development since 1990. Additionally, DBT through Biotech Krishi Innovation Science Application Network (Biotech-KISAN) program empowers farmers, especially women farmers by understanding the problems of water, soil, seed and market faced by the farmers and providing simple solutions to them.

5. A. BIOTECHNOLOGY BASED PROGRAM FOR SOCIETAL DEVELOPMENT

The program aims to benefit the vulnerable section of the society particularly farmers, women and SC/ST population across the country, especially focusing on the Aspirational Districts. The projects are implemented in agriculture and allied sector including animal husbandry, dairy, fisheries, integrated farming system, health & nutrition and environment & biodiversity conservation. During 2023, the Department had supported 30 ongoing projects in aspirational districts benefitting over 6000 persons. Out of these, around 72% of the total beneficiaries were women and 50% belonged to SC/ST communities. The projects have resulted in approximately 33% increase (on an average) in income of target beneficiaries and generated self-employment opportunities.

Major achievements during 2023 in various sectors of societal development program are as follows:

Agriculture and Environment Management

Koraput district of Odisha faces seasonal hunger and malnutrition owing to low seed replacement rate due to erosion of local landraces of paddy. Agriculture is the main occupation of the region and farmers rely on own saved seed and traditional agriculture practices like broadcasting that results in low productivity and returns. To overcome this issue, a project is being supported in Koraput district for conservation and scaling up of 8 promising local landraces of paddy (Machhakanta, Kalajeer, Umuriachudi, Basanti, Raghusai, Kudaichudi, Dialibhog, Sunachudi). The project has resulted in production of 621 quintals of seeds by using seed production technologies including pure seed collection from mother panicles, seed germination test, organic seed treatment, preparation of raised bed nursery, proper land development, application of botanical extracts like- beejamruta, jeebamruta and handikhata. These seeds will cater around 6500 farming households. 20 women self help groups (SHGs) have been formed and empowered for seed production and marketing. Besides this, soil samples have been analyzed for the richness and deficiency of both micro and macro nutrients and training programmes were organized for soil health management, seed production and post-harvest technology, grading and marketing thereby benefitting 1365 tribal farmers.

The tribal communities of Andhra Pradesh practice

podu cultivation on semi-circular broken chain of hills and hill slopes and gather Non Wood Forest Produce (NWFP) from surrounding forests for survival. Extensive podu cultivation has degraded forest and private lands and over exploitation of forest resources has led to disappearance of most of the NWFP. To restore the degraded forest lands for augmenting the income of tribal communities, a Bio Resource Complex has been established in Adarimetta, Paderu in Andhra Pradesh for domestication of broom grass. Broom grass plantations using microbial applications such as arbuscular mycorrhiza (AM) fungus *Claroideoglomus etunicatum* and plant growth-promoting rhizobacteria (PGPR) *Pantoea dispersa* have been taken up in a total of 50 acres of land in 10 villages of Ramachandrapuram cluster of Hukumpet mandal. The broom based value addition methods and standardised microbial technologies are being taught to the communities for forest species cultivation in sloppy lands along with broom grass. Moreover, inter cropping of pulses with broom grass cultivation by applying microbial culture is also being promoted. The project has facilitated skills on broom weaving, making diversity of brooms, value additions to broom panicles and value chains in the brooms and broom based enterprises in women and youth of the region **(Figure 5.1).** Scaling up broom grass domestication has not only increased the income of tribal peasants but also controlled soil erosions in the region.

Figure 5.1: *Training on weaving of brooms.*

The fish waste generated in the coastal regions is a serious issue of environmental concern. A project for recycling fish waste to livestock feed and manure for agriculture, and production of chitosan from sea shell and fish scales using a combination of marine microbes (marine actinobacteria and Bacillus sp.) and enzymes (papain, trypsin, and acidic protease) is being supported in Ramanathapuram, Tamil Nadu. More than 200 fishermen communities in and around Rameshwaram have been trained for efficient recycling of fish waste into value-added products like CIBA-PlanktonPlus and CIBA-HortiPlus, and recycling of shrimp/crab waste to value-added products like chitin and chitosan. PlanktonPlus, a product developed by Central Institute of Brackishwater Aquaculture, Chennai (CIBA) boosts plankton growth in aquaculture systems and in turn enhances aquaculture production. The dry powder HortiPlus is used as a manure/ fertilizer in horticultural plants **(Figure 5.2).**

Figure 5.2: *Fish waste to value added products end-product; CIBA – Plankton plus and CIBA- Horti plus*

Fisheries and aquaculture

The aquaculture productions are significantly lower in Assam in comparison to national average although it ranks among top 5 states in India in terms of presence of number of water bodies. To promote integrated fish farming, fish cum duck farming & backyard poultry cum fish farming for enhancing livelihood of rural population, a bioresource complex was set up in Goalpara district of Assam. A low cost fish hatchery has been established that resulted in significant breeding & culture of Cat Fishes like Magur & Pabda **(Figure 5.3)**. Moreover,

Figure 5.3: *Breeding and culture of catfish using low cost hatchery.*

derelict and unproductive fish ponds have been transformed to productive fish ponds. Fish feed was produced using animal waste besides enhancing plankton productivity through fermented mixtures of cow dung, rice bran, mustard oil cake, and molasses through yeast.

Ramanathapuram is considered to be one of the most backward districts of Tamil Nadu. It falls in the rain shadow region and is highly prone to drought. Though marine fishing is dominant in the district, the coastal communities are also dependent on the inland and brackish water mono-cropping aquaculture for their livelihoods. Therefore, a project demonstrating and skilling the local community in Integrated Multitropic aquaculture (IMTA) is being supported in Karankadu and Regunathapuram villages of Ramanathapuram district. IMTA combines cultivation of fed aquaculture species (finfish/shrimp) with organic extractive aquaculture species (bivalves) and inorganic extractive species (seaweeds) in appropriate proportions to create a balanced system. The beneficiaries are being educated in mussel farming, ornamental fish farming, seaweed farming and floating cage culture in brackishwater **(Figure 5.4)**. As a result, 90 percent of beneficiaries have started spending 1-2 hr/day for IMTA after attending to their regular routine job. Moreover, the fishing hours of beneficiaries have been reduced significantly thereby leading to rural economic development and improvement in the livelihood status of the beneficiaries.

Figure 5.4: *Skill development training for culturing bivalves.*

Livestock and poultry farming

Artificial insemination is widely used to increase productivity in cattle in India; however, this technology is still limited in use in goats. Therefore, to elevate livelihood status of the rural population, through improved breeding practices like artificial insemination (AI), a project is being supported by the DBT in Bahraich district of Uttar Pradesh. The project has resulted in training 20 women as Pashusakhis for advanced goat farming with an average monthly income of Rs 2000/-. Additionally, 32 Goat AI workers have been educated in implementing USG-based pregnancy diagnosis, thereby resulting in 839 Goat AIs with a 49.6% conception rate **(Figure 5.5).**

Figure 5.5: *Enhancing goat productivity through artificial insemination.*

In another DBT supported project different strains of chicken like Aseel and Kadaknath have been introduced for backyard chicken rearing to improve livelihood and nutritional security of rural community in three villages; Panikulam, Monganvalasai and Kolunthurai of Ramanathapuram district in Tamil Nadu. 30-35 villagers have been imparted training for managing backyard poultry using various equipment's and management practices. Three batches of one month old Aseel chicks along with package of inputs viz., feed, cages, oral pellet vaccine, chickguards, vitamin tonics etc. were supplied to the villagers. The health conditions of the birds were closely monitored and necessary preventive cum control measures were also offered. Beneficiaries were able to sell their grown-up cocks, hen and eggs at a profit of Rs.150/- per bird resulting in the return on investment in the ratio of 1:1.67. The project has created 30 successful farm entrepreneurs.

Food processing

A multi-purpose processing and incubation unit has been established at Khariar in collaboration with Lokadrusti NGO, NIT Rourkela and IIT Delhi to benefit the tribal community of Nuapada district in Odisha. The tribal community of the region strives to generate basic livelihood by utilizing the locally available horticultural and non-timber forest produce (NTFP) such as sal, karanja, jatropha, chironji, mahua, tendu, tamarind, amla, jamun, jackfruit and lemon. The processing unit transforms these forest produce to value added products like juices, concentrates, jam, jellies, chocolate, triphala powder, TAMRAS, biscuits, mahua health drinks, nutra- beverage and candies to support tribal economy. The local SHGs, food processor organisations (FPOs) and local youth have been identified and are being trained in the complex.

In Kandhamal, one of the most backward districts of Odisha, a decentralized food processing facility for making products from millets and sweet potatoes has been established to solve the deep-rooted food insecurity and malnutrition in the tribal community. Under the project, seven workshops involving 320 beneficiaries from 85 SHGs in six Gram Panchayats have been conducted for sensitization, training, and demonstration for production of value-added products including chips, sev, jam, and gathia, from sweet potatoes and bread, pasta, noodles, and cookies from millets. This has further resulted in formation of a self-employment venture comprising of ten women called **Ama Snacks, Raikia**. Biofortification of millet and sweet potato flour using lactic acid bacteria *Lactobacillus plantarum* to enhance folate content has also been executed.

Lack of knowledge on technologies related to post-harvest management and processing of foods in the rural community of Namsai district, Arunachal Pradesh has caused huge monetary loss due to mismanagement of the agricultural produce in the markets. The Department has established a rural bioresource complex in Namsai for sustainable income generation through production of value added products like pickles and chips, candy, chips, ready to serve (RTS) beverages and nectar through fruit and vegetables processing using biotechnological interventions **(Figure 5.6).** 2 Panchayat level federations (PLF) and 9 SHGs consisting of 215 women have been trained on the process technology, packaging, marketing and branding of the finished products. 2 PLF and 6 SHGs have become entrepreneurs and are marketing their products.

Figure 5.6: *Hands-on training program on preparation of chips.*

Hailakandi district of Assam is one of the worst performing districts of the country in terms of human development index, employment rate and industrialization due to unavailability of technology and infrastructure like bio/agro/ food processing unit for commercial exploitation of the abundant farm & forestry products in the region. In this context, a Bio Resource Complex at Hailakandi has been established wherein a pilot level facility for producing three types of products viz. (i) Dehydrated flaked products (Tea based and Hibiscus sabdariffa leaves and calyx based variety of dry beverage blends), (ii) Flavored Tea blending line and (iii) Infusions based beverage and condiment (Hibiscus calyx extracts and sauce) has been developed. The facility is handholding over 50 SHG members and has recently created one Start up, **MySuFu**. A forward linkage with Tholua India for entrepreneurs active in the area of dehydrated fruits and vegetables has been established. Besides this, a data base of 310 medicinally important plants has been developed.

Department of Biotechnology launched a special call for proposal for implementation of Societal Development Programmes and setting up Rural Bioresource Complex in Rural Areas and Aspirational districts of India in the area of Human Health and Nutrition. The aim of the Call for proposals is to enable dissemination of field-tested and proven biotechnological innovations/technologies already available with DBT AIs, national laboratories, universities, scientific research institutes etc. for immediate benefit of the vulnerable population (women /SC/ST/rural community).

5. B. BIOTECH-KRISHI INNOVATION SCIENCE APPLICATION NETWORK (BIOTECH-KISAN)

Biotech-Krishi Innovation Science Application Network (Biotech-KISAN), a scientist-farmer partnership scheme that empowers farmers, especially women farmers for agriculture innovation. It aims to understand the problems of water; soil, seed and market faced by the farmers and provide simple solutions to them. The Scheme is for farmers, developed by and with farmers, it empowers women, impacts locally, connects globally, is Pan- India, has a hub-and spoke model and stimulates entrepreneurship and innovation in farmers. The programme has now been scaled up and expanded its activities covering 115 Aspirational Districts in the country. 52 Biotech-KISAN Hubs have been established in collaboration with ICAR covering all 15 agro-climatic zones across the country. Over 200 entrepreneurships have also been developed in rural areas. The programme has benefitted over three lakh farmers (directly and indirectly) so far by increasing their agricultural output and income. These farmers have adopted best farming practices and various scientific interventions in their farms, which have been developed by different scientific institutions and laboratories in the country. A large farming community has also benefited through various training programmes and workshops conducted by Biotech-KISAN Hubs. The formation of Self Help Groups (SHGs) or Farmer Producer Organizations (FPOs) has also been promoted by Biotech-KISAN Hubs for developing viable marketing linkages of farmers' produce.

Major highlights of the progress made in ongoing programmes are as follows:

Under the Biotech KISAN Hub at Indira Gandhi Krishi Vishwavidyalaya, Raipur, the project was operated in six tribal-dominated Aspirational Districts of Chhattisgarh state. A total of 2173 farmers were benefitted under the project. One of the underlying accomplishments of this project is that about 45% to 50% women farmers have benefitted and more than 60 % farmer families were from Tribal communities of the Bastar zone. The income of farmers was enhanced to 40-50 % by the cultivation and production of quality seeds of improved bio-fortified rice varieties. The farmers were also encouraged for value addition of their produce through the formation of FPOs and SHGs in tribal areas. These all interventions led to improved socio-economic status of the farmers in the Bastar zone of Chhattisgarh.

In Biotech-KISAN Hub Programme implemented in Nadia, Murshidabad, Birbhum, Maldah and South Dinajpur districts of West Bengal, through West Bengal University of Animal and Fishery Sciences, Kolkata, a total of 37552 of farmers of Aspirational districts have been benefitted (28756 women farmers) through 14 technological package of practices (i.e. Application of region specific Mineral Mixture supplementations, Deworming with specific Anthelminthics, Feeding of Concentrate Mixture and Azolla feeding, Proper Housing and Management, Cultivation of Green Fodder, Vaccination of Goats against PPR, Vaccination of Goats against Goat Pox, Vaccination of Poultry, Adoption of Superior quality Germplasm of Black Bengal Goat, Adoption of Superior quality of Vanraja Chicks, Adoption of Superior quality of Indian major carps, Application of divided dose of lime for water treatment, Application of Ornamental fish farming, Value Addition in Meat and fish Products) under the project. Total 14 FPOs and 134 Farmer Interest Groups (FIGs) have been constituted for effective entrepreneurship development and getting best price of their household farm products.

Biotech-KISAN hub at MANTHAN, Bhopal has continued activities in eight Aspirational districts of Madhya Pradesh in collaboration with the ICAR-IISR, ICAR-CIAE and with eight KVK in each district. The project has economically benefited 67,630 farmers through improving their farm income and socio-economic stataus by adoption of new farming technologies. The overall activities undertaken in this project benefitted farmers and also attracted many other farmers to adopt the new technology laid out under the project. Technology for quality seed production especially in self pollinated crop has been is transferred to FPO.

A project "Popularization of biofortified maize hybrids in Himalayan states and Central India with special reference to North Eastern Region for Sustainable Nutritional Security" was implemented for popularizing nutritionally enriched maize especially in the Himalayan region. The region encompassing North-eastern hill regions and western Himalayan states are maize eaters and their poultry and piggery industry is also dependent on the maize. The QPM along with provitamin A enriched maize is also developed for further improvement in nutritional benefits. These maize varieties developed by ICAR-Indian Agricultural Research Institute, New Delhi, ICAR-Indian Institute of Maize Research and ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora were demonstrated in Sikkim, Nagaland and Tripura (NEH region) and Himachal Pradesh, Jammu and Kashmir and Uttarakhand (Western Himalayan region) under the project.

Under the Biotech-KISAN Hub at Professional Assistance for Development Action (PRADAN), Deoghar, Jharkhand, the activities have been continued on demonstration of innovative

technologies in Tasar culture and 2,100 families have been covered. A total of 137 trainings were organized to train 2046 women and 605 male participants. By using the technologies, the production of seed cocoons has improved by 69%, the cocoon production in forest-based rearing increased by 71%, and yarn production and organic compost production have increased by 100%. The enhanced production has created a significant impact on other farmers and now these technologies are being adopted by the other families.

Under Biotech-KISAN Hub in Tripura, activities have been conducted on seed production and management practices of Pabda and minor carps involving 243 fish farmers in 22 villages of four districts in Tripura and 923 farmers have been benefitted through technical support in terms of training and demonstrations as well as through critical farm inputs. 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 Bodoland University, Kokrajhar, extensive production of mushroom followed by production of value added product of mushroom and its marketing by agencies like Mushroom FPOs and individual organization was given a prime focus. Farmers have been trained for cultivation of 24 species of Mushroom, 13 types of Value added products. This led to the total cumulative estimated production of Mushroom in Kokrajhar district as 76 tons. 78 demonstrations, 90 farmers level training were provided and a total of 76% SC/ST population was covered under the hub. The project witnessed transforming economic upliftment, technology, skill development and extensive entrepreneurship development.

Establishment of organic hub for promotion of organic and alike farming in farmer's field of Northeast, 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. Maize, Turmeric and Tomato related technologies were demonstrated in 30 hactares of the selected villages. An increase of 18-20% yield with 50% reduction of pests and disease incidence was recorded in the demonstrated area. Six (6) farmers Biotech Kisan Fellows were trained as master trainers for fellow beneficiaries of the aspirational districts. Proven technologies on biopesticides were licensed to Govt. of Meghalaya, Govt. of Nagaland, Jalpaiguri Vivekanada Educational Society, West Bengal and M/S Larry Enterprises, Meghalaya. A biopesticides production unit has been established for entrepreneurship development, mother culture maintenance, mass culture of biopesticides, packaging, sealing etc.

A project has been initiated at International Rice Research Institute (IRRI) South Asia Regional Centre (ISARC) Varanasi for enhancing Technological Innovations in Agriculture for Increased Food Security and Income as well as Capacity Development of Women Farmers of Rice-Based Agri-Food Systems in India. The project's emphasis on women's empowerment is evident through the targeted training of 600 women scientists and farmer participants, backed by finalized monitoring and evaluation indicators. The ongoing recruitment process enhances the project team's capabilities, ensuring expertise and proficiency for effective implementation.

Biotech-KISAN Hub Programme implemented in Champhai, Lawngtlai, Kolasib, Lunglei, Serchhip and Aizawl districts of Mizoram has conducted 462 frontline demonstrations (FLD) of selected vegetables and spices crops at the farmer's field. A total of 12 farmers training programmes and 01 scientist training programme were organized.

Total 360 farmers were admitted to 12 training programmes. A total of 90 lead trainers have been skilled to train and guide other farmers in their respective districts. Pamphlets indicating a package of practice for each crop were prepared in English and Mizo language and printed copies of the pamphlets were distributed to large number of farmers. To enhance marketability of Mizo chilli, ginger and turmeric, the marker compound-based evaluation in quality has been carried out.

At Biotech-KISAN Hub at South Asia Biotechnology Centre, Jodhpur, the focus is on strategically important aspects of the high value seed spices including cumin, paan methi, fenugreek and isabgol. The Hub has identified '*Abu Saunf Fennel*' as a priority crop for improving quality of seed production, nursery seedling production, distribution of quality seedlings, refining cultivation practices, focusing on crop nutrition and crop pollination, integrated pest and disease management, improving drying techniques to improve market realization. A detailed monograph titled "Sustainable Practices for Quality Production of IPM Cumin (*Cuminum cyminum L.*)" was prepared detailing GAP, IPM and value chain development in cumin.

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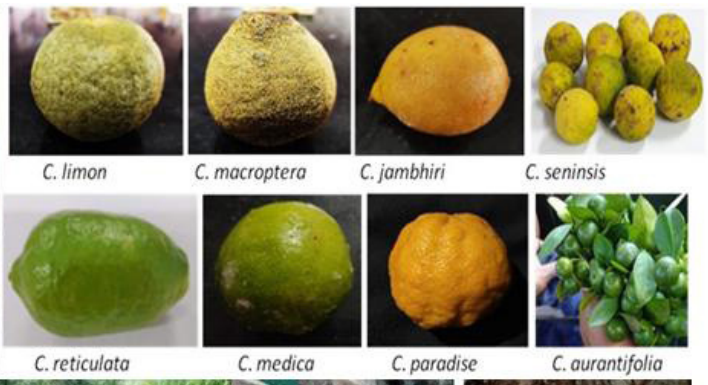

6. PROMOTING BIOTECHNOLOGY IN THE NORTH EAST REGION OF INDIA

6 PROMOTING BIOTECHNOLOGY IN THE NORTH EAST REGION OF INDIA

he North East Region (NER) of India has been identified as one of the biodiversity hotspots of the world. The region, though endowed with one of the best bioresources of the country faces several challenges in terms of poor agricultural/ horticulture outputs, high disease burden in the homogeneous ethnic communities, degradation of the fragile ecosystem, lack of skilled manpower, good research infrastructure etc. In order to give focused attention for the region, the Department has earmarked 10% of its annual budget every year for implementing special programmes for the NER since 2010. The specialized programme for NER aims at promoting and strengthening biotechnology related activities for addressing local challenges and harnessing endemic bioresources for the economic development of the region.

The Objectives of the NER Programme are as follows:

a) To facilitate biotech-based development in the North Eastern Region of India through conceptualization, implementation, mentoring and monitoring of biotechnology intervened R&D programs for holistic developments in the region.

b) To initiate Bio-resourse-based Entrepreneurship programmes in NER to uplift rural income of farmers and small entrepreneurs of the Region.

c) To establish of Research Resources, Service Facilities and Platforms to provide support to a broad range of multidisciplinary, shared research resources critical for advancing various areas of life sciences and biotechnology in the North East Region.

d) To implement programmes to ensure that human resource development matches the evolving needs of the North East Region.

Major initiatives taken: Under the NER programme, DBT announced a call for proposals on "Traditional Fermented Foods (TFF) of North Eastern Region of India: Health Implications and Development of safe/ hygienic food products. Proposals received under this specific call are in the evaluation process.

Major achievements during 2023-24:

Quantitative and Qualitative indicators for Major achievements	
Number of projects completed	14
Number of Process/Product/ Technology Developed	05
No. of Research Publications	70
No. of Patents Applied	01
No. of Human Resources Trained	1100

Biotech Hubs were established in NER universities, colleges, and institutions to support and promote biological sciences and biotechnology education, research through the provision of necessary infrastructure and advanced technology training to students, faculty, researchers, and local entrepreneurs. This year, 54 biotech hubs of Phase-I were further supported under Phase II (**Figure 6.1**).

***Figure 6.1**: Hands-on Advanced techniques in Molecular Biology and Bioinformatics at the Mizoram University under the Biotech Hub programme of the NER*

Through the project, "Programme Support for Training and Capacity Building in Northeast India," to the North East Centre for Biological Sciences and Healthcare Engineering (NECBH) at IIT Guwahati support will be provided to the students and researchers, primarily from NER, to get the most benefit out of the available resources **(Figure 6.2).**

***Figure 6.2**: XRD facility created under the NECBH Project at IIT Guwahati*

To emphasise services to farmers, and academics, the "DBT-North East Centre for Agricultural Biotechnology (DBT-NECAB): Phase III" project has been supported (**Figure 6.3**). Similarly, to strengthen Citrus research in NER, facilities were established at Institute of Horticulture Technology (IHT), Mandira, Assam, for the generation of certified scion material from Khasi mandarin (*Citrus reticulata*) and sweet orange **(Figure 6.4).** Rootstocks free from Citrus greening bacteria (CGB) and *Citrus tristeza* virus have been developed.

In view of promoting sustainable bioresources, a total area of 64.1 acres was covered for captive cultivation of selected medicinal crops like Curcuma caesia and compound-rich lemongrass (elemicin-rich and methyl-eugenol-rich). About 649 farmers and entrepreneurs from NER benefited from the training and awareness program. Additionally, an essential oil distillation unit has been installed at Mudoi village, Arunachal Pradesh, to support farmers in revenue generation. Furthermore, the *Docynia indica*, commonly known as Assam apple or wild apple, has been successfully explored towards making value-added products such as pickles, jam, candy, juice, etc., and the knowledge is being popularised among the tribal communities of Assam and Meghalaya through awareness campaigns and meetings **(Figure 6.5).**

Figure 6.3 *Plant Phytotron Facility at the NECAB, AAU Jorhat & Bioformulations developed under the NECAB project.*

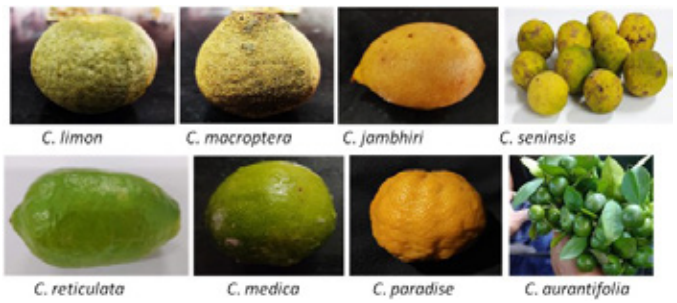

Figure 6.4: *Different citrus species collected from North East India*

Figure 6.5: *Value-added products from Wild Apple (Docynia indica). Pickle, Candy, Jam, Bottle for fermentation, Juice, Squash, fermented health drink, Mouth freshener.*

The diagnostic efficacy of an in-house lateral flow assay (LFA) for the detection of IgM/IgG anti-Brucella antibodies for rapid serodiagnosis of human brucellosis was evaluated in a joint effort by the College of Veterinary Science-Assam Agricultural University, Khanapara, & the ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, Bangalore **(Figure 6.6).**

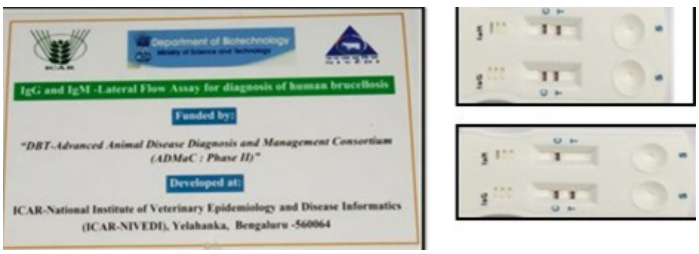

Figure 6.6: *IgM/IgG based LFA kit for diagnosis of human brucellosis*

In one of the projects, Scientists have developed biosensors to identify serum-based biomarkers (GSH, LDH, and Cardiac Troponin I) widely used for cardiac diseases, liver fibrosis, & kidney disorders. In addition, a novel technique for detecting general (pan) malaria and *Plasmodium falciparum*-specific malaria has also been devised. It has been demonstrated that the approach could be implemented both in instrument-based laboratory settings and in instrument-free paper-based portable platforms**.**

Figure 6.7: *Planting material distribution and plantation by the farmers in the High Altitude areas.*

In one of the project under the Himalayan Bioresource Mission (HBM) 1 lakh rooted plants of *Picrorhiza Kurroa* were planted by 100 farmers. *Picrorhiza kurrooa* is a well-known herb in the Ayurvedic system of medicine and has been traditionally used to treat disorders of the liver, upper respiratory tract, dyspepsia and scorpion sting **(Figure 6.7).** In another project under the HBM mission an in-house cultivation technology was used and 75 households were trained to grow edible and medicinal shiitake mushroom having high nutraceutical value **(Figure 6.8).**

Figure 6.8: *Shiitake cultivation on oak wood logs*

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7. PROMOTING ENTREPRENEURSHIP AND INDUSTRIAL GROWTH

7 PROMOTING ENTREPRENEURSHIP AND INDUSTRIAL GROWTH

7.A. BIOTECHNOLOGY PARKS

The Department of Biotechnology promotes innovative research & development activities in biotech sector and also helps to translate research into products and services. The Department has been establishing specialized Biotechnology Parks in the country in partnership with various state Governments. The Biotechnology Parks, offer facilities to Scientists, and Small and Medium sized Enterprises (SMEs) for technology incubation, technology demonstration and pilot plant studies for accelerated commercial development of innovative leads. The overall objectives of Biotech Park scheme is to translate research outcomes into large scale manufacturing and product development and commercialization of biotechnologies by providing necessary infrastructure support to develop high quality basic infrastructure and high end central equipment facilities. This has helped in the promotion of commercial development of biotechnology within the country by setting up of research laboratories for product development, start-up companies and small and medium enterprises. The Department has so far supported 12 biotechnology parks at 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. These parks are successfully accelerating the commercialization of new technologies, nurturing and maintaining emerging ventures and assisting new enterprises to forge appropriate linkages with other stakeholder of biotechnology sector including academia and Government. In the current year, DBT has approved a project for Setting up a Madhya Pradesh Biotechnology Park. 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 Madhya Pradesh but also from nearby States. This will also provide the opportunity to develop a culture for promoting plant tissue culture industries to enhance the farmer's income.

Major achievements of Biotech Parks during 2023-24 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 mandate of the Park is to improve the quality of life and economic status of people through biotechnological interventions. 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 incubated a large number of entrepreneurs. Currently Biotech Park is holding hands with 14 incubatees in which 5 are new entrepreneurs namely M/s Vatican Shona Agrotech Pvt. Ltd., M/s Capre Diem (UK based), M/s Adayma Herbals Pvt Ltd, M/s Ceyon Healthcare

Pvt. Ltd. and M/s Rad Care Research Pvt. Ltd. with these entrepreneurs. Presently Park is actively expanding its Analytical and Quality Assurance and Extraction Unit facilities along-with strengthening of HRD programs. 195 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 this current year, a total of 234 biotech/bioscience students were trained in different areas of Biotechnology for a period ranging from 1-6 months. An MOU has been signed on June 7, 2023 between Biotech Park, Lucknow and ISMN, International Institute of Food and Nutrition, (Study Centre) Department of Physiology, King Georges Medical University to support each other endeavors in delivery of academic programmes and research activity. On February 16, 2023 M/s Gene to Protein Pvt. Ltd. a co-occupant of the Biotech Park, Lucknow has launched their new product the 'GreenRTM dye' for nucleic acid staining and the qPCRMastermix. A two days seminar were organized on "Nutrition for Health Summit" Nature Health and Vegan Festival 2023 at Biotech Park, Lucknow in association with Department of Bio Engineering and Centre for innovation and Entrepreneurship Development, Integral University, Lucknow held on 15-16 October 2023.

Chhattisgarh Biotech Park

The Chhattisgarh Biotech Park was setup in joint collaboration of Department of Biotechnology, Govt. of India and Department of Agriculture, Farmer Welfare & Biotechnology, Government of Chhattisgarh. Chhattisgarh Biotechnology Promotion Society is the nodal agency for CG Biotechnology Park. The Park has seen significant success by promoting research & development in biotechnology. Through strategic partnerships and linkage development with academic institutions, industry leaders, incubators and government support, the park has become a catalyst for innovation. The Biotech Park's Incubation Centre has BS-IV standard lab, cumulating space for 23 companies. The Park has been promoting in agri-biotech, healthcare and industrial biotech sectors. Applications for incubation is open throughout the year and till date it has successfully supported more than 15 biotech startups in terms of handholding and mentoring support and farmers for societal benefit leading to the development of novel products (More than 20,000 litres of biofertilizers/ biopesticides) and solutions. The park emphasizes on imparting skill based trainings to 30 under-grad and postgraduate students from five different institutes for their holistic development so as to increase their employment ratio and thus creating a pool of talented professionals contributing in creating the region as biotech hub. The Chhattisgarh Biotech Park reflects the commitment to fostering scientific advancement, economic growth and job creation in the biotechnology sector. 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 involved and successfully supported more than 15 biotech startups in terms of handholding and mentoring support by organizing WISE: "Workshop on Innovation, Start-ups & Entrepreneurship" event. Startups/ young entrepreneurs have been continuously supported as per their requirements and more than 500 youth have been participated in different activities during start-up programs. Center also encourages best innovation/Start-up ideas for incubation & entrepreneurship development in the state. The Park is committed to foster scientific advancement, economic growth and job creation in the biotechnology sector. To cater social responsibility,

Chhattisgarh Biotech Park developed a bio-fertilizer using 6 microbial strains to improve the soil health and overcome the shortage of chemical fertilizers. The Park has produced more than 15000 liters of bio-fertilizers which was distributed to farmers' community, Gothan samitis and Self Help Groups of the state. In addition to this center has also provided training for use and scaling-up the bio-fertilizers.

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 Technology Incubation Centre of Guwahati Biotech Park (TIC, GBP) is involved with numerous activities related to promotion of entrepreneurship and human resource development in the area of Biotechnology and allied sectors especially for North Eastern region. The Technology Incubation Centre 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. For the development of the entrepreneurship ecosystem and encouraging the students as well as the industry of the region the Technology Incubation Centre of Guwahati Biotech Park has undertaken the responsibility to coordinate with various institutes of repute in and around the region. All the students of these institutes are visiting GBP to use equipment facilities awarded from DBT project.

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

The Biopharma Growth Phase Park (B-Hub) at Genome Valley, Hyderabad is a joint initiative of the Government of Telangana and Department of Biotechnology (DBT), Government of India with the overall aim to facilitate the growth and expansion of early-stage companies by offering R&D Lab Suites, Collaborative Spaces and Support Infrastructure. Spread across 2 acres in India's first systematically developed Lifesciences Cluster; B-Hub will facilitate the growth and expansion of early-stage companies by offering R&D Lab Suites, Collaborative Spaces and Support Infrastructure. The first-in-class Biopharma Scale-up facility will cater to both start-ups and established businesses, inducting them into Genome Valley's vibrant ecosystem. B-Hub is envisaged as a state-of-the-art scale-up manufacturing facility offering provision for modular R&D laboratory space. Establishment of the B-Hub facility along with the scale-up infrastructure and training will give India an impetus to lead in biopharma innovation. 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 Lifesciences sector.

Figure 7.1: *Biopharma Growth Phase Park (B-Hub) at Genome Valley, Hyderabad*

Industrial Biotechnology Parks (IBTPs) at Jammu & Kashmir

The Department of Biotechnology, Govt. of India and J&K Science, Technology & Innovation Council have jointly conceptualized the project of establishment of two Industrial Biotech Parks, one in Ghatti, Kathua in Jammu and other in Handwara, Kupwara in Kashmir region. The project has executed through CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM), Jammu as knowledge partner in the project 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 outside Industrial Houses.

Figure 7.2: *Industrial Biotech Park at Handwara, Kupwara in Kashmir*

Kolkata Biotech Park

Kolkata Biotech Park is a joint initiative of Government of West Bengal and Department of Biotechnology (DBT), Government of India with the overall aim to support start-ups and biotech industry in the state of West Bengal. This project was sanctioned by the Department of Biotechnology in February 2023. Presently, Kolkata Biotech Park has incubated 7 biotech companies (incubatees) who are already functional in the biotech park and 6 more biotech companies have been in-principle selected, whose lab modules are under construction and will be handed over soon. With this, 71% of the total incubation areas have already been allotted to the incubatees. The Park has been facilitating commercialization of biotech products and processes by extending a range of business support services namely Intellectual Property Management and Technology Transfer, Consultancy, Project Management, Regulatory Support and Information Dissemination. As of now, incubatees of the Kolkata Biotech Park has created direct job for 24 people and around 90.0 lakhs of investment has been made by the incubatee companies.

7.B. Make-in-India & Start-up India Programs in Biotechnology

National Mission of Make-in-India is being led by the Department and supported by BIRAC since 2015. It has established Biotechnology Industry Facilitation Cell PMU for Make-in-India at BIRAC. The unit is involved in Bioeconomy mapping, Strategic Analysis of Startup Innovation Ecosystem growth and opportunities, Strategic discussion meets, Policy inputs, State Connect, Regulatory facilitation, VC and Private investments mobilization for biotech sector like different PPP initiatives. For example, Fund of funds – AcE, BioAngels, CSR, steering mega events - Global Bio-India, Biotech Startup Expo, Landscaping reports, expanding Startup ecosystem, global connect and others.

Make-in-India PMU at BIRAC as an umbrella unit shall set up PDC and ICC to support Next Level Initiatives:

- **Project Development Cell (PDC)** shall boost FDI and manufacturing in Biotech sector
- **National Investment Clearance Cell (ICC)** for Biotech to promote Ease of doing business.
- **Biofoundry & Biomanufacturing** for scale up support to Startups and medium scale companies: To enable piloting & manufacturing of products, the Biofoundry and Biomanufacturing infrastructural and R&D funding support would be extended to Startups, SMEs, Industry and Academia. The cabinet note for Biomanufacturing initiative is under approval for INR 1500 Cr allocation.

Global Bio-India 2023: was organized in Bharat Mandapam, Pragati Maidan from 4-6th December 2023. The largest Biotech Expo of 500+ biotech startups, incubators, industry, other stakeholders was inaugurated by Hon'ble Minister Dr. Jitendra Singh, Minister of State (I/C) Ministry of Science and Technology; Ministry of Earth Sciences; Minister of State Prime Minister's Office; Ministry of Personnel, Public Grievances and Pensions; Department of Atomic Energy and Department of Space, Govt of India.

- The event witnessed a footfall of **7000+ delegates from 25+ countries** over 3 days.
- **29 New Products developed by Biotech Startups** were launched in the Global Bio India 2023 event.

Figure 7.3: *Global Bio-India 2023*

India BioEconomy Report 2023 launched in the Global Bio-India 2023 showed that India's bioeconomy has grown to $137.2 Bn USD in 2022 with a double digit CAGR consistently for last 6-7 years. The report was launched by Hon'ble Minister Dr. Jitendra Singh, Minister of State (I/C) Ministry of Science and Technology; Ministry of Earth Sciences; Minister of State Prime Minister's Office; Ministry of Personnel, Public Grievances and Pensions; Department of Atomic Energy and Department of Space, Govt of India. This detailed referral document covering various aspects of India Bioeconomy is being published by BIRAC regularly through MII PMU. This has become an important referral document at central, national and international levels.

BIO International Convention 2023 was held during June 5-8, 2023 in Boston Convention & Exhibition Centre. The India Pavilion had high-level Indian delegation led by Secretary DBT, BIRAC, CEOs of leading Biotech companies, Academic Heads, and Startups. A brain storming session was held to understand the Global manufacturing practices, existing challenges and to discuss the policy requirements to enable "High Performance Biomanufacturing" globally. There was participation from EU, UK, USA, Poland, Africa, Ireland and global and Indian Agencies like NIH, USFDA, ABLE and BIRAC. The importance of revision of existing regulatory framework, supply chain, pilot scale to large industry scale were recognized as common challenges. The event gave opportunity to interact with different CDMOs in Process Development and GMP Contract Manufacturing of Biologics.

BIRAC Participation in G20: BIRAC contributed in the Startup20 group, a new engagement group added in G20 activities during India's G20 Presidency in 2023. BIRAC participated actively in various Startup20 summits across the country and contributed for drafting the Startup Policy Communique released at the Startup20 Shikhar Summit held in Gurugram. The Communique focuses on an inclusive ecosystem promoting innovation, economic growth and collaboration at global level. BIRAC also participated in different working groups meeting held under G20 India Presidency, including Health Working Group (HWG) and G20 Digital Innovation Alliance (G-20 DIA) and G20-Chief Science Advisers Roundtable (G20-CSAR).

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:
- Number of Startups has reached 7000+
- The Incubation centre network supported by BIRAC has expanded to 75 across 22 States/ UT.
- Product Launch platform: 29 startup products were launched from the prominent platforms of Global Bio-India 2023.
- Cumulatively INR 5500+ Cr has been raised by 130+ startups as follow on funding.

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. More than 790 queries from Startups have been addressed.
- **Regulatory Facilitation Information Cell (RFIC):** Biotech Startups seek regulatory guidance from RFIC, which is established at BIRAC's Regional Centre – BRBC, Pune. So far,

250+ startups facilitated; 11 ISO certifications assisted (4 received), 10 Product Approvals for Startups.

Fund of Funds - AcE initiative with an initial corpus of INR 150 Cr is steered through Make-in-India PMU. It has been able to successfully attract SEBI registered Alternate Investment Funds (Category I and II) for investment in biotech Startups and SMEs. AcE fund's **14 Daughter Funds** have supported 81 biotech Startups, SMEs with a total funding support of **INR 1000 Cr so far**. Encouraged by the success of this initiative, a proposal for AcE 2.0 with a fresh fund corpus of Rs. 500 Cr is under discussion.

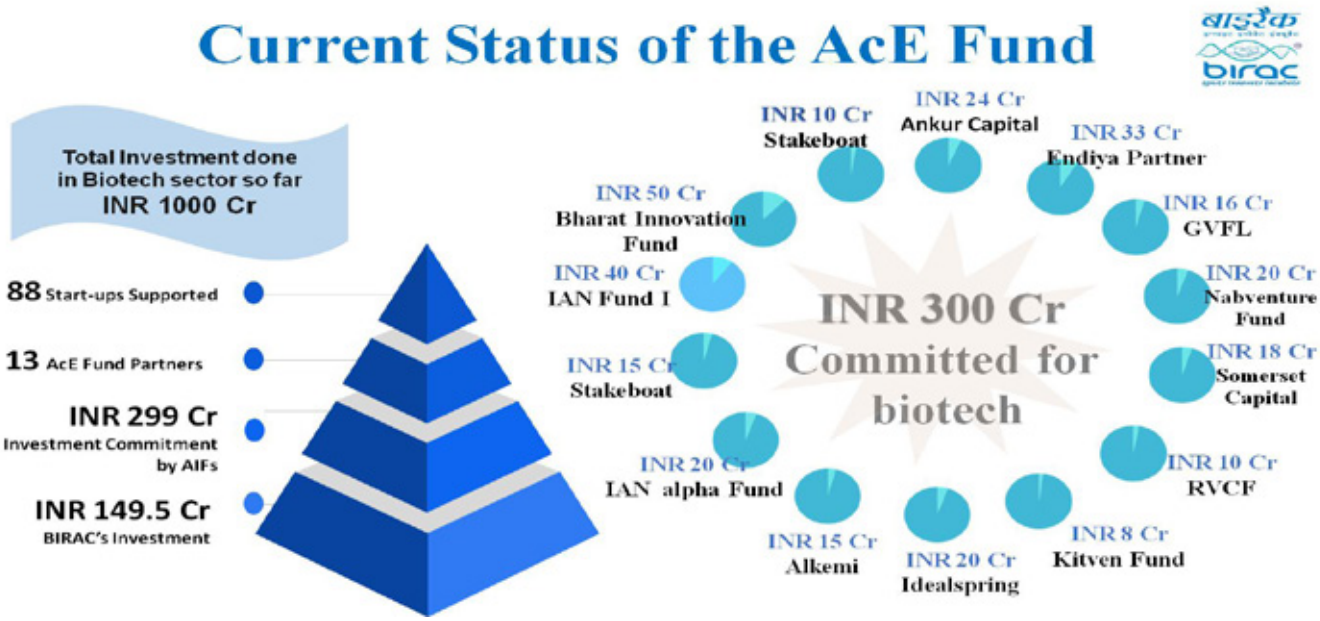

Figure 7.4: *Current Status of AcE- Fund*

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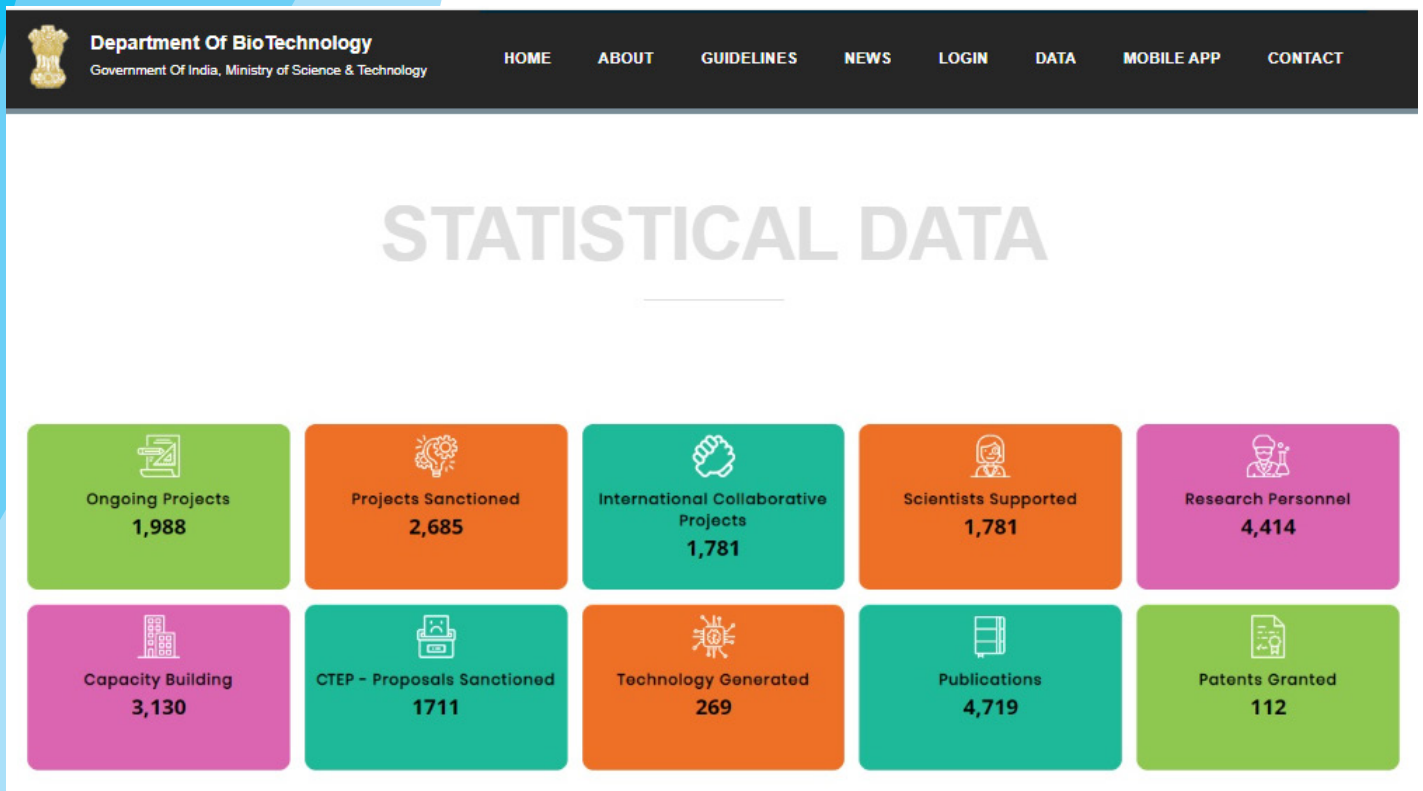

8. DATA MONITORING AND ANALYSIS

8 DATA MONITORING AND ANALYSIS

Data Governance, Automation and Security

Monitoring & Supervision of Projects is an integral part of any Implementing Organization which needs a robust data capture, processing, and storage system. Ease of data submission, easy data retrieval, User friendly report generation through Dash-boards, extracting required information for decision making and reporting purpose are some of the hall-marks of the Data-Ecosystem. Anonymization as per the prevailing law and data security adds further challenges to this entire ecosystem.

The Department of Biotechnology has a robust data capture and processing system. At policy level, it has put in place a standardized guidelines and framework for the ethical utilization of data, known as the Biotech-PRIDE (Promotion of Research and Innovation through Data Exchange) Guidelines. These guidelines ensure the secure and ethical processing, storage, and sharing of generated data, thereby upholding data security. Collaborative endeavours with NITI Aayog have been initiated to address issues related to data linkage between National Programmes and Sustainable Development Goals through defining and adopting various measurable Output-Outcome Indicators. The department has actively participated and contributed for Data Governance Quality Index (DGQI) initiated by NITI Aayog.

The Department manages all its IT activities / tasks, including handling application development, security audit, hosting of applications and various automation through NIC thereby, minimizing human intervention starting from Research & Development Project submission to Funding till its Technical completion. Initiatives have been launched to improve the efficiency of data organization, storage, and protection. During the year, the Department has undertaken following activities.

Output-Outcome Monitoring Framework (OOMF)

The Department of Biotechnology (DBT) operates under the guiding framework of the Output-Outcome Monitoring Framework (OOMF), a system devised by NITI Aayog to strengthen the monitoring & evaluation of various schemes/programmes by streamlining scientific indicators related to each scheme/programme being implemented in the department. This framework serves as the backbone for monitoring and evaluating various Central Sector Schemes and Central Sponsored Schemes of different Ministries/Departments. For DBT, it steers the oversight of two key Central Sector Schemes: (1) Research and Development (R&D) Scheme and (2) Industrial and Entrepreneurship Development (IED) Scheme. For the year 2023- 24, total of 110 output and outcome monitoring indicators have been defined. The progress is updated both quarterly & annually by DBT on OOMF dashboard developed and maintained by NITI Aayog. Based on the Scheme requirement and in consultation with NITI Aayog, the Output-Outcome Indicators are decided in advance and the targets in respect of each indicator is communicated to NITI Aayog.

The following table depicts year-wise the total number of Indicators reported for the above-mentioned Schemes.

Year-wise Indicators Reported

Sl No	No. of Indicators	2020-21	2021-22	2022-23	2023-24	2024-25 (Proposed)
1	Output	104	106	87	68	59
2	Outcome	79	83	51	42	37
3	Grand Total	183	189	138	110	96

The financial performance is captured trough the Budget Allocation and its Utilization in both (1) Research and Development (R&D) Scheme and (2) Industrial and Entrepreneurship Development (IED) Scheme. The details of Budgetary allocation and its Utilization is given below.

Scheme-wise Budget Expenditure

Sl No	Name of the Scheme	FY-2022-23		FY-2023-24	
		Budget Estimate (Rs. In Crore)	Expenditure (Rs. In Crore)	Budget Estimate (Rs. In Crore)	Expenditure (Rs. In Crore)
1	R & D	1315.00	968.95	1345.00	498.57
2	IED	365.00	238.46	300.00	00.00
3	Total	1680.00	1207.41	1645.00	498.57

The Output- Outcome Indicators tracks the set targets and corresponding achievement of various Components / Programmes of the Schemes. Some of the selected Indicators for IED Scheme are given in the following Table.

Scheme: Industrial and Entrepreneurship Development

Sl No	Name of Indicators	2022-23		2023-24	
		Target	Achievement	Target	Achievement
1	No. of new biotech parks established	2	1	2	2
2	No. of entrepreneur, start-ups supported	850	1140	1000	1378
3	No. of Bio-incubators supported	70	75	70	75
4	No. of Small Business Innovation Research Initiative (SBIRI) supported in the current year	54	40	40	35
5	No. of Biotechnology Ignition Grant (BIG) grantees supported in the current year	300	381	300	300
6	No. of Biotechnology Industry Partnership Programme (BIPP) projects supported in the current year	45	34	36	30

Sl No	Name of Indicators	2022-23		2023-24	
		Target	Achievement	Target	Achievement
7	No. of patents filed/granted	62	92	62	36
8	No. of beneficiaries utilizing the resources established in the cluster	798	8439	1218	1756
9	No. of Entrepreneurs, Startups/SMEs/ Industry supported	850	3367	1005	1461
10	No. of startups getting follow on funding	32	32	32	48

Data Governance Quality Index (DGQI)

Development Monitoring and Evaluation Office (DMEO) of NITI Aayog, introduced the Data Governance Quality Index (DGQI) in 2020 to assess the data preparedness of Ministries and Departments. The objective of this exercise is aimed at addressing data domain challenges within government systems, facilitating the development of more cohesive monitoring systems, such as a unified online dashboard, capable of integrating various departmental schemes. It aims at (i) Facilitating the evaluation and appraisal of data readiness within Ministries/Departments based on standardized criteria; (ii) Developing a self-assessment tool for Ministries/Departments to identify areas for enhancing their data systems internally; (iii) Empowering overseeing agencies to conduct comparative evaluations of data readiness, thereby identifying IT best practices and fostering knowledge sharing among participating agencies. The main aim is to bolster data-driven decision-making processes.

DBT participates in the DGQI activity and strive to improve the use of administrative data for improved decision making in policymaking and monitoring & evaluation (M&E). It has collected and collated various datasets generated during implementation of R&D and IED Schemes by Scientific Directorates for managing scheme related activities falling under different thematic areas.

For the Q3 of FY 2023-24, DGQI score has shown improvement standing at 4.68 out of the total score of 5 from the corresponding period last year which was 4.58 out of 5. Department of Biotechnology secured 1st position among scientific Ministries/Departments and 13th position among all Ministries/Departments for Q3 FY 2023-24. During the evaluation exercise conducted by NITI Aayog in collaboration with IIT Madras (Chennai), DBT has actively participated.

Cyber Crisis Management Plan (CCMP)

Cybersecurity within government organizations is imperative to safeguard against potential threats and ensure the continuity of essential services. Government Ministries and Departments are becoming more reliant on network critical infrastructure as Information Technology usage expands. Consequently, disruptions in the functioning of critical infrastructure information systems are being observed, resulting in profound impacts on operations and services provided. Recognizing this, the Government is intensifying its efforts to bolster cybersecurity across all government entities.

During the Financial year, the Department has prepared Cyber Crisis Management Plan (CCMP) to effectively manage cyber emergencies. The Cyber Crisis Management Plan (CCMP) of DBT clearly outlines comprehensive strategies for addressing various types of cyber incidents, establishing policies, defining actions, and assigning responsibilities to ensure a coordinated

response. Its has been prepared to quickly identify, exchange information, respond to, and remediate cyber incidents that could impact critical business functions and processes. Key milestones include the preparation phase, aligning the CCMP with DBT guidelines; an approval process with multiple reviews by Cert-In, ensuring the plan's compliance with cybersecurity standards; and an ongoing implementation phase. DBT is working in close coordination with all the Autonomous Institutions and BIRAC, individually, for the preparation of a robust Cyber Crisis Management Plan.

During the period, we have successfully mitigated 4 cases of security vulnerability / threats on the web portals of various AIs and BIRAC under DBT as reported by the National Critical Information Infrastructure Protection Centre (NCIIPC). These efforts signify DBT's commitment to enhancing cybersecurity resilience and adopting a proactive approach to potential cyber threats. Security audits of data portals, encompassing both servers, have been conducted, along with the implementation of measures to ensure data confidentiality and security.

Common Fellowship Portal (CFP)

The Common Fellowship Portal (CFP) was inaugurated by Hon'ble Union Minister Dr. Jitendra Singh on March 12, 2024, at the National Media Centre, New Delhi. It serves as a unified interface for applicants and various fellowship schemes offered by the Department of Biotechnology (DBT). Developed by the National Informatics Centre (NIC) using open-source technologies such as the Laravel Framework, PHP, ReactJS and MariaDB on a Linux platform, the portal aims to simplify and streamline the application process. Accessible at https://fellowships.gov.in, the CFP saves time and energy for aspiring students and startups by providing a single point for submitting applications, creating profiles, and auto-filling information for different applications. The CFP is a collaborative effort involving departments under the Ministry of Science & Technology, including DST, DBT, and DSIR/CSIR. It will soon extend to other departments like ICMR, UGC, and AICTE. A unique feature of the portal is the Eligibility Calculator, which helps applicants check their eligibility for various fellowship schemes by providing specific details. This tool acts as a

Figure 8.1: *Launch of Common Fellowship Portal*

gateway to research aspirations, enhancing the user experience by reducing the effort required to gather and submit application information.

Electronic Project Management System (eProMIS)

As a part of automation process, the Department has implemented a web-enabled Project Management Information System (eProMIS) which facilitates the submission, evaluation, management, monitoring, and closure of research proposals and projects. Hosted on the NIC Cloud, it captures and manages the complete life cycle of proposals and approved projects. The system supports online review and tracking of proposals, offering an end-to-end solution for managing all departmental schemes. It also auto-generates sanction orders, minimizing errors through accurate data input. Steps have been initiated to synchronize the various data tables and link the outcomes and outputs to National Programme and Sustainable Development Goals. The year-wise total number of projects being processed in eProMIS is given below.

Year-wise Research Projects processed through eProMIS

Sl No	FY	Total No of On-Going Projects	Total No of Completed Projects
1	2020-21	2767	812
2	2021-22	2460	828
3	2022-23	1941	560
4	2023-24	1848	373

Web Portals, Dashboards and APIs

Presently, there are 11 web Portals and 3 Dashboards in operation in the Department of Bio-Technology. For automatic data submission, the Department has prepared APIs which automates the process of data submission to various Dash-boards which includes Minister Dashboard, Prayas Dashboard. The DBT-Dashboard updates data from 16 Autonomous Institutes/ PSU / Statutory Institution covering modules such as Publication, Patent, Technology Transfer, scientific information, RTI, and Public Grievance data. This dashboard serves as a centralized platform for tracking and reporting on the department's various activities, ensuring accurate and comprehensive information is available for decision-making and public accountability.

Evaluation of Innovation Excellence Indicators

The Office of Principal Scientific Adviser (PSA), in consultation with NITI Aayog, has defined 62 innovation excellence indicators to measure the performance of the R&D Institutions on the basis of their activities undertaken by the Institutions. 13 Autonomous Institutions and one Statutory Institute of DBT have participated in Evaluation of Performance of Public funded R&D Institutions. The data collection and report preparation of Round-I has been done by CII and CTIER teams. The exercise of the Round I have been completed and the report has been published by PSA. The Round II exercise has started in FY 2023-24 and 12 Autonomous Institutions and one Statutory Institute of DBT are participating in this exercise. The main outcome of the exercise is to throw light on (i) Innovation metrics and the research conducted by different publicly funded R&D institutions; (ii) R&D Institutions' performance regarding their socio-economic impact, excellence in science, technology, and innovation (STI), and organizational capabilities and practices; and (iii) Opportunities and measures to enhance the R&D Institutions' performance in those specific areas.

Gender Budget Reporting

As a signatory to the 2030 Agenda for Sustainable Development, India is participating in the international review of the progress of Sustainable development Goals (SDGs) on a regular basis. One of the key goals of the Sustainable Development agenda is to achieve gender equality by 2030. One of the key indicators of Gender equality is Budgetary allocations and special initiatives to promote participation of women in employment force, participation in decision making etc. The amount of money invested in women's interests not only demonstrates government commitment to achieving Goal-5 of the Sustainable Development Goals – Gender Equality – but is also essential to bring about equality between women and men, and ensure better lives for women and their families.

Financing for gender equality is central to mitigate gender inequalities and Gender Budgeting is a critical strategy in this endeavour. Govt of India has already introduced Gender Responsive Budgeting (GRB) to monitor policy commitments related to gender equality by addressing different needs of women and girls through special policy initiatives and provisioning of budgetary allocations. A Gender Budget Statement (popularly known as Statement 13) has been introduced which consists of Part-A and Part-B wherein, Part A includes Schemes with 100% allocation for women while Part B of the Statement includes Schemes/Programmes with 30% to 99% allocation for women.

The Department of Biotechnology has initiated a programme specifically dedicated to women i.e. BioCARE. To enhance the participation of Women Scientists in Bio-Technology Research Programme, The Department has already launched a Bio-Technology Carrer Advancement and Re-orientation Programme (BioCARE) for women scientists. The Scheme gives opportunities to unemployed women scientists having a break in career to be back to the mainstream by getting their first grants as Principal Investigator. Women Scientists who are employed or unemployed or are desirous of coming back after a break can get back to the mainstream by getting their first grant as the Principal Investigator.

To recognize the contribution of Senior and Young Women Scientists working in the areas of Biology / Biotechnology, the Department has started Janaki Ammal National Women Bio-scientist Fellowship. The Senior Category Fellowship is awarded to the Women Scientists who have done excellent research and has applied the results for the benefit of students and society. The Young Category Fellowship is given to the Women Scientists who are below 45 years of ageand engaged in basic & applied research in the areas of Bioscciences and Biotechnology including Agricultural, Biomedical and Environmental sciences with potential application of product / technology development. Both the programmes are being reviewed in terms of physical and financial vis-a-vis the annual targets and achievements.

Women Specific Programme Achievements

Sl No	Name of the Indicator	FY-2022-23		FY-2023-24	
		Targets	Achievements	Targets	Achievements
1	No of Projects / women scientists supported under BioCARE	30	7	50	53
2	National Women Bio-Scientist Award/ Fellowship	3	3	3	3

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DEPARTMENT OF BIOTECHNOLOGY
Ministry of Science & Technology
Government of India

Guidelines and Standard Operating Procedures for Research on Genetically Engineered Insects

2023

9. REGULATION & INTELLECTUAL PROPERTY

9 REGULATION & INTELLECTUAL PROPERTY

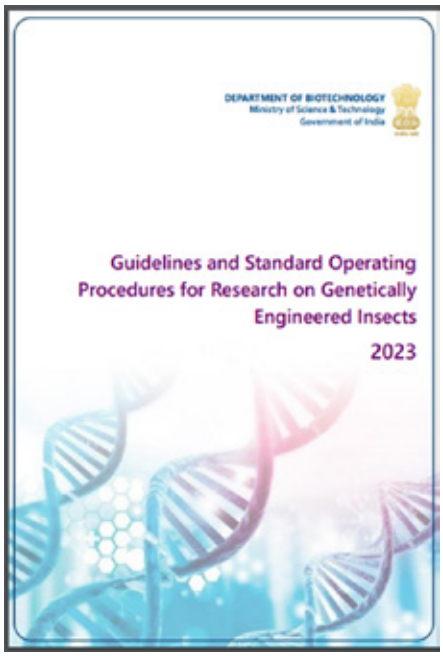
9.A. BIOSAFETY REGULATION

In India, all activities related to Genetically Engineered organisms (GE organisms) or cells and hazardous microorganisms and products thereof are regulated as per the "Manufacture, Use/Import/ Export and Storage of Hazardous Microorganisms/ Genetically Engineered Organisms or Cells, Rules, 1989" (Rules, 1989) notified by the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India under the Environment (Protection) Act, 1986 (EPA 1986). As per the Rules, 1989, the Review Committee on Genetic Manipulation (RCGM) functions in the Department of Biotechnology (DBT) to monitor the safety related aspects in respect of on-going research projects and activities involving genetically engineered organisms/hazardous microorganisms.

The Review Committee on Genetic Manipulation (RCGM) is mandated to monitor the safety-related aspects in respect of ongoing research projects and activities involving genetically engineered organisms/hazardous microorganisms. RCGM brings out Manuals of guidelines specifying procedures for regulatory processes with respect to activities involving genetically engineered organisms in research, use and applications, including industry, with a view to ensuring environmental safety. All ongoing projects involving high-risk category and controlled field experiments are reviewed to ensure that adequate precautions and containment conditions are followed as per the guidelines. RCGM lays down procedures restricting or prohibiting production, sale, importation and use of such genetically engineered organisms or cells as are mentioned in the Schedule. Following are the key highlights of the activities undertaken during the period:

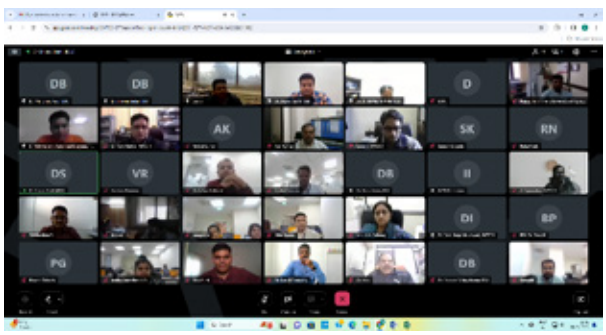
1. **Preparation of Regulatory guidelines/ SOPs/Guidance documents**:
   - **a)** "Guidelines and SOPs for Research on Genetically Engineered Insects, 2023".
   - **b)** Entry/revision of risk group of following microbes in "List of Infective Microorganisms corresponding to different Risk Groups, 2021".
     i. Pseudorabies Virus
     ii. Tomato Leaf Curl New Delhi Virus
     iii. Hansenula polymorpha
     iv. Banana Bract Mosaic Virus
     v. Banana Bunchy Top Virus
2. ***Genome Edited plants***: RCGM considered two new applications pertaining to exogenous DNA free SDN-1 Genome Edited plants as per extant guidelines & SOPs.
3. ***Facility visit for Certification of BSL-3 facilities***: Inter-Ministerial Committee for Certification of BSL-3 facility visited 04 Organizations, to understand the design, procedures and engineering controls in the facility, and provide suggestions so that the facility meets to the specific requirements.
4. Review of applications: RCGM, DBT considered 993 applications in its 31 meetings (249th to 280th Meetings) during the period January, 2023 – March, 2024.

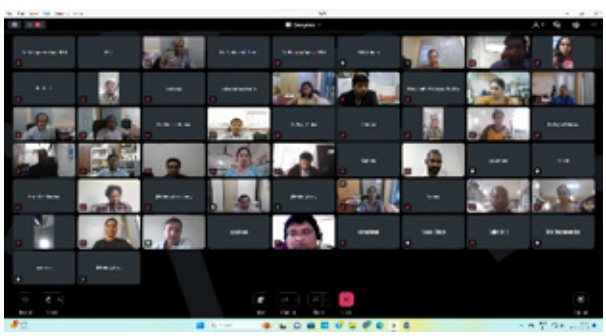
5. Risk Assessment & Risk Management Plan (RARMP):
   a) Prepared 08 Risk Assessment & Risk Management Plan.
6. ***Biosafety Protocols and Guidelines***: The following guidelines related to biosafety of recombinant DNA research have been ***notified:***

DBT notified the Guidelines and Standard Operating Procedures for Research on Genetically Engineered Insects 2023, vide OM dated 17.04.2023. This document has been prepared for GE insects including vectors of human diseases (Mosquitoes like Aedes aegypti, Aedes albopictus and Anopheles stephensi), crop insect pests (e.g. pink bollworm, fruit fly species and diamond back moth) and beneficial insects (e.g., silkworm, honeybees and biological control agents like insect parasitoids and predators). It aims to specify the regulatory pathway for import, export, transfer and receive as well as for conducting research on GE insects. The document also addresses the containment requirements as well as data requirements for ensuring biosafety and trait efficacy.	
DBT notified the Entry of 05 micro-organisms in "List of Infective Microorganisms corresponding to different Risk Groups, 2021" superseding the Annexure I of "Regulations & Guidelines for Recombinant DNA Research and Biocontainment, 2017"	

7. ***Monitoring of IBSCs and Assessment of compliance documents***: RCGM, DBT has taken several reforms including empowering of IBSCs, hence stringent mechanism to monitoring the IBSCs through their Minutes, Annual Compliance Reports and Medical Surveillance Reports has been started with IBKP portal. RCGM Secretariat is facilitating RCGM in the monitoring of IBSCs and assessment of compliance documents.
8. ***Biological Research Regulatory Approval Portal (BioRRAP)***: BioRRAP tracks the regulatory approvals for a research proposal on a single portal and provides more credibility and recognition to such biological researches. RCGM Secretariat facilitates the functioning of BioRRAP.
9. ***Fortnightly workshops/interactive Session for Biosafety Awareness for Researchers***: DBT along with BSU scientists conducts online

interactive sessions for awareness generation among Researchers (Principal Investigators, Scientists, Post-doctoral researchers) on Biosafety Rules and Regulations. During this period, 27 interactive sessions were conducted, which were attended by approx. 1200 Researchers from Universities, Institutes, Private organizations, Start-ups and Industries. These sessions are being highly appreciated by everyone, especially the question answer round, where specific queries of participants are addressed.





Further, RCGM, DBT facilitated the First Workshop to create awareness about Biosafety measures organized by IBSC, BITS Goa on 02.08.2023.

10. **Inter-ministerial issue:** Departmental comments have been provided for 104 applications of the export of SCOMET dual-use items and 20 applications of fixation of I/O adhoc norms, as per applications received from DGFT.

Departmental comments have been provided for 99 applications for R&D recognition and SIRO certification to DSIR and comments were also provide to MEA on 18 proposals linked with Australia Group Meetings.

9B. INTELLECTUAL PROPERTY (IP):

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. The technologies developed at academia are generally not market-ready and up-scaling with persistent efforts is required to realize their value and potential. Hence transfer of research outcomes from publicly-funded research labs to SMEs/Start-ups is important. Before 2023-24, as per DBT grant MoA, the IPs developed with

Major achievements

- Notified the Guidelines and Standard Operating Procedures for Research on Genetically Engineered Insects, 2023.
- **Evaluated 3439 applications in the field of Biopharma and Agri-Biotechnology**, of which **993 applications were considered in 249th to 280th RCGM meetings**.
- **08 Risk Assessment & Risk Management Plans were prepared**.

DBT grant support can be transferred to industry only on a non-exclusive basis. This has become a deterrent to technology and product development, as industries are not willing to invest significant time and finances into furthering technologies which may also be taken up by others. Many deliberations were held with scientists, IP experts, academicians, policymakers, Government officials and it has been recommended that grant MoA should be amended to provide options for all forms of licensing. DBT thereafter constituted a Working Group to draft a Report and recommendations. The recommendations were shared with DPIIT and their recommendations obtained. DBT committee under the Chairmanship of Additional Secretary & Financial Advisor, was constituted to suitably draft the Policy and implementation modalities of the WG recommendations. The exercise resulted in DBT-IP Guidelines 2023.

DBT-IP Guidelines:

The Department has notified DBT-IP Guidelines 2023 (https://dbtindia.gov.in/regulationsguidelines/guidelines/dbt-ip-guidelines-2023). These guidelines enable seamless transfer of IP at academic institutes/research laboratories towards commercialization into technologies/products for larger societal impact. These guidelines define ownership of IP and different modalities of IP assignment.

Figure 9.1: *Consultation process with timelines undertaken for drafting the DBT-IP guidelines 2023.*

Major changes in the DBT-IP Guidelines 2023 are:

1. The patent was earlier co-owned by DBT. Now it is completely owned by the host institute.
2. Earlier licensing of IP was allowed only through non-exclusive mode. As per these guidelines, now the host institute shall constitute an institutional IP Committee. The Committee based on technology readiness level (TRL), timelines and investments required for commercialization of the IP will decide for exclusive or non-exclusive licensing on case to case basis. Additionally, assignments may also be considered for spin-outs and startups creation.
3. Online mechanism mandating reporting of Publications and Patents from supported projects. The PIs need to report publications (https://dashboard.dbtindia.gov.in/sbt/publication/) and patents (https://dashboard.dbtindia.gov.in/sbt/patents/) on DBT website.

The Department is developing a showcase portal to showcase the publications and patents generated in projects supported by DBT. The DBT grant MoA format has also been revised as per provisions of DBT IP Guidelines 2023.

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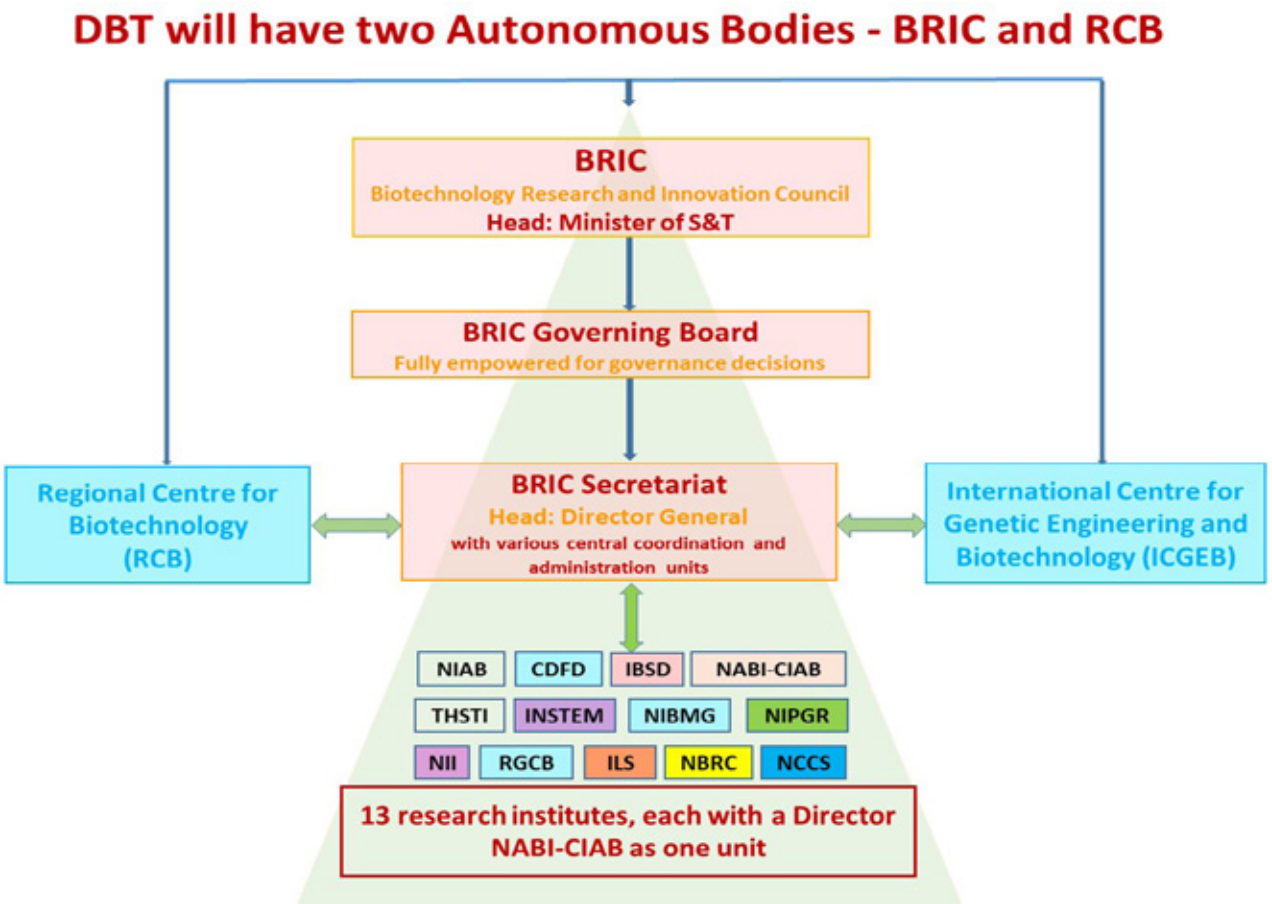


10. iBRIC, RCB, ICGEB and Public Sector Undertakings

10 iBRIC, RCB, ICGEB and Public Sector Undertakings

BIOTECHNOLOGY RESEARCH AND INNOVATION COUNCIL (BRIC)

In pursuance of directives of Government of India, the Department of Biotechnology, Ministry of Science and Technology, had with the approval of the Cabinet, rationalized its 14 different Autonomous Bodies (ABs) by inter alia subsuming them under one Society viz. Biotechnology Research and Innovation Council (BRIC). The new Society has been registered under Societies Registration Act XXI of 1860 on 10th November, 2023.

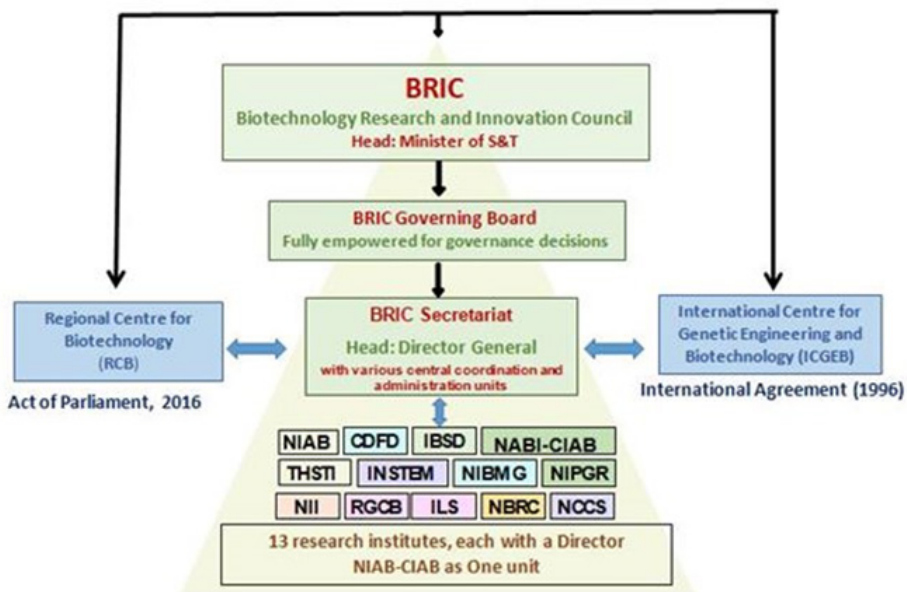


Figure 10.1: *BRIC administrative structure*

BRIC has been built on the foundations developed at the DBT institutions to foster synergies while maintaining their distinct research mandates. It is intended to integrate the multi-disciplinary research, training, and innovation programs operational across various DBT institutions for maximum impact and establish structures that leverage existing strengths to build systemic collaborations, identify convergent directions, and establish mechanisms for research validation and translation to maximize biotech research impact aligning to national mission-oriented goals.

The Department has theme based Research Institutions and supporting one International Centre. These institutions facilitate flow of knowledge from Basic Science to Translational Research in Health, Agriculture, Bioresources and Basic & Emerging Biotechnologies. The institutions under the BRIC play an indispensable role in building the country's scientific expertise and capacity through their doctoral and post-doctoral programs and trainings for postgraduate degree students. iBRIC (institutions of BRIC) along with Regional Centre for Biotechnology (RCB) and International Centre

for Genetic Engineering and Biotechnology (ICGEB) has rolled out a globally competitive interdisciplinary PhD program - "i3c BRIC-RCB PhD Programme in Biosciences" which has been envisioned to be at par with International Research Programs. This is on the principles of ideate, immerse, innovate and collaborate (i3c). This collaborative initiative offers a multidisciplinary PhD program in Biosciences to students with a Master's degree in Life Sciences as well as B.Tech/BE in Non-biological sciences & Medicine graduates. The program provides unique course curriculum as well as hands-on experience into high-end facilities to all the research scholars. It also includes an Immersion Program to identify unmet needs, frame key research hypothesis and questions based on the exposure of students to real-world challenges in biotechnology.

During the year, the research outcome of DBT Autonomous Institutions has resulted in more than 1300 Publications and 90 patents (applied & obtained). More than 40 technologies / products/ processes have been developed, and Over 8000 human resource have been trained. Apart from these research institutions, the Department also has 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.

BRIC-CENTRE FOR DNA FINGERPRINTING AND DIAGNOSTICS (CDFD), HYDERABAD, TELANGANA

Over the two decades, the Centre for DNA Fingerprinting and Diagnostics (CDFD) in Hyderabad has been a leader in DNA-based forensic identification and medical diagnostics. In addition, the institution has led globally competitive research across domains, particularly with a focus on human health. Additionally, CDFD engages in cutting-edge research across various fields of modern biology, including microbiology, cell biology, disease biology, genetics and epigenetics, and computational biology. CDFD mission is to carry out research, services and training in DNA Profiling and diagnosis of Genetic Disorders; to undertake basic and applied R&D work in frontier areas of modern biology; and to achieve global excellence in fundamental and applied research and simultaneously endeavour to transfer the benefits of modern biology to every section of the society.

Services provided: A total of 128 cases were analysed for Human DNA Fingerprinting, 4449 samples were analysed for various human genetic disorders and approx. 700 basmati rice samples were analysed for purity testing and adulteration during the reporting period. The CDFD Diagnostics division has been recently accredited with NABL. The three pie charts, detailing about these services are enclosed herewith. In Covid-19 Laboratory, a total of 1,121 samples have been sequenced and the results observed a continuous increase in Omicron sub-lineages. Interestingly, one sample revealed new EG.5 variant (eris) during this period.

Scientific Achievements:

CDFD has delineated the mechanism behind how a particular potassium ion transporter is maintained in a silent state in *E.coli*. We also revealed that the regulatory nucleotide (p)ppGpp buffers cell division under conditions of low membrane fluidity. One of the laboratory provided novel insights into the role of MLL in centrosome structure and functions. Our research discovered a new histone modification - H2B Y121 phosphorylation – controlled by a phosphatase SHP-1, that exhibits a functional crosstalk with H2B ubiquitination during transcription.

Researchers at CDFD studied the role of histone acetylation and its regulator Sirtuins family HDAC in early stages of DNA double strand break repair pathway choice. A group have demonstrated how

two similarly looking mutations at the same position in the NAA10 gene employ different mechanisms to perturb the activity of NAA10 protein. Another group investigated how helix loop helix and homeo domain containing transcription factors regulate cell diversity in developing central nervous system. One group is working towards identification of loss of function in SerpinA11 as a novel gene responsible for a perinatal lethal serpinopathy. One of the study has established PI3P as a key determinant of membrane transport in *Candida glabrata*.

CDFD is also working towards the impact of DNA topology in genome organisation and functional regulation. We have designed and developed 64k SNP high throughput genotyping chip for *Amaranth* in a collaborative work. One of our study has observed regression in tumorigenesis by regulating Profilin *in vivo.* One group is trying to understand the biology of human pathogens *Entamoeba histolytica* and *Naegleria fowleri.* We are also working towards designing therapeutics to control tuberculosis and other health disorders like sepsis, cancer and tissue injury. In cancer research we discovered novel alternating functions of cancer genes based on differential intra-cellular localization.

Researchers at CDFD elucidated the role of DedA family proteins, particularly XdfA, in Xanthomonas campestris pv. campestris (Xcc). The unexpected association of XdfA with magnesium transport challenges conventional wisdom and opens up new avenues for research into bacterial physiology and pathogenicity. Active research is being carried out towards characterisation of Rho and mycobactericidal proteins from mycobacteriophages.

Publications and Patents: CDFD has published more than sixty research articles in peer reviewed international journals of high repute including Nature Communications, Cell Reports, Brain, MBio, PLoS Biology, Frontiers in Immunology, J. of Cell Science etc. One Patent has been Granted in Nov, 2023 titled "A Novel Therapeutic For Treatment Of Sepsis" and one Indian Patent filed in Oct 2023 for a promising Sub-Unit Vaccine to manage TB-associated diabetes complications, titled "Recombinant Proline-Proline-Glutamate Protein Based Vaccine and Method of Development Thereof".

Human Resource Development: During the reporting period, 24 research scholars joined CDFD for PhD programs, and 12 students were awarded PhD degrees. Currently, over 100 research scholars are pursuing their PhD at CDFD. The Centre provides training through summer programs and project training, and organizes various workshops for researchers, police officials, and medical professionals.

Facilities and Infrastructure: CDFD boasts cutting-edge infrastructure including an Experimental Animal Facility, a Biosafety Level-3 Laboratory for infectious disease research, and a Sophisticated Equipment Facility accessible nationwide. The mission program, PRaGeD, focuses on Pediatric Rare Genetic Disorders in India, striving to raise awareness, facilitate genetic diagnosis, identify new genes, offer counseling, and innovate therapies. CDFD has initiated the establishment of a business incubator to support startups in the field of life sciences and related disciplines. A total of 5 startups have been selected for incubation. Various initiatives, such as workshops, webinars, are conducted to foster innovation.

Societal impact

CDFD's DNA fingerprinting and diagnostics services have significant social relevance. The activities of the COVID lab have also had a direct impact on society. CDFD's infrastructure is available for use by external researchers, and the Centre engages

in human resource development and outreach activities to benefit students. The institute has also facilitated numerous requests for educational visits from schools and colleges nationwide to inculcate spirit of modern science in the younger generation.

BRIC-INSTITUTE OF BIORESOURCES AND SUSTAINABLE DEVELOPMENT (IBSD), IMPHAL, MANIPUR

Institute of Bioresources and Sustainable Development (IBSD) has been engaged in research activities and numerous outreach programmes for the development of bioeconomy from bioresources. BRIC-IBSD is committed for integration of multi-disciplinary, inter-disciplinary and multi-stakeholder research on bioresources of NER. The mission of the institute is "Bioresources development and their sustainable use through biotechnological interventions for the socio-economic growth of the North Eastern Region. BRIC-IBSD is working on different research areas to promote the bioresources of NER and integrated study for their scientific validation, value addition to propel innovations, discoveries and inventions for catalyzing the growth of industry in the region for livelihood generation and boosting bioeconomy from bioresources.

Major Initiatives

Phytopharmaceutical Mission: BRIC-IBSD has established Phytopharmaceutical Mission in NER and working on documentation, evaluation and validation of traditional healthcare practices of NER to promote the drugs from our ancestors, drugs from nature and to explore the tradition to translation with innovation. Under this programme, IBSD is working on:

- Exploring the traditional healthcare practices and bioresources used in these practices and their scientific validation with translational component.
- Value-addition to the traditional knowledge through translational and transformational research.
- Use of bioresources for socio economic development of the region
- Encouraging the Start-ups programme under 'Aatmanirbhar Bharat Abhiyaan'
- Capacity buildings, training, promotion and development of bioresources for therapeutic potentials

Synergy Research Mission: Globally, there is an increasing application of synergistic multimodal treatments or multi-target approaches in developing novel therapeutic strategies that have shown promise in treating complex diseases. Ethnopharmacological knowledge of natural products has been the primary driver of such discoveries. However, there is a gap in establishing the mechanism of action, experimental design, and quantification of synergy at different dose and effect levels. In this context, BRIC-IBSD has initiated Synergy Research Programme to understand the functional associations between targets, diseases, and pathways associated with traditional herbs or formulations based on multilevel systemic interactions using a 'simple neighbourhood' network connection approach. This initiative aligns with the broader goals of personalized medicine and has the potential to revolutionize treatment regimens for complex diseases.

Antimicrobial Resistance (AMR) Programme: Antimicrobial-resistant pathogens are increasingly associated with nosocomial infection leading to significant burden on healthcare systems. With the rise of antimicrobial resistance (AMR) and the emergence of new viral pathogens, there is an urgent need for novel therapeutic strategies. The North Eastern Region of India is rich in biodiversity, and its traditional medicinal plants have been utilized for centuries by indigenous communities in

primary health care to combat various ailments and to enhance immunity. These traditional medicinal plants are often consumed in various forms such as decoctions, infusions, powders, or extracts, and their efficacy against AMR pathogens and viral infections is supported by traditional knowledge; however, there is a lack of scientific validation. BRIC-IBSDis working on scientific validation of traditional medicinal plants for their efficacy against AMR pathogens and viral infections to standardize plant extracts or formulations to ensure quality, safety and efficacy.

Genome sequencing & DNA barcoding of medicinal plants: Considering the vast medicinal plant resources in NER, there are greater possibilities to discover novel biomolecules, genes, enzymes and biosynthetic pathways. BRIC- IBSD is working on documentation, validation and evaluation of medicinal plants used by many traditional communities in NER. Realizing the uniqueness of these medicinal plant species, BRIC-IBSD is work on the development of genomic resources for these plant species using transcriptomics and genomics approaches to identify genes/ enzymes and to explore biosynthetic pathways for therapeutically important metabolites and characterization of regulatory genes for metabolic engineering to enhance the secondary metabolites. IBSD is working on the development of DNA barcodes for authentication and identification of medicinal plants in NER.

Probiome of Fermented Food: Fermented foods, made through desired microbial growth and enzymatic conversion of food components have been an essential part of our diet. Several earlier studies demonstrated the health benefits of fermented foods like preventing lifestyle-based metabolic disorders and improving immunity against new infections. Probiome, the food fermenting beneficial microbiota would bring such health effects on the human. Though hundreds of varieties of fermented foods are prepared and consumed in NER, only limited fermented foods are consumed with live microbes (without cooking), like fermented milk products (e.g. Churppi of Sikkim and Arunachal Pradesh; Doi of Assam), fermented rice (e.g. Pota Bhat of Assam), fermented finger millet (e.g. Tongba of Sikkim) and fermented soybean (e.g. Bekang-Um from Mizoram). Developing an appropriate starter culture is one major step for the industrialization of these fermented foods, no such starter culture is currently available in Indian market. BRIC-IBSD is working on the development of starter culture consortiums and further optimisation of the fermentation process for the product/process/ technology.

Notable Outcomes

Indicators	Number
Projects completed	01
Process / Product / Technology Developed	03
Research Publications	44
Patents Applied	01
Patents Obtained	02
Human Resources Trained	465

IBSD established BioNEST Incubator at Shillong, Meghalaya: For the promotion of Start-ups in NER, IBSD has setup Bioincubators Nurturing Entrepreneurship for Scaling Technologies (BioNEST) incubator 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, Aspirational District of Meghalaya. Under this incubator, more than 100 women entrepreneurs have been trained and encouraged for orchids cultivation and propagation. this project is implemented through a Hub and Spokes model at Umsning Block of Ri-Bhoi district

of Meghalaya. Women entrepreneurs from around 11 villages of Meghalaya namely Nongdiengngan, Nongmahir, Umshorshor, Mawser, Wahlakha, Umdiker, Umsaw, Sohdade, Sohjarang, Nongkseh and Mawparhut are benefitted under this project.

IBSD organized program on National Certification System for Tissue Culture Plants in NER: IBSD organized an Awareness Program in collaboration with NIPGR, New Delhi on 'National Certification System for Tissue Culture Plants (NCS-TCP)' for the development of bioeconomy from bioresources through agribusiness in Sikkim on December 29, 2023.During the event, more than 100 progressive farmers and entrepreneurs from different districts of Sikkim participated in the program and interacted with experts. All the scientists, scholars and staff of IBSD, Sikkim Centre, participated in this programme.

Scientific Achievements

Valeriana jatamansi Jones. syn. *V. wallichi* (Family: Caprifoliaceae) is globally known and amongst the 27 listed medicinal plants under National AYUSH Mission (NAM) by National Medicinal Plants Board, New Delhi, Government of India. *V. jatamansi* is a temperate Himalayan critically vulnerable plant enlisted as plants of conservation concern under Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix-II with regulated foreign trade. Deplete wild population of *V. jatamansi* has prioritized conservation via ex-situ raising. The study conducted for *V. jatamansi* ex-situ raising at Sikkim Himalayan low altitude (tropical hills) region in different potting mix and evaluated for growth, yield and metabolite content substantiated with eco-physiological parameters. The study paves the way forward, overcoming accessional and agro-climatic differences in growth, yield and metabolite; as appropriately monitored potting media help in consistent and optimized yield and metabolites in *V. jatamansi*.

Flemingia procumbens is commonly known as 'Soh-phlong' consumed by people in Meghalaya as juicy root tubers as Ready-to-use-product (pealed tubers). Due to increasing market demand of 'Soh-phlong', it is important to identify and quantify the active constituents to determine the quality of tubers. Therefore, a simple, rapid and reproducible high-performance thin-layer chromatography (HPTLC) method was established for the quantitative estimation of genistein in the hydroalcoholic extracts of *Flemingia procumbens*Roxb. tuber.

Societal Impact

Traditional Healers Meet at IBSD, Meghalaya Centre: BRIC-IBSD organized Traditional Healers Meet at IBSD, Meghalaya centre on April, 18, 2023. This programme was organized by IBSD in coordination Bio Resource Development Centre (BRDC), Shillong and Society for Ethnopharmacology (SFE), India. During the programme, many traditional healers from East Khasi Hill, West Khasi Hill, Garo and Jantia Hill shared their ideas, experiences and showcased their products/ formulations.

Women Bio-Entrepreneurs Meet for Orchid Floriculture in NER: BRIC-IBSD organized Women Bio-Entrepreneurs Meet at Meghalaya Centre on April 19, 2023 to strengthen women bioentrepreneurs where 50 beneficiaries participated shared their experiences. The programme was attended by representatives from BRDC, Shillong who highlighted research and outreach activities for the promotion of Orchid floriculture.

INSA popular lecture for students, researchers in NER: BRIC-IBSD organized INSA popular lecture on "Detailed studies of plant pathogens can lead to novel means of disease control" at Meghalaya centre on November 21, 2023.This lecture was delivered by Prof. Steven E. Lindow, University of California, Berkeley and highlighted the research

work on *Xylella fastidiosa* which causes major diseases of grape, citrus, olive, almond and many other major crop plants. He highlighted various examples of plant pathogens which can lead to novel means of disease control.The programme was attended by students and faculties from Shillong College, St. Anthony's college and other institutions from Shillong, Meghalaya. During the programme, many researchers, scientists also joined online from different centres of IBSD and other DBT institutes.

BRIC-IBSD participated in Global Bio-India 2023: BRIC-IBSD participated in the Global Bio-India 2023 organized by DBT, New Delhi from December 3-6, 2023 and highlighted various research activities & outreach programs of IBSD for the development of Bioeconomy from Bioresources of NER. Many entrepreneurs, researchers, students visited IBSD stall to explore various research opportunities in NER. The three days event was participated by scientists, scholars, staffs of IBSD, other national institutes, various startups from all over the country.

Skill development training programme for women of NER: BRIC-IBSD organized skill development training programmes for women of Manipur on December 13, 2023 to encourage them to be entrepreneurs and promote startups in NER.

BRIC-INSTITUTE OF LIFE SCIENCES (ILS), BHUBANESHWAR, ODISHA

ILS strives to achieve excellence in innovation and entrepreneurship under DBT recognized themes of precision therapeutics, climate-resilient agriculture, functional food and marine research. Based on research observations, expertise and activities, ILS is carrying out high-quality multidisciplinary research in the area of life sciences for betterment of human health and welfare. The research at ILS Bhubaneswar is directed towards the four broad focus areas of Infectious Disease Biology, Cancer Biology, Plant & Microbial Biotechnology as well as cross-cutting areas. The goal is for overall development and betterment of human health, longevity, agriculture and environment.

Major Initiatives

ILS has initiated major programs on bioprospecting from plants, microbes, and marine resources. These programs are supported by DBT-sponsored Himalayan Bio-mission and Marine biotechnology projects, as well as a project from the Ministry of Ayush, which have taken shape during the year 2023-24. This has led to the identification of natural products with anti-malarial, anti-cancer, and anti-viral potential. These R&D activities of ILS will continue with a marine/deep ocean program supported by the Ministry of Earth Sciences (MoES), which will utilize advanced biotechnological tools to identify novel bioactive agents of importance with applications in Medical, Pharmaceutical, Nutraceutical, Cosmetic, and other Industries. The program will also identify and characterize marine organisms, including microbes and viruses, using genomics and metabolomics.

Indicators	Number
No. of projects completed	05
Number of Publications	87
Technologies Transferred	01
Number of patents filed	05
Number of patents obtained	01
Number of Human Resources trained	168
Start-up	01

Scientific Achievements

Malaria parasite biology and anti-malaria drug development: The research work carried out on malaria parasite biology has addressed the role of food vacuole transporter in disease pathogenesis

and metabolic adaptations in the asexual stage parasites.

Bacteria cell division and novel anti-bacterial targets: ILS scientists have shown that FtsEX complex, a component from the divisome complex, can regulate septal peptidoglycan synthesis. The research at ILS has shown that Min system, a component responsible for the mid-cell localization of the divisome complex, can control bacterial motility through regulating expression of flagellar proteins. These findings not only help us to decipher the bacterial division mechanism, but also help to identify novel drugable targets in bacteria.

Candida pathogenesis and vaccine development: Systemic infection by *Candida* species is associated with >50% mortality and represents major healthcare problems. Since no antifungal vaccine is available, ILS is developing an attenuated strain of *C. albicans* with whole cell vaccine potential by targeting DNA replication and repair pathways.

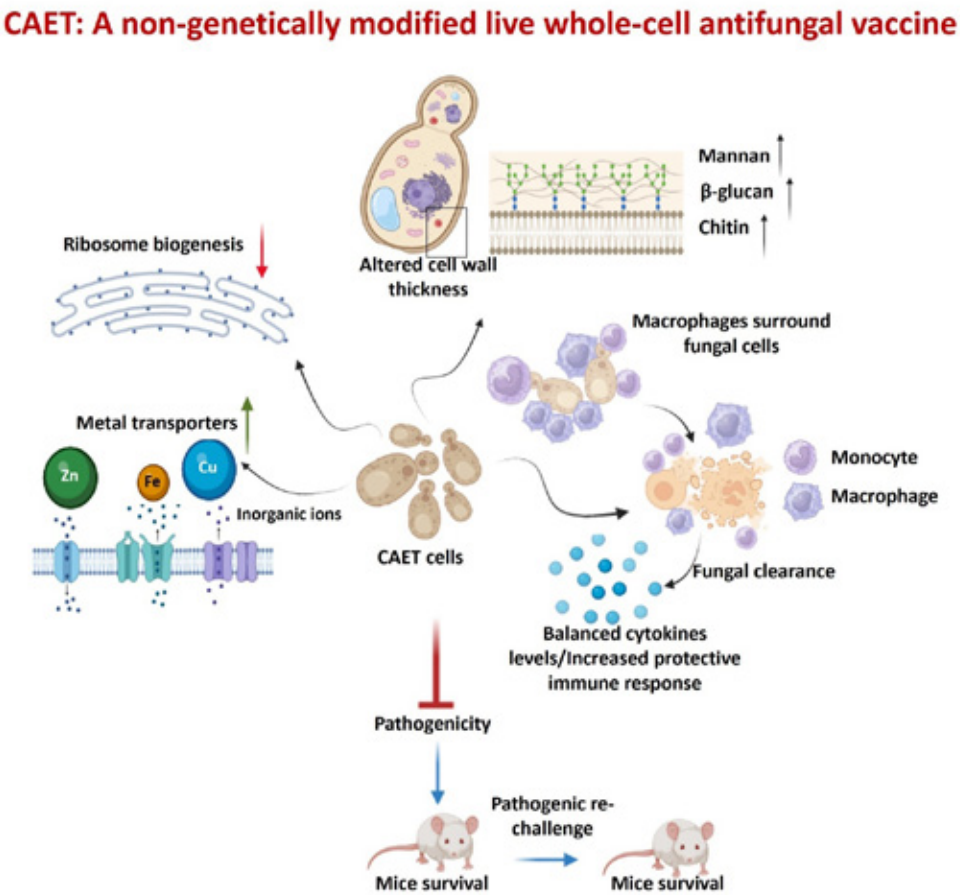


Figure 10.2: *Model depicting the attributes of CAET whole-cell vaccine candidate. EDTA alters the cell wall thickness by altering its composition. Metal transporters and several cell wall and membrane associated genes get upregulated. To mitigate the essential metal scarcity, genes involved in ribosome biogenesis and one-carbon metabolism were down-regulated. CAET cells get phagocytosed efficiently and eliminated faster by macrophages. CAET infected mice survived and induced robust host immune responses to protect the lethal challenge. Thus, CAET is a potential live whole-cell vaccine candidate.*

Therapy through modulation of host immunity: Imbalance in tolerance and inflammation in immunity could lead to autoimmune diseases and opportunistic infections including sepsis. Researchers at ILS have found that nuclear receptor corepressor 1 (NCoR1) depletion in dendritic cells (DC) leads to immune-tolerance by increasing the Glycolytic and fatty acid oxidation pathways .

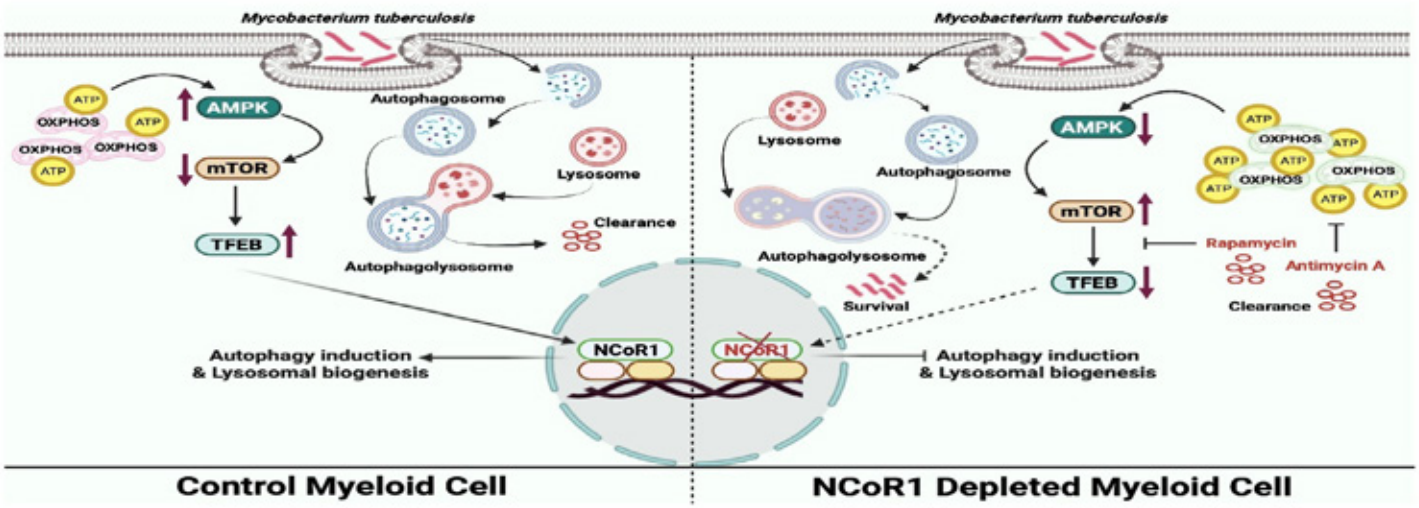


Figure 10.3: *Schematic representation of how Mtb survives easily in NCoR1 depleted macrophage cells and in myeloid specific NCoR1 ablated mice. Mechanistically, NCoR1 ablation suppressed autophagy mediated Mtb killing through AMPK-mTOR-TFEB signalling axis.*

Chikungunya virus perturbs the Wnt/β-catenin signalling pathway for efficient viral infection: In this study, the Molecular Virology group at ILS, identified the cellular factors that interact with the Chikungunya virus (CHIKV) non-structural protein 2 (nsP2). The group found that α-1 Catenin and β-Catenin /Wnt pathways are dysregulated during CHIKV infection. Both α-1 Catenin and β-Catenin proteins interact with CHIKVnsP2 proteins.

Phytonanomedicine-based anticancer therapy: Research at ILS has focused on targeting cancer stem cells (CSCs), a minor population of tumor-initiating cells that exhibit self-renewal abilities, support tumor progression by initiating tumor growth and metastasis and contribute to treatment failure in cancer. They have shown that nimbolide-loaded and piperlongumine-loaded nano formulations target triple-negative breast cancer CSCs through epigenetics and metabolic reprogramming respectively.

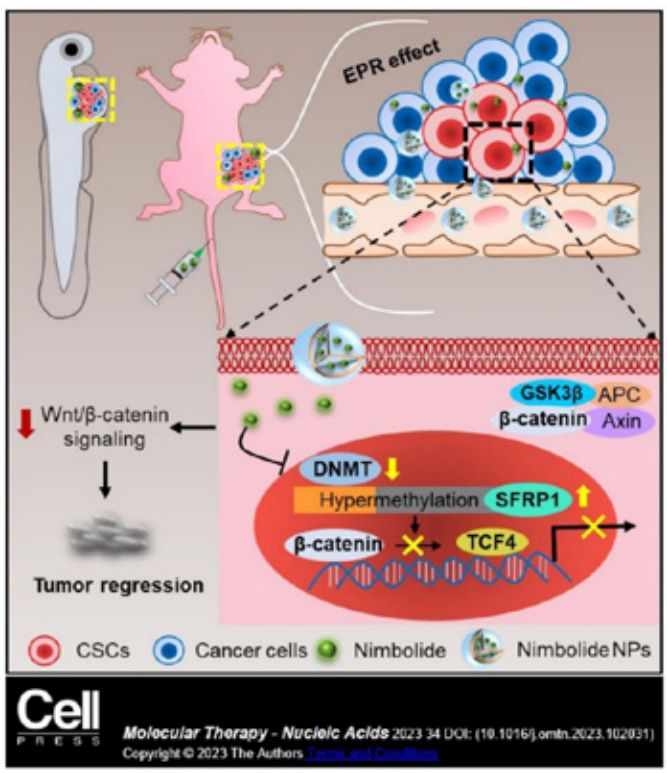


Figure 10.4: *Schematic representing nimbolide loaded nanoformulations passively target triple-negative breast cancer CSCs through epigenetic pathways.*

Statins abrogate gemcitabine-induced PD-L1 expression in pancreatic cancer-associated fibroblasts and cancer cells with improved therapeutic outcome: Gemcitabine has been the most commonly used, single chemotherapeutic agent in pancreatic cancer. However, the response rate for only gemcitabine therapy is very poor. The findings of a recent research study conducted at ILS has elucidated a novel mechanism how gemcitabine induces immunosuppression in pancreatic cancer by inducing immune checkpoint proteins (PD-L1 and PD-L2) expression in cancer associated fibroblasts (CAFs) and pancreatic cancer cells.

Animal challenge and Immunogenicity assay platforms: ILS has developed platform facilities in the last years which is offering research platforms to academic institutions, pharmaceutical companies and start-ups on a fee-for-service mode. Realizing the importance of preclinical animal models, under the mission COVID Suraksha, DBT-BIRAC has supported ILS to establish an ABSL-3 platform to provide services for screening of antivirals. Apart from studies by ILS scientists, it has also served several public and private-funded organisations including six pharmaceutical companies for SARS-CoV-2 related studies. The COVID Suraksha Mission has also supported establishment of an immunogenicity platform at ILS. The national facility includes a state of the art full spectra multicolor flow cytometer (Cytek Aurora with 5 lasers) and Meso Scale Discovery SQ120mm platform. These two instruments have the capability to analyse the humoral and cell mediated immunity to assess the vaccine efficacy in the clinical trial samples or the samples from animal trials. The facility has organized hands on workshops to train the stakeholders including clinicians, faculty members, Postdocs, PhD and masters students.

Development of Scientific Entrepreneurship and Ecosystem: ILS Bhubaneswar has taken a major step forward in promoting entrepreneurship in the biotechnology sector by establishing a biotech incubator. The incubator is focused on domains such as bioinformatics, biopharmaceuticals, bioprocessing, industrial biotechnology, MedTech, food and wellness, indigenous biotech products, agriculture, and allied areas. Highlights/output of facility in this year (2023 -2024). This incubator also received Emerging Incubator Award of the year 2023 by MSME Department, Govt. of Odisha.

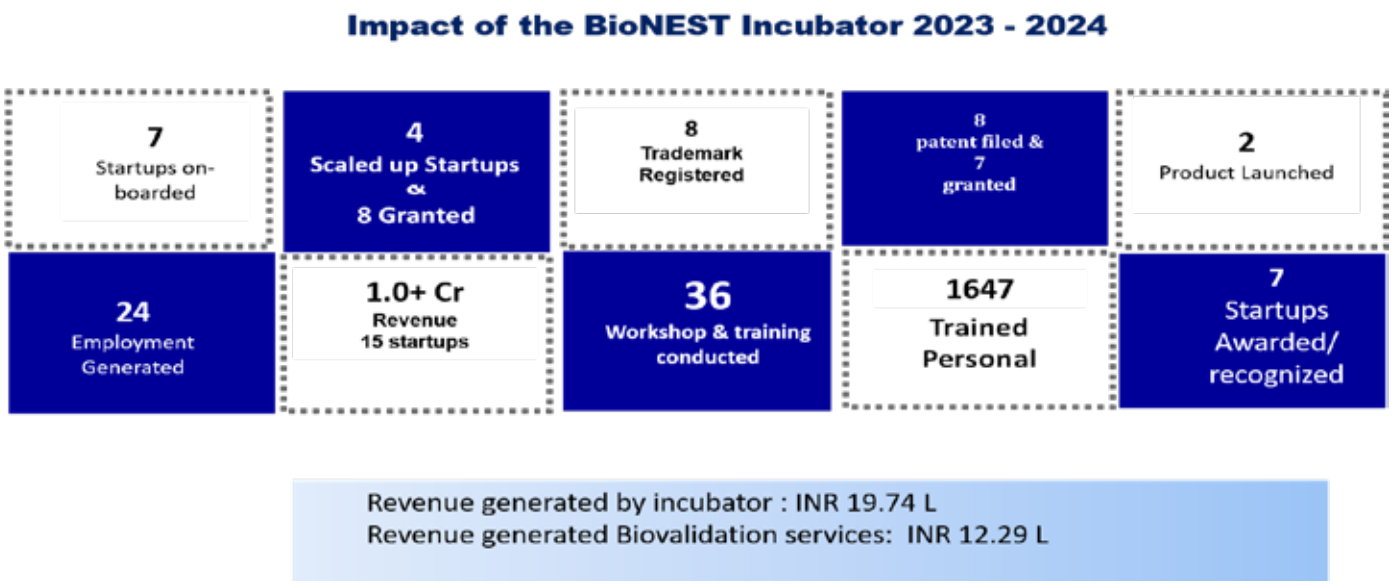


Figure 10.5: *Impact of the ILS-BioNEST incubator (2023-24)*

Societal Impact

ILS has established a Biotech-Kisan hub to promote cultivation of biofortified crops (rice, maize, millet and tuber crops), crop diversification with vegetables and scientific rearing of fish and goats in two aspirational districts of Odisha. More than 500 hundred acres of vegetables, 100 acres of protein & zinc rich paddy and 20 acres of biofortified tuber crops were cultivated benefiting 600 farmers who received training and quality seed developed by research laboratories.

BRIC-INSTITUTE FOR STEM CELL SCIENCE AND REGENERATIVE MEDICINE (inStem), BANGALORE, KARNATAKA

inStem's scientific program is primarily allied to areas of stem cell research that bolster translational and regenerative medicine. The programs include focused research in cardiovascular disease, metabolic disorders, barrier dysfunction and brain development and disorders. On the one hand, teams working to decipher the metabolic regulation of cell fate examine the effect of varying environmental conditions on cellular behaviour with special focus on stem cells. On the other, models for investigating neurodevelopmental, cardiac and gut disorders are developed by groups focused on disease physiology. Additionally, a few research groups also pursue chemical biology approaches to generate therapeutic leads and support scaffolds for stem cell-based therapies.

In the pursuit of modern medical interventions for genetic disorders such as hemoglobinopathies by the inStem Centre for Stem Cell Research (CSCR), a translational unit of inStem,a gene therapy clinical trial for haemophilia is underway. Further, novel approaches to prime editing in hematopoietic cells have been devised to correct sickle cell disease and thalassemia. inStem's mandate is to solve complex problems in areas of directed differentiation and tissue regeneration with disease relevance. The institute's laboratories offer advanced training and its constituent labs function through collaborative research programs involving in-house and inter-institutional interdisciplinary programs with translational emphasis. inStem also continues its contributions to the INSACOG program. inStem has also developed national scientific facilities such as National Cryo-EM Facility, National Mouse Research Facility. inStem regularly organizes skill and capacity building workshops for students, researchers and faculties on various topics such as Mouse Cryobiology & IVF, Crispr / Cas techniques, Integrated OMICS as well as stem cell research.

Major Initiatives

Women's health, especially reproductive biology is a greatly understudied area. Understanding mechanisms involved in early development will help make transformative discoveries and the development of safer alternatives to existing drugs and products. Named "WoRtH"[Programme in Women's Reproductive Health], this first-of-its-kind, ambitious project will develop stem cell and organoid-based tools to enable the discovery of candidate drugs and test an array of intervention strategies in vitro. inStem secured a major grant from the Bill & Melinda Gates Foundation towards this project to advance women's health.

inStem has also set up a unique stem cell research enabling platform through the "ESCORT program" (recommended for funding by the Department of Biotechnology, Government of India, under the aegis of SAHAJ) to Enable Stem Cell and Organoid Research and Training and equip academia and industry with the skills to generate stem cells and organoids, through extensive hands-on training and hybrid workshops.

Towards skill-building and training, inStem organized many workshops and training such

as the Hands-on Workshop on Cryobiology and Assisted Reproductive Technologies (ARTs) in the Laboratory Mouse (2023) and the Workshop on Human Pluripotent Stem Cell Research. Higher level training such as those for faculty were also organized – e.g., The IRMI- Capacity Building Workshop on Academic Integrity and Regulatory Compliance and the Faculty Development Programme on CRISPR Genome Editing: Generating Mouse Models for Human Therapeutics (February 2024).

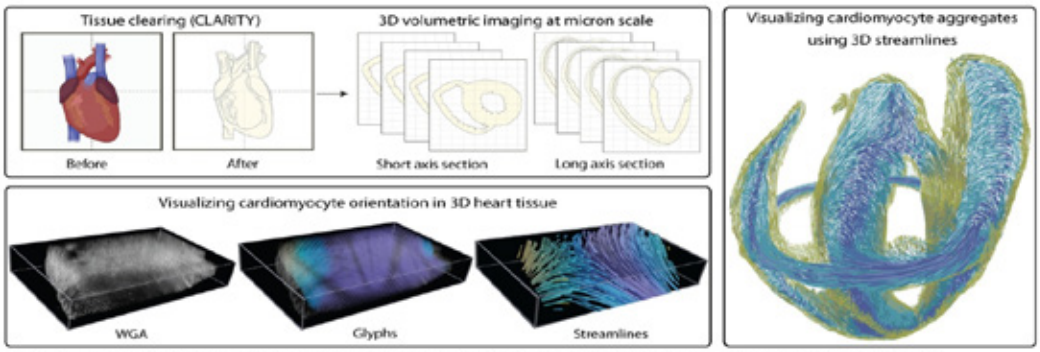
Notable Outcomes

The efforts of the highly driven faculty and well-trained scientific staff of inStem have yielded many high-quality publications in frontier areas of stem cell science and regenerative biology, in reputed journals like Nature Communications, PNAS and EMBO. The scientific endeavours at inStem have also led to7 patents in the past year. New scientific initiatives such as development of a human stem cell biobank, to cater to service nationwide, have been taken up. Training and outreach have been centre-stage at inStem, with many efforts towards skill-building in the biological sciences. These include hands-on trainings in stem cell research, gene editing, animal handling and genome engineering to create animal models, mass spectrometry, and CIFF microscopy course. inStem also contributed towards finding solutions for the challenges posed by the spread of COVID-19 infection, which led to surveillance testing, a biorepository of SARS-Cov2its genome sequencing and diagnostic kit validation. The effort to serve the society at large continues with many novel technologies such as the latest nanofiber-sheet-lined blood bags that enhance the viability of stored blood which can be of immense medical value, especially considering the scarcity of rare blood group donors. inStem's achievements showcase the efforts at bridging the findings from basic fundamental research to valuable translational output, together with balancing scientific training of the future scientific workforce and thriving for public engagement at all possible levels.

Indicators	Number
Details of projects completed	53
Details of Process/Product/ Technology Developed	3
Process/Product/Technology Transferred to User Agency/ Industry/ Stakeholders	01
No. of Research Publications (please enclose detailed list with impact factor separately)	81
No. of Patents Applied:	07
No. of Patents Obtained:	02
No. of Human Resources Trained:	2993
Major Honours & Awards received by scientists:	13

Major Achievements

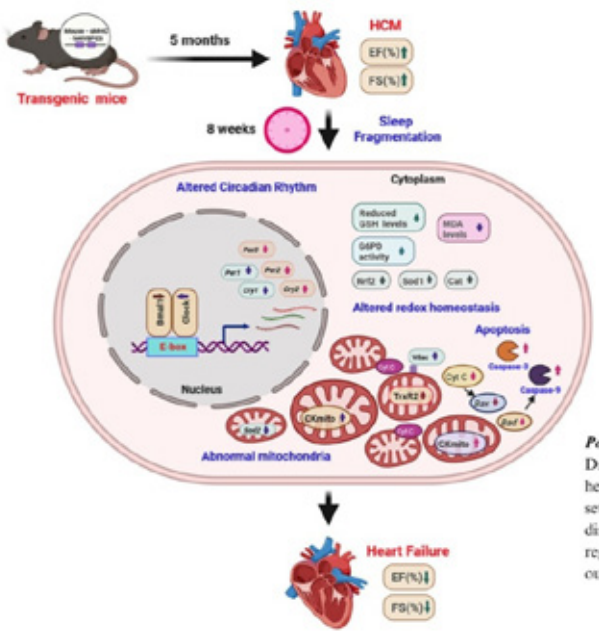
First-ever 3D model of heart muscle cells and fibres: Rhythmic contraction of the heart's muscle cells (cardiomyocytes) leads to the regular beating of the heart, a vital sign and necessity to be alive and healthy. The findings from this research closes a great gap in the field of cardiovascular biology since a 3D map that indicates the direction and orientation of the many cardiomyocytes that make up a heart has been demonstrated for the first time. Using a powerful microscope and advanced computer analysis, DBT-iBRICinStem scientists created a detailed 3D map of how heart muscle cells are arranged. They used mouse heart for this study. The research groups used a microscope to look at heart cells and then used computer technology – computer vision - to analyze the images and create a 3D model showing how these cells are oriented or arranged in space. The model is three orders of magnitude higher in resolution (micrometer resolution) than known previously (millimetre resolution).



First-ever 3D model of heart muscle cells and fibres: Collaborative investigation by Dr Sirajuddin and Dr Perundurai demonstrated computational reconstruction methods can be applied at fine spatial scales to further understanding of heart wall electrical function and mechanics and set the stage for the study of micron-scale fiber remodeling in heart disease.

Figure10.6: *Cardiomyocyte orientation recovery at micrometer scale reveals long-axis fiber continuum in heart walls.*

Poor-quality sleep can worsen heart patients' situation: Hypertrophic cardiomyopathy is a genetic disorder prevalent in the Indian population. Even though many patients die of sudden cardiac arrest or heart failure, the reasons remain elusive. Since the link between HCM and lifestyle is not well studied, scientists at inStem worked on discovering the effect of disturbed sleep, or sleep fragmentation on the propensity for heart failure. A transgenic mouse model was developed that has a modified C10 domain of the human MYBPC3 protein that mimics the effects of a 25 bp deletion that causes HCM and is a specific sarcomere gene variant commonly found among Indians. After being subjected to 8 weeks of sleep fragmentation, the measure of detrimental changes at the physical and biochemical level in the mice revealed that sleep fragmentation is a risk factor for heart patients. Following interventions to improve sleep patterns have the potential to help HCM patients, making the study directly relevant for cardiovascular medicine.



Poor-quality sleep can worsen heart patients' condition:
Dr Perundurai's team shows that sleep fragmentation is a risk factor for heart failure transition. This has important implications in clinical settings where hypertrophic cardiomyopathy (HCM) patients with sleep disorders have worse prognosis because strategic intervention with regularized sleep patterns might help such patients to have better outcomes.

Figure 10.7: *Sleep fragmentation induces heart failure in a hypertrophic cardiomyopathy mouse model by altering redox metabolism.*

New understanding of the metabolic states of cells in the skin reveals therapeutic target for skin disorder psoriasis: The skin may experience inflammation even in the absence of infection, due to environmental toxins, trauma, injury or inflammatory disorders such as psoriasis. This is known as sterile inflammation, since it occurs in the absence of any microbial infections that activate the immune system. The exact causes and mechanisms underlying sterile inflammation are incompletely understood although immune cell responses and cellular metabolism are known to be disturbed. Particularly, the relation between metabolites generated by skin cells and their effect on macrophages, the resident immune cells, is unexplored. Scientists from iBRIC- inStem discovered through mouse studies that the epidermis cells produce lactate which is taken up by the macrophages, initiating a cross-talk that leads to inflammation in the skin. This novel role of lactate is also a plausible target for skin disorders such as psoriasis since blocking the lactate transport channels by treatment with Syrosingopine leads to recovery from symptoms in the mouse model for psoriasis.

Societal Impact

inStem undertook various initiatives that directly benefit the society and delivered products and services advantageous for the community at large. A novel blood bag technology was also developed at inStem that addressed the lack of technologies to enhance the quality and shelf-life of blood, specifically for storing rare blood groups.The nanofibrous sheets created for this purpose are efficient in scavenging DAMPs – components that damage the red blood cells' membrane integrity, making them fragile - from stored human RBCs. The translational Unit of iBRIC-inStem – CSCR – is also conducting a gene therapy clinical trial for haemophilia, a prevalent blood disorder. There, the project – 'Control of Thalassemia and Sickle Cell Disease in Odisha' is a first of its kind venture worldwide, providing extensive and relevant public education and diagnosis combined with establishment of services for counselling, testing and pre-natal diagnosis with opportunity for safe medical termination of pregnancy, if needed.

BRIC-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. This 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. In NABI, agri-waste is used to isolate bioactive compounds with high market value, directly benefitting farming community by increasing their income and providing new avenues to establish industrial units along with providing employment opportunities by utilization of Agri-waste.

Major Initiatives Taken:

- In a major step towards R&D excellence, National Genome and Training Centre (NGeTC) established at NABI, Mohali. Core focus of the training centre are training manpower by employing practical applications of genome editing and Research & Development by generating catalogue of mutations in multiple crops for the traits related to nutritional & processing quality.

- During the year "DBT-SPEEDY SEEEDS" the first-of- its-kind "National Speed Breeding Crop Facility" has been established. The facility will directly help (a) Scientists and Researchers from government institutions, private institutions and leading industries in India engaged in agricultural and biotechnology research and development of improved crop varieties and products, (b) Plant Breeders working for crop development and (c) Progressive farmers who are contributing to adoption of new varieties with superior yield and nutritional traits.

Notable Outcomes and Achievements

During the year, NABI has been able to publish the research outcomes in 109 peer reviewed scientific journals. About 13 patents have been granted during the year and four have been filed. One of the technologies developed at NABI and related to '*Dehydrated Natural Saffron Colour*' has been commercialized during the year by the licensed company, Vexcel Upkram Pvt. Ltd., Ranchi, Jharkhand. The product has been branded as 'SHROOTS' and is commercially available at Amazon. Moreover, about three other technologies have been transferred to different companies during the year. NABI have been able to train a total of 220 students during the year as short-term trainees and JRF, SRF and Research Associate. During the year, one of the major achievements has been to set up a National Genome and Training Centre (NGeTC) at National Agri-Food Biotechnology Institute (NABI), Mohali which was inaugurated by Hon'ble Minister of Health & Family Welfare, Science & Technology and Earth Sciences Dr. Jitendra Singh on 5th January 2023. Core focus of the training centre are training manpower by employing practical applications of genome editing and Research & Development. Further, another major facility has been built at NABI which is the "National Speed Breeding Crop Facility" also inaugurated by the Union Minister of Science & Technology, Dr. Jitendra Singh on 11th March, 2024.

Scientific Achievements

Major portion of wheat grain consist of carbohydrate, mainly starch. The proportion of amylose and amylopectin in starch greatly influence the end product quality. Advancement in understanding starch biosynthesis pathway and modulating key genes has enabled the genetic modification of crops resulting in enhanced starch quality. However, the regulation of starch biosynthesis genes still remains unexplored. So, to expand the limited knowledge, here, NABI has characterized a Ser/Thr kinase, SnRK1α in wheat and determined its role in regulating starch biosynthesis. SnRK1 is an evolutionary conserved protein kinase and share homology to yeast SNF1. Yeast complementation assay suggests TaSnRK1α restores growth defect and promotes glycogen accumulation. Domain analysis and complementation assay with truncated domain proteins suggest the importance of ATP-binding and UBA domain in TaSnRK1α activity. Sub-cellular localization identified nuclear and cytoplasmic localization of TaSnRK1α in tobacco leaves. Further, heterologous over-expression (O/E) of TaSnRK1α in Arabidopsis not only led to increase in starch content but also enlarges the starch granules. TaSnRK1α was found to restore starch accumulation in Arabidopsis *kin10*. Remarkably, TaSnRK1α O/E increases the AGPase activity suggesting the direct regulation of rate limiting enzyme AGPase involved in starch biosynthesis. Furthermore, in vitro and in vivo interaction assay reveal that TaSnRK1α interacts with AGPase large sub-unit. Overall, our findings indicate that TaSnRK1α plays a role in starch biosynthesis by regulating AGPase activity.

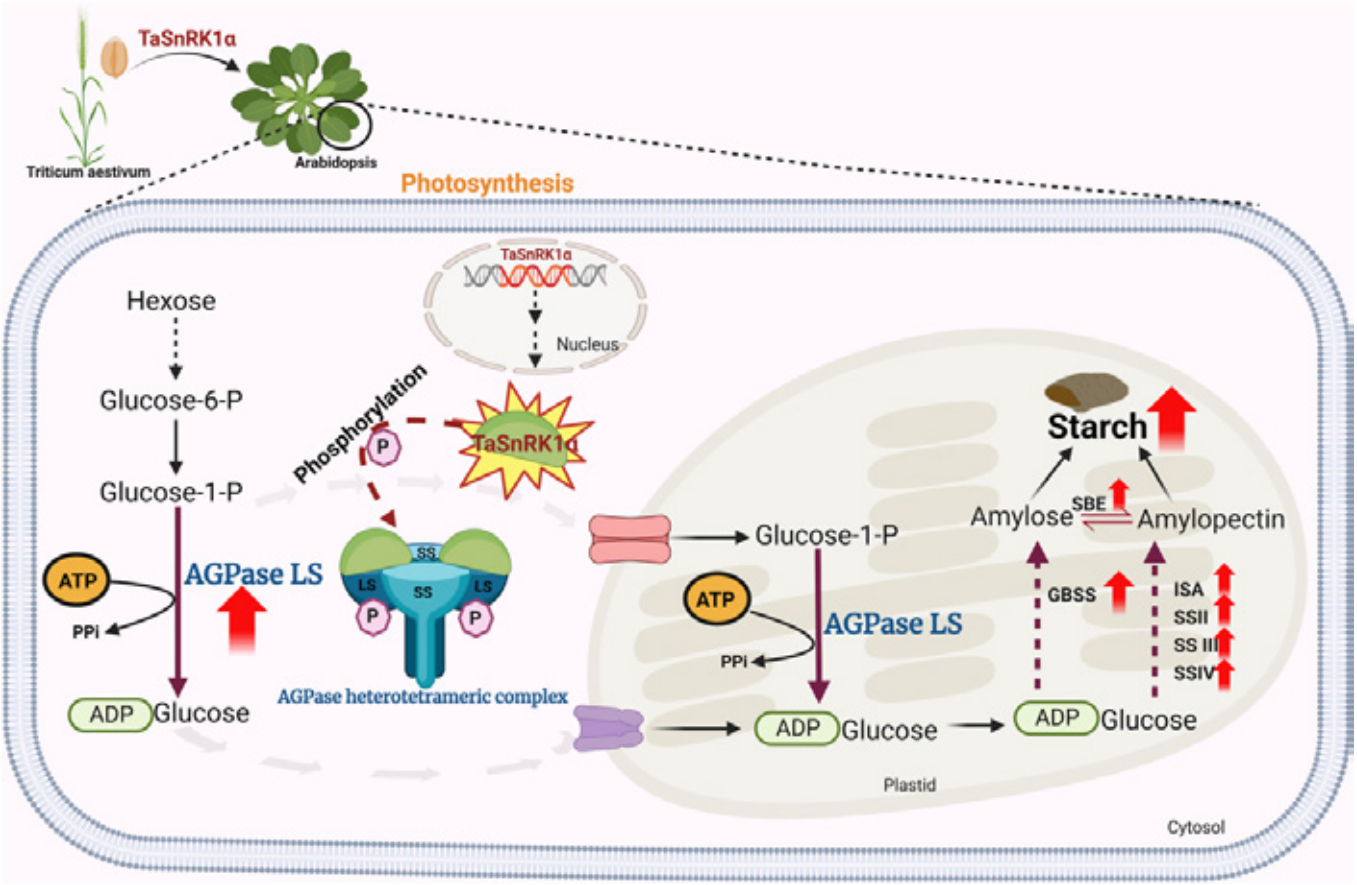


Figure 10.8: *Diagrammatic representation of TaSnRK1α mediated regulation of starch biosynthesis pathway. Overexpression of TaSnRK1α increases AGPase activity.*

L-Ascorbic acid (AsA) is a potent antioxidant and essential micronutrient for the growth and development of plants and animals. AsA is predominantly synthesized by the Smirnoff-Wheeler (SW) pathway in plants where the GDP-L-galactose phosphorylase (GGP) gene encodes the rate-limiting step. In the present study at NABI, AsA was estimated in twelve banana cultivars, where Nendran carried the highest (17.2 mg/100 g) amount of AsA in ripe fruit pulp. Five GGP genes were identified from the banana genome database, and they were located at chromosome 6 (4 MaGGPs) and chromosome 10 (1 MaGGP). Based on in-silico analysis, three potential MaGGP genes were isolated from the cultivar Nendran and subsequently overexpressed in Arabidopsis thaliana. Significant enhancement in AsA (1.52 to 2.20-fold) level was noted in the leaves of all three MaGGPs overexpressing lines as compared to non-transformed control plants. Among all, MaGGP2 emerged as a potential candidate for AsA biofortification in plants. Further, the complementation assay of Arabidopsis thaliana vtc-5-1 and vtc-5-2 mutants with MaGGP genes overcome the AsA deficiency that showed improved plant growth as compared to non-transformed control plants. This study lends strong affirmation towards development of AsA biofortified plants, particularly the staples that sustain the personages in developing countries.

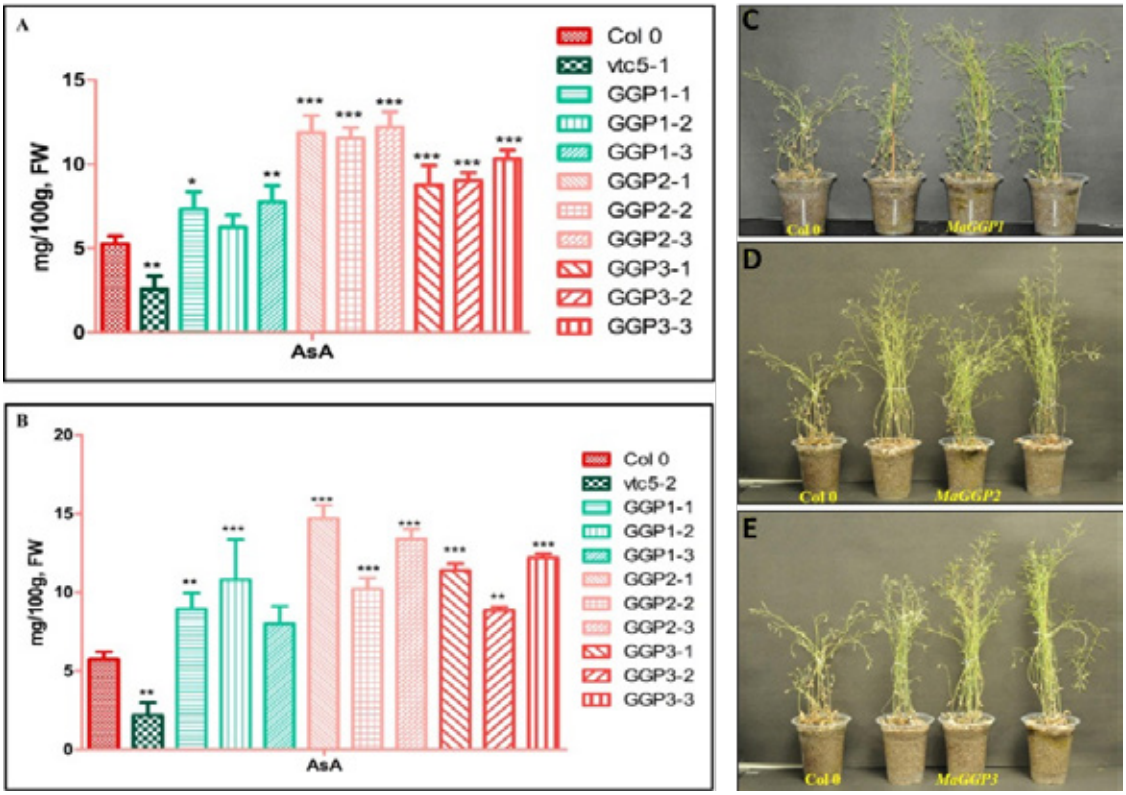


Figure 10.9: *The MaGGP genes complemented lines have higher ascorbic acid content and MaGGP transformed lines show resilience towards drought stress than the control plants.*

Obesity is a worldwide epidemic leading to decreased quality of life, higher medical expenses and significant morbidity. In this direction, NABI aimed to determine the therapeutic potential of such combination of sub-effective doses of various dietary TRP channel agonists like capsaicin (TRPV1), cinnamaldehyde (TRPA1), and menthol (TRPM8) against diet-induced obesity, and explore the involved cellular processes. This can be crucial for designing therapeutics with higher efficacy at decreased dosage, while limiting associated side-effects.

Lignin is a renewable, biodegradable, and cost-effective biopolymer present in agri-biomass. This bioresource could be utilized as a sustainable alternative for biomaterial development. Bio-based and biodegradable polymers are ideal for sustainable polymer packaging too. In the study at NABI, lignin was extracted from wheat straw using the soda method with 18–20% yield followed by its characterization. The purified soda lignin was utilized for the synthesis of lignin nanoparticles (PNSL) and copper oxide nanoparticles (L@CuONPs) followed by their incorporation into the PVA-PEG film (PVA-PEG-PNSL-L@CuONPs nanocomposite films). The antimicrobial activity against *Escherichia coli*, *Bacillus megaterium,* and *Candida albicans* of nanocomposite films reached up to 5 log reduction (~99.999%). Furthermore, the UV protective activity of these lignin-based biodegradable nanocomposite films was validated which paves its way as an eco-friendly, cost-effective, and sustainable biomaterial. Moreover, lignin-based films derived from renewable sources have potential applications in the food packaging industry because of their low cost, biocompatibility, flexibility, and transparency.

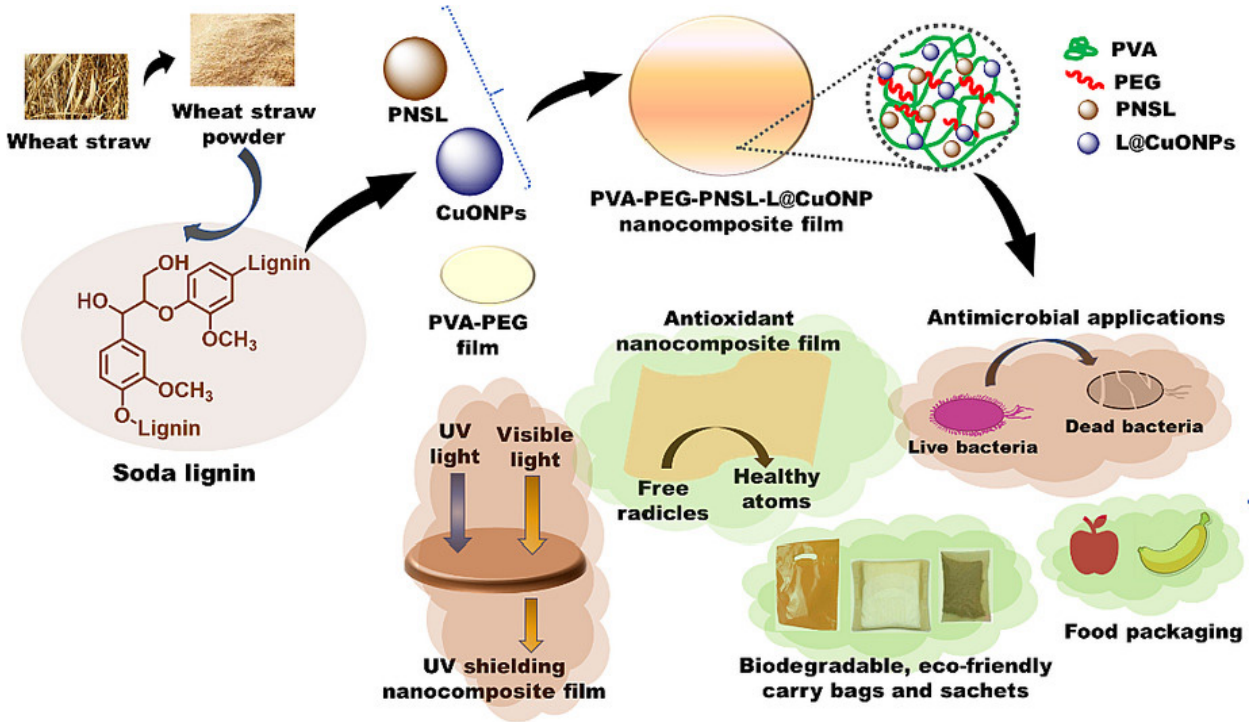


Figure 10.10: *Flow diagram representation of the process for sustainable preparation of agri-biomass-derived lignin nanocomposite films for packaging applications.*

Process/Product/Technology Transferred to User/Agency/Industry/Stakeholders:

- Lignin-based biofertilizer and biopesticide technology of NABI was licensed to High Vision Technologies.
- NABI has signed an NDA-MTA with UPL Limited, Mumbai, India to evaluate the developed edible fruit coating materials by NABI and explore the possibility of commercialisation.
- NABI signed MoA with Kothari Sugars and Chemicals Limited for the demonstration of technology for the production of D-allulose.

Process/Product/Technology commercialized: A product called *'Dehydrated Natural Saffron Colour'* covered under the IPR *via* patent application no. 202211005755 licensed to Vexcel Upkram Pvt. Ltd., Ranchi, Jharkhand on 29/11/2022 through BCIL, now has been commercialised by the company under the brand name 'SHROOTS'. The product is commercially available at Amazon.

Societal Impact

- Lignin is a renewable, biodegradable, and cost-effective biopolymer present in agri-biomass. Towards this, NABI has developed lignin-based films that have the potential applications in the food packaging industry. This bioresource could be utilized as a sustainable alternative for biomaterial development.
- NABI has developed eco-friendly and biodegradable nanocomposite films from wheat straw which have potential biodegradable antimicrobial properties for use in active food packaging systems for shelf-life extension of perishable commodities during transportation and storage.
- NABI has also worked on the development of a symbiotic combination constituting probiotic mix. This synbiotic blend can be used for alleviating gut inflammatory conditions such as that of ulcerative colitis.

- Through pharmaco-nutritional studies, NABI has developed novel class of functional foods (cobiotics) to prevent double nutritional burden (under nutrition and over nutrition) in India. This can be crucial for designing therapeutics with higher efficacy at decreased dosage, while limiting associated side-effects.
- NABI has worked towards generating fundamental knowledge of iron signaling network in wheat which has provided insights into early phase of iron deficiency and can be utilized in future for developing biofortified wheat.

BRIC-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 in the country. NBRC is a NAAC-accredited Deemed to be University and awards M.Sc. and PhD degrees. NBRC has also been recognised as an Institution of Excellence by the Government of India. The institute has a diverse research base covering all aspects of neuroscience research, from molecular activity to the human behaviour underlying brain functions. We investigate human brain function using high-end Magnetic Resonance Imaging (MRI) and Magnetoencephalography (MEG), as well as Electroencephalography (EEG) and other non-invasive tools. Some key focuses have been detecting and understanding dementia and related neurodegenerative disorders, nerve regeneration, mechanisms of viral infections in the brain and nerve secretion. In addition, research in NBRC also focuses on studying the connectomics of auditory perceptions and the effects of molecules in neuronal functions such as learning and memory.

Major Initiatives:

NBRC is coordinating a DBT-funded comprehensive and multi-centric Dementia Science Programme to collect data regarding incidence, prevalence, biomarkers, and risk and protective factors. This program 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 diagnosing dementia and its classification.

Magnetoencephalography (MEG) Resource Facility in NBRC is a collaborative project between NBRC and the 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.

A new long-term research consortium focusing on certain neurodevelopmental disorders (NDD), particularly Autism and intellectual deficiency (ID) syndrome, has been initiated with an objective to develop better diagnostic tools adapted to the ethnocultural milieu of the country and identifying key intervention targets during in the next decade. NBRC has taken a lead role by establishing the networking group with interested researchers across the country covering both the participating clinicians and researchers as one of the major initiatives in this direction. A proposal has been submitted for the pilot run of the project, which is under consideration. NBRC researchers also joined an international effort to develop image analysis protocols for low magnetic field, portable, "Hyperfine" MRI machines in collaboration with the Bill & Melinda Gates Foundation.

Scientific Achievements

NBRC has made significant progress onmultiple fronts including the development of specific brain function analysis tools, the physiological regulation of neuronal growth development and functions, and the molecular basis of viral infection in the brain. In the areas of brain function studies, NBRC developed a data-driven unsupervised approach for characterizing the temporal stability of functional brain architecture and used the methodology to define a biomarker for identifying brain stability with aging. This method can be applied to identify the early signs of many different neurological disorders such as epilepsy and Alzheimer'sand mental health assessment.In addition, we identified how focal lesions in the brain unsettled the excitation-inhibition (E-I) balance and the timelines of recovery of function from such lesions associated with stroke. In particular, such direction of research identifies how structural connection topology impacts the functional connection properties - a relevant principle that subserve many brain disorders. Using human electrophysiology, it was demonstrated the inter-hemispheric transfer of cortical information results in hemispheric specialization of tonal auditory processing which is relevant for understanding diseases like central auditory processing disorders (CAPD) and tinnitus. Further methods that unravel signal processing complexities in EEG- specifically distinguishing spontaneous brain activity from event related brain activity have been developed.

In addition, NBRC understood how the spatiotemporaldistribution of RNA-protein interactions in neurons could help to visualize the dynamics of neuronal activity in a brain and modify them without altering the genomes via conventional methods.Such an understanding could

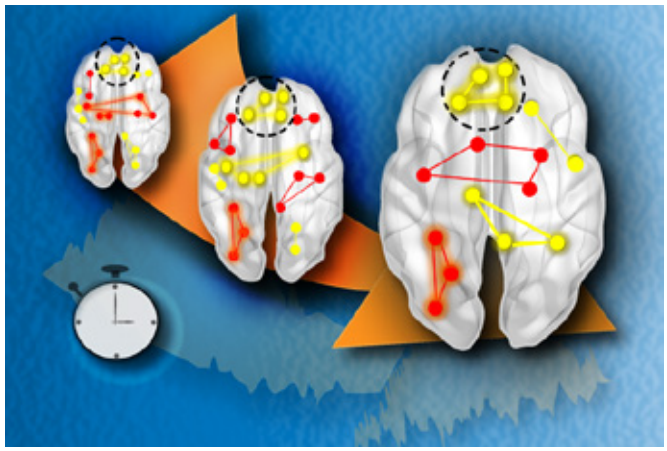


Figure 10.11: *The main theme of the illustration is the temporal ''stability'' of brain network patterns. The three brains are different configurations of brain networks at different instances of time. Some brain network patterns are ''similar'' for an extended duration of time, indicating the ''stability'' of those patterns (inside the black circle). The colour scheme (red/yellow) indicates brain network patterns that are closer (yellow indicating less angular/mahal distance). The arrow indicates the 'arrow of time', flanked by a clock. The background is calm water with consistent ripples like resting state activity. Calm water can also be interpreted with stability.*

also play an important role in manipulating neuron regeneration in the adult brain as wedemonstratea link between the RNA-binding proteins and cytoskeletal machinery in regulating the structure and function of neurons. Secretion is an essential property of all neurons, and it plays a vital role in maintaining intern-neuron communications, which is critical for every brain function. NBRC researchers elegantly demonstrated how theinter-organellar organelle cross-talk and the endoplasmic reticulum stress contribute to exocytosis regulation and neurotransmitter release. This insight is expected to enable us to understand the basic aspects of neuropeptide release and neurotransmitter release in pathophysiological conditions where ER stress is prevalent.

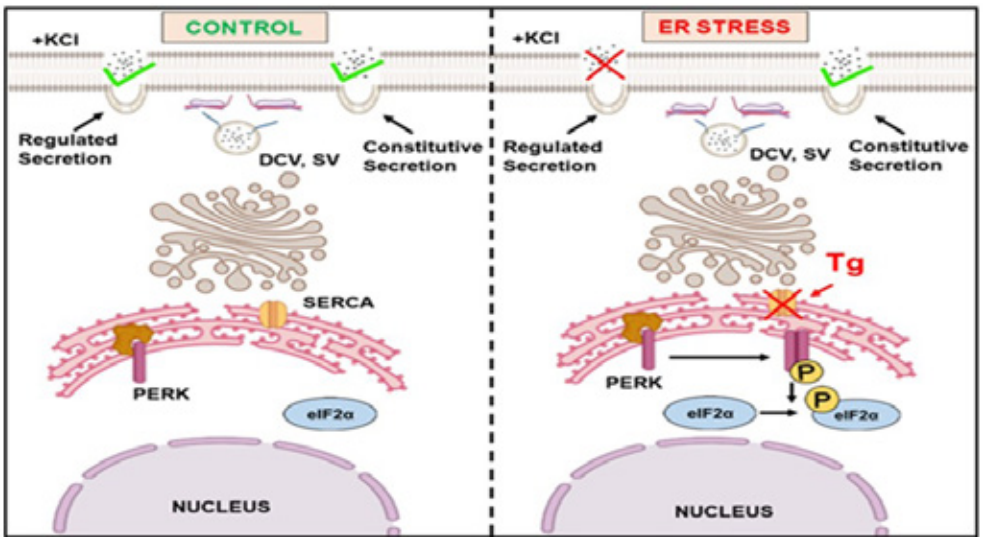


Figure 10.12: *ER stress impedes regulated secretion by governing key granulogenic and exocytosis molecular switches.*

A collaboration between AIIMS, New Delhi and NBRC also elicited the interconnection between the epigenome and anti-proliferative signatures in gliomas – a debilitating form of brain cancer. The finding suggested how an assessment of distinct epigenomic architecture could serve as a predictive biomarker in determining responsiveness to chemotherapeutics.

Work on viral infections in the Brain has yielded several new insights including a novel role of non-structural ZIKA Virus proteins in altering the fate of Neural Stem cells through autophagy – a potential cause of microcephaly in new-born babies, which further suggestedthat the lattercould be potentially targeted for anti-ZIKV therapy. Continuing in this line of work we found how the central nervous system infected by flaviviruses such as Japanese encephalitis virus, Dengue virus, and West Nile virus results in neuroinflammation and neuronal damage, a main cause of brain damage in the infected children. We found little-known long non-coding RNAs (lncRNAs) play a major role in flavivirus-induced neuroinflammation and neuronal cell death. We characterized the role of a flavivirus-induced lncRNA named JINR1(JEV-induced non-coding RNA 1) and worked out the underlying molecular mechanisms. Together this research helped to identify some major targets of moderating the effects of the virus infection.

Societal Impact

Patients with epilepsy visit the campus for medical check-ups using the magnetoencephalography facility in collaboration with AIIMS, New Delhi. NBRC has also started a public interface programme to highlight the prevalence of the syndrome amongst the school children to the teachers by bringing together a panel of counsellors, clinical experts and researchers.

BRIC-NATIONAL CENTRE FOR CELL SCIENCE (NCCS), PUNE, MAHARASHTRA

NCCS is involved in cutting-edge interdisciplinary research in diverse areas of cell biology relevant to human health, aimed at understanding the biology of diseases like cancer, malaria, tuberculosis,

metabolic disorders like diabetes and obesity, as also neurobiology, stem cell biology, immunology and microbiology. NCCS contributes immensely to capacity building of the nation by providing high-quality training in research, and also supports cell biology research across India through various services.

Notable Outcome & Achievement:

Contributions of the National Cell Repository: NCCS has facilitated cell biology research across India by providing 5747 cell cultures to 500 organizations.

Research Achievements: The valuable scientific expertise and outcomes of NCCS have relevance to biomedical research, and have yielded 98 articles published in leading peer-reviewed journals.

Capacity Building: Over 650 beneficiaries received cutting-edge research training and mentorship through various initiatives of DBT-NCCS, including the academic programmes (117 students enrolled fpr a PhD, 114 Project Trainees and Indian Science Academies' Summer ResearchTrainees, 67 participants from various institutes in the PhD coursework conducted by NCCS, and 06 postdoctoral scientists), training workshops and participation in extramurally-funded research projects.

Indicators	Number
Projects completed	30
Research Publications	98
Patents Applied for	03
Patents Obtained	05
Human Resources Trained	>650
Awards & Honours of NCCS	30

Scientific Achievements

NCCS investigated a different RNA species called chimeric transcripts (CTs) in ovarian cancer samples, to understand how genes combine in unique ways to generate variability in biological systems. The diverse range of CTs that they discovered sheds light on the complexity of cancer cells. These insights into the potential impact of CTs on the survival and evolution of cancer cells, published in the Computational and Structural Biotechnology Journal, could guide the diagnostic and therapeutic strategies for ovarian cancer in the future.

Researchers at NCCS explored the influence of two proteins, IL-6 and IL-17, and the intricate signaling pathways influenced by them, on lung cancer. These studies, published in the International Journal of Molecular Science, revealed that they play a role in promoting inflammation in the lungs, which can contribute to the development and progression of cancer. This research sheds light on potential druggable targets that could help develop new therapeutic approaches for non-small cell lung cancer.

Research published in Cell Death and Disease, investigated the role of a protein called FBXW2 in breast cancer. The study found that FBXW2 can regulate the activity of other proteins involved in cancer progression, such as Moesin. The identification of these molecular players and how they function inside the cell provide valuable insights into how breast cancer develops and spreads, thus providing potential targets for new and more effective treatments for breast cancer. This research brings us closer to developing better therapies that could improve the outcomes for people with breast cancer.

Kainate receptors are molecules that play key roles in the central nervous system. Different forms of this molecule have been identified in the brain, among which the 'GluK1-1' variant is abundant in the adult brain. It has fifteen extra amino acids inserted in a certain part of the molecule called the

amino-terminal domain (ATD), which results from a specific step, the alternative splicing of exon 9. Researchers at NCCS discovered that this small change in a brain receptor, resulting from the exon 9 splice insert, can change the behaviour of the receptor, affecting how it responds to signals in the brain. The study, published in eLife, emphasizes the need to investigate all possible variations of this receptor molecule, in order to gain a more comprehensive understanding of their distribution and functional diversity. This would prove valuable to design rational therapeutic approaches for disorders involving kainate receptors.

NCCS paper in the FEBS journal examined how the balance between the cell's self-cleaning process, called autophagy, and cell death is affected in stem cells by the regulation of gene activity through epigenetics. They found that a molecule called EZH2 plays a crucial role in this process during stem cell differentiation. The identification of such novel regulatory mechanisms could open up new avenues for the development of treatment regimens to mitigate autophagy-mediated disorders.

Researchers investigated how neurons in the central nervous system (brain and spinal cord) die in neuronal autoimmune diseases. They show how pathogenic immune cells, called Th17 cells, damage the blood-brain barrier in the central nervous system (CNS) and promote the death of nerve cells. These findings, published in Clinical Immunology, help us understand cellular and molecular details of CNS autoimmunity and offer valuable clues for developing novel therapies to combat the disease and safeguard nerve cells.

A study reported in International Journal of Antimicrobial Agents examined a collection of facultative anaerobic microorganisms from the human gut for their potential to inhibit harmful bacteria that are associated with the human microbiome. From among 330 different gut microbes studied, some were found to produce molecules that can fight off specific types of harmful bacteria, without destroying other bacteria, including the beneficial ones. These findings provide valuable clues for designing better targeted probiotics, and for developing new antimicrobial agents that could help combat antimicrobial resistance by reducing the use of antibiotics.

Societal Impact:

The cell biology research done at NCCS has biomedical relevance, and is aimed at serving the society in the long run by revealing the cellular and molecular basis of various human health issues. Additionally, NCCS has played an important role in capacity building of the nation by providing high-quality research training. The services provided by NCCS have also benefitted students, faculty and other researchers across the country, thereby facilitating cell biology and microbiology research in India. The outreach activities of NCCS also served to take various aspect of science to over 2000 students, educators and the general public.

BRIC-NATIONAL INSTITUTE OF ANIMAL BIOTECHNOLOGY (NIAB), HYDERABAD, TELANGANA

The National Institute of Animal Biotechnology (NIAB) leverages cutting-edge research to enhance health, productivity, and sustainability of livestock, with practical applications benefiting both public and private stakeholders. It also fosters the development of the next generation of animal biotechnology experts through human resource development at Masters, doctoral and post-doctoral levels. The institute places a strong emphasis on furthering scientific discoveries through translational research, aiming to develop new technologies towards vaccines, diagnostics, and improved treatments for animals; enhancing fertility of livestock; and using animals as models and for biomanufacturing. By

supporting and encouraging bio-entrepreneurship in animal biotechnology, NIAB bridges the gap between research and the marketplace, ultimately benefiting both animals and humans.

The Mission of NIAB is development of sustainable and globally competitive livestock industry through innovative technology and the Vision is to demonstrate excellence in promoting and commercializing leads in biotechnology and to produce globally competitive livestock products, pharmaceuticals and biologicals for animal health care. The Mandate is to drive the development of a sustainable and globally competitive livestock industry in India through cutting-edge animal biotechnology research and development, with a focus on commercializing innovations for the benefit of animal health and the production of high-quality livestock products. The major Objectives of NIAB are enhance animal health and productivity, develop new technologies through translational research, promote bio-entrepreneurship in animal biotechnology, achieve global competitiveness for the Indian livestock industry and human resource development for the next generation of animal biotechnology.

Major Initiatives

NIAB has actively fostered International collaboration with Animal and Plant Health Agency (APHA) and Pirbright Institute in the UK. Through a series of visits and discussions by the Director and NIAB scientists exchanged knowledge and explored potential partnerships. This included discussions with the APHA regarding brucellosis research and the establishment of a dedicated reference laboratory at NIAB. Also connected with the Pirbright Institute, where presentations on ongoing research and brainstorming sessions paved the way for collaborative projects mainly on LSDV. Reciprocal visits from UK researchers from the Pirbright Institute, including the CEO and Director WOAH experts from APHA and Dr. Gareth Wynn Owen, Deputy High Commissioner, British Deputy High Commission, Telangana further solidified this initiative.

The nutrigenomics group of NIAB is investigating alternate feed sources for ruminant nutrition, evaluating their influence on ruminant productivity and greenhouse gas emissions. This includes assessing non-traditional feed sources such as yeast/microbial-derived proteins and aquatic weeds and their potential to improve digestibility, reduce enteric methane emission, and contribute to circular economy.

NIAB is engineering udder glands of farm animals to turn them into bioreactors for producing therapeutic proteins in milk. They've developed milk-specific expression vectors and efficient signal peptides for protein secretion. They've also successfully produced an expression vector for bovine follicle stimulating hormone (FSH) and are working on human tissue plasminogen activator (tPA) secretion in goat milk.

NIAB scientists focussing on creating 3D printed mineralized hard constructs utilizing hydrogels formulated with acrylate/vinyl groups in polymers to achieve superior mechanical properties enriched with the adult and fetal stem cells. The team has undertaken the functionalization of gelatin with acrylate groups using methacrylic anhydride. This enables tailored crosslinking, perfectly aligning with the post-printing process requirements of 3D printing. The resulting constructs exhibit enhanced mechanical properties and mineralization potential. Further this novel 3D printed hydrogel technology which represents a pivotal advancement in the quest to develop effective and reliable solutions

for bone regeneration using it as a strong scaffold enriched with stem cells.

Notable Outcomes

Indicators	Number
No. of projects completed	*29*
Number of Publications	*42*
Technologies Developed	*04*
Technologies Transferred	*01*
Number of patents filed	*03*
Number of patents obtained	*01*
Number of Human Resources trained	*222*

Scientific Achievements

NIAB has made significant achievements in mammary gland bioreactors for biotherapeutic production. They isolated mammary epithelial cell-specific promoters from the Indian river buffalo genome and created milk-specific expression vectors. Evaluating signal peptides from five milk protein genes revealed limitations in β-Casein and β-Lactoglobulin. To address this, they engineered the synthetic signal peptide CSN2-BLGHyb, which outperforms human insulin and serum albumin signal peptides.

NIAB has generated an immortalized goat mammary luminal epithelial cell line using CRISPR/Cas9 and the PITCh system. This cell line, created by integrating the P2A-gTERT-T2A-PuroR cassette into the KRT19 gene locus of GMEC, exhibits higher telomerase activity and normal chromosome numbers. Functional studies show that these cells produce elevated levels of human interferon-□ (hIFN□) compared to other cell lines and can be induced by lipopolysaccharides, making them a promising model for mastitis infection studies. This novel cell line holds great potential for enhanced biotherapeutic and nutraceutical production in vitro.

NIAB developed a new and improved blood test to detect parvovirus infections in lab mice and rats. This test uses engineered proteins and requires less blood than existing methods. This can help ensure the health of lab animals and improve the accuracy of research experiments.

NIAB investigated Leptospira lipid A, a molecule, as a potential vaccine adjuvant to fight leptospirosis, a zoonotic disease. Their findings showed that Leptospira lipid A generated a strong immune response and protection in animal models. This suggests promise for its use in developing more effective vaccines against this serious illness.

One of the study uncovers how postovulatory aged oocytes (POAO) meet their fate. Increased ROS, Ca+2 channels, and retrotransposon activity trigger apoptosis, causing POAO death. Suppression of these factors delays the process. Histone acetylation rises due to NAD+ downregulation and SIRT3 inhibition. Interventions like NMN supplementation delay POAO death. Our findings extend to higher vertebrates, revealing a metabolic cascade leading to DNA damage-induced apoptosis in POAO.

Societal Impact

The National Institute of Animal Biotechnology plays a vital role in improving societal well-being through its research on animal health and productivity. Our efforts translate to advancements in several areas. NIAB's work on healthier livestock breeds and improved animal healthcare can lead to increased food security and safer food products. We also contribute to scientific progress by fostering innovation in animal biotechnology, which has potential applications in medicine and other industries. IndiGau chip developed by NIAB will help in conservation of indigenous breeds, selective breeding for desirable traits, provide economic benefits for farmers and will contribute to the long-term sustainability of indigenous cattle

farming. Antimicrobial Sensitivity Testing and Antibiotic detection kit offers a cost-effective point-of-care solution by providing on-site results within 2-6 hours, crucial for timely and targeted antibiotic treatment, addressing concerns about antibiotic residues in milk and contributing to the prevention of antimicrobial resistance. Technologies developed for heat detection at barn level are expected to contribute greatly to efficient breeding of animals. Work towards the detection of toxins and antibiotic residues are likely to be useful for feed manufacturers as well as regulatory bodies to ensure quality feed for animals. By training future scientists, NIAB helps build a skilled workforce for continued advancements in this field. Overall, our work contributes to a more sustainable food supply, healthier animals, and progress in biotechnology, all of which benefit society as a whole. The MILAN (Meeting of Livestock Owners, Agriculturalists, and NIAB Scientists) program at LUVAS (Lala Lajpat Rai University of Veterinary and Animal Sciences), Hisar connected farmers, scientists and researchers to discuss advancements in animal biotechnology. Farmers learned about value-added dairy products and diagnostic tools, empowering them to increase income and address challenges. The program fostered collaboration to develop solutions for point-of-care diagnostics, milk adulteration detection and peak lactation maintenance. A goat rearing program in Yadgir district, Karnataka empowered 303 farmers through self-help groups. Training on breeding, healthcare, and nutrition led to improved herd health, increased milk production, and economic gains. Farmers built pucca houses and more children attended school due to the program's success. The initiative's sustainability is ensured through training on fodder preparation, mineral mixes, and proper animal care.

BRIC-NATIONAL INSTITUTE OF BIOMEDICAL GENOMICS (NIBMG), KALYANI, WEST BENGAL

The National Institute of Biomedical Genomics (NIBMG), located in Kalyani, West Bengal, India, near Kolkata 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. NIBMG is grounded on the tenet that genetics and genomics comprise a powerful body of knowledge and techniques to understand human health and disease. Over the years, the Institute has conducted cutting edge biomedical genomics research on major public health problems of relevance to both India and the globe. These include cancer (oral, cervical, breast, GI tract), genomics of other chronic diseases like neuromuscular degeneration, non-alcoholic fatty liver disease, diabetic foot ulcers, maternal and child health (preterm birth) and infectious diseases (SARS-CoV-2, Tuberculosis, Leishmania, neonatal sepsis). In addition to these, it also conducts research on population genetics and statistical and computational genomics. This has resulted good number of research articles in international peer reviewed journals of high impact

Major Initiatives

NIBMG has played a leading role in Coordinating the Indian SARS-CoV-2 Genomics Consortium (INSACOG). It started with 10 National laboratories and today the consortium has expanded to 54 laboratories in a Hub and Spoke model. NIBMG has been leading the SARS-Cov-2 genome sequencing in West Bengal and is also responsible for sequencing samples from the North-East states: Assam, Meghalaya, Mizoram, Manipur, Nagaland, Sikkim, Arunachal Pradesh. The Institute sequenced over

35,500 SARS-COV-2 genomes and submitted to GISAID. NIBMG team has been actively contributing to centralized analysis for the consortium and is responsible for phylogenetic analysis of genomes. In the Phase-II of INSACOG, NIBMG has also been involved in the wastewater surveillance for detection of SARS-CoV-2 and its variants. NIBMG is carrying out wastewater surveillance in Kalyani, along with Sikkim, Tripura, and Mizoram.

NIBMG is also a partner in the GenomeIndia Project which aims to make a detailed catalogue of genetic and phenotypic variations of ethnic populations of the Indian mainland. The institute has achieved the target of population sample collection and data on ~10k individuals is being generated and shared across centers. The institute has prepared a jointly called VCF files working on the pipelines of secondary data analysis with other phenotype and biochemical data. The institute has also initiated an International collaborative project funded by CEFIPRA. This project aims at investigating the small molecule which may be used for colon cancer. We are also a part of a national consortium project which has been set out to perform whole genome sequencing of MTB clinical strains for determining drug resistance and strain lineage in India.

Collaborative Research Work with other institutions: In the past year, NIBMG has initiated a collaborative research program with CSIR-IGIB to bring together scientists from both the Institutes to work together on research questions of mutual interests. Additionally, NIBMG has initiated a study, in collaboration with NIMHANS, on understanding alternative splicing during brain development which will lead to development of a reference atlas for global reference and will be representative of the national data.

Infrastructure developed: A new Bacteriological Facility and Radiation Research Facility has been developed which will be a dedicated arsenal for bacterial manipulation and use of radioisotopes for research, respectively. Additionally, work for a BSL3 facility and Animal holding facility is also underway.

Notable Outcomes

Indicators	Number
No. of projects completed	09
Number of Publications	47
Number of Human Resources trained	85

The cellular heterogeneity in oral squamous cell carcinoma of the gingivobuccal region OSSC-GB, was unravelled using single-cell RNA sequencing of oral tumors. It was found that two dominant cellular programs namely, partial epithelial-mesenchymal transition (pEMT) and fetal cellular reprogramming in OSCC-GB with distinct differences between patients with or without oral submucous fibrosis. Overall, these findings shed light on unique aspects of cellular heterogeneity and cell states in OSCC-GB.

The research work being carried out on cervical cancer demonstrated the functional association between long intergenic noncoding RNAs (lincRNAs) and HPV16-related cervical cancer pathogenesis which may assist in patient therapeutics and prognostication. In another study Sinha et.al reported that lncRNA AC103563.8-E7-EZH2 axis, may be crucial in regulation of MAL expression through chromatin inactivation in HPV16-CaCx pathogenesis and warrants therapeutic strategy development.

Another study deciphered the role of BLM helicase and RAD54 in development of chemoresistance in colon cancer cells. They further demonstrated that three FDA/European Medicines Agency-approved candidate small molecules could disrupt the BLM-RAD54 interaction rendering the cells responsive to therapy in pre-clinical mouse models.

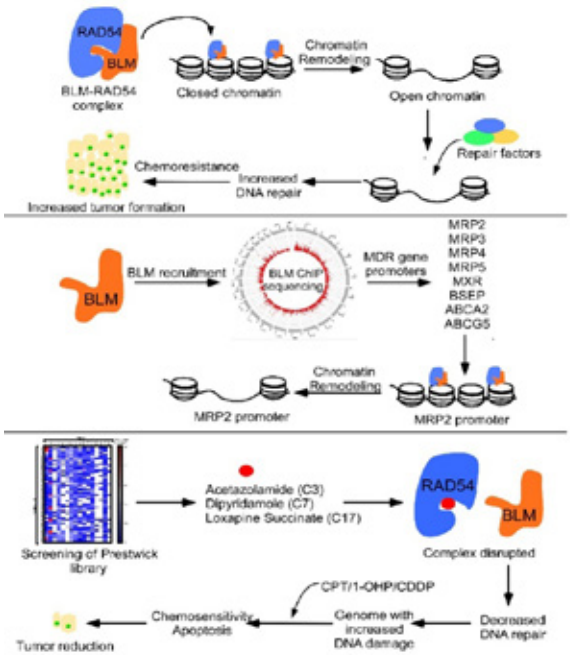


Figure 10.13: *Graphical abstract demonstrating the molecular mechanism of how BLM-RAD5 complex in promotes chemoresistance. Three FDA/EMA-approved small molecules revert chemoresistance in colon cancer by disrupting RAD54-BLM mediated chromatin remodelling.*

A toolkit Mapinsights has been developed which performs quality control (QC) analysis of sequence alignment files, capable of detecting outliers based on sequencing artifacts of High-throughput Sequencing (HTS) data at a deeper resolution compared with existing methods.

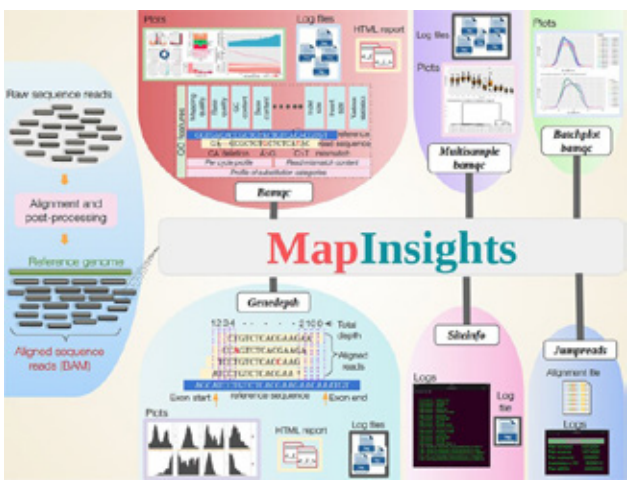


Figure 10.14: *Graphical abstract demonstrating how Mapinsights performs quality control (QC) analysis of sequence alignment files and detects outliers of HTS data compared with existing methods*

Societal Impact

NIBMG focuses on understanding the genomics of diseases of public health importance, such as various types of cancers, infectious diseases, and chronic diseases. The outcomes of these studies contribute towards understanding the biology of the disease and developing strategies for early detection, alternate therapies, or prognosis of the disease. Genetic Services Unit (GSU) established by NIBMG has been performing genetic tests and providing reports free-of-cost to patients referred by clinicians of Government run hospitals in West Bengal. GSU currently offers tests for 52 different genetic conditions. Referrals for genetic testing to GSU were made by almost 960 clinicians from 98 departments of 29 different specialties of 23 Government Medical Institutions of West Bengal across the State. NIBMG also conduct regular Outreach activities for students from schools and colleges around the area. In the past year we have conducted 16 outreach events with more than 300 students.

BRIC-NATIONAL INSTITUTE OF IMMUNOLOGY (NII), NEW DELHI

The National Institute of Immunology has been leading the way in advancing research in immunology for human health and well-being. Researchers at the institute are trying to address interdisciplinary research questions in areas of biological sciences spanning from immunology, infectious and chronic disease biology, molecular and cellular biology, chemical biology, and structural biology to computational biology. The institute has access to scientific and technical facilities of international standards and conducts cutting-edge research in emerging areas such as genomics, proteomics, systems biology, and artificial intelligence. The research excellence of NII is demonstrated through the national and international recognition received by our scientists and students for their contributions to the field of immunology.

Major initiatives

Human Immunology Program: Expanding the understanding of immunological principles and characterization of the human immune response to various infectious agents or vaccines is key to future disease preparedness. India with its large genetically diverse population exposed to diverse conditions and pathogens provides an extraordinary opportunity to study human immunology. In this context, NII's Human Immunology Program is a population-based, immuno-phenotyping in steady state, during disease and vaccination to understand the baseline immunity and pathogen-specific immune dynamics. The project aims to create a knowledge base for the design of new therapeutics and vaccines by identifying "protective" and "susceptible" immune correlates. Additionally, the platforms developed for immunophenotyping and immuno-informatics could also be quickly adapted to address emerging disease outbreaks.

Indian TB Genome Sequencing Consortium: To tackle the global health challenge of tuberculosis (TB) and contribute to the national mission of TB elimination, the Indian TB Genome Sequencing Consortium (InTGS) has been formed. InTGS aims to make mapping drug resistance possible through genomics and artificial intelligence to allow rapid identification of drug-resistant TB strains in patients and facilitate strategies for better control of TB. Under the InTGS project, the goal is to develop a well-characterized repository of 32000 *Mycobacterium tuberculosis* (*Mtb*) clinical isolates consisting of their whole genome sequence data. By September 2024, complete genome sequences of at least several thousand *Mtb* isolates will be made available. Furthermore, thousands of isolates will undergo drug sensitivity testing, and the transcriptomic data of a few hundred isolates will be accessible in this repository. The project will also see the development of AI/ML tools for data analysis and identification of genomic signatures of drug resistance. The repository will not only further research in tuberculosis but will also provide a tremendous advantage in drug discovery, the development of diagnostics, and the testing of novel antimicrobial agents.

Translating Research into Practical Applications: While studying the fundamental mechanisms of biology and disease is crucial, it is equally important to translate these discoveries into practical applications for the benefit of people. Thus, many of the projects at NII are driven by the goal of product development. A few such notable initiatives of the year are:

- One of the research groups of NII is working towards developing an improved malaria vaccine that can induce protection against infection in humans and minimize community transmission. The team has used human malaria parasite antigens expressed at the liver stage and mosquito stage as chimeric antigen for immunizations and efficacy studies. The preclinical studies with advanced chimeric antigen vaccine candidates have shown encouraging results and are being considered for translation into human study (India Patent no. 508461).
- SG001, a potential disease-modifying therapeutic small molecule for the prevention and management of Alzheimer's disease, was developed and tested at NII. The compound was shown to modulate GSK-3 activity and improve cognition in animal models. A US patent has been obtained for the compound (Patent no. US 11,820,764).
- The generation of gut microbiota-derived trimethylamine *N*-oxide (TMAO) from the metabolism of dietary L-carnitine and choline is associated with adverse effects in humans, particularly inflammatory effects in colon

cells. A rapid, highly sensitive, and economical molecularly imprinted polymer-based electrochemical sensor was developed at NII in collaboration with JNU (New Delhi) to detect TMAO in clinical samples (India Patent no. 509887).

Notable Outcomes

Indicators	Number
Projects completed	16
Research Publications	85
Patents Applied	5
Patents Obtained	5
Human Resources Trained	211

Major Achievements

Taurine deficiency may be a driver of aging in animals: Taurine is a semi-essential amino acid made within our body and is also obtained from an animal-based diet. Studies have shown an association of taurine in blood with health and its decline in some tissues with age. A multi-national, collaborative study involving the National Institute of Immunology and other institutes showed the deficiency of taurine to be a driver of aging in animals. The group found taurine abundance decreases substantially with age in the bloodstream of mice, monkeys, and humans. Taurine supplementation increased health span and life span in mice and *Caenorhabditis elegans.* Evidences in humans, such as increase in taurine levels with exercise, suggests that taurine deficiency may be a driver of aging in humans as well. However, a randomized clinical trial would be necessary to determine if taurine supplementation improves health in humans. The study was published in **Science**. https://doi.org/10.1126/science.abn9257

Single-cell RNA-seq analysis of hCMV-specific T Cells: The acquisition of immunological memory of infections is the hallmark of protective immunity and hence forms the basis for vaccinations. However, the rarity of the pathogen-specific memory T cells has made it difficult to interrogate them at a molecular level. In a study published in Immunology, researchers at NII have characterized the rare human Cytomegalovirus (hCMV) antigen-specific memory T cells in an unbiased manner using high throughput single-cell multi-omics. The study shows that the hCMV-specific memory T cells are highly heterogeneous and comprise different flavors of long-term and effector memory T cells. The study can serve as a knowledge base for designing vaccines and therapeutic strategies to control hCMV infections, especially in immune-compromised individuals and infants born to hCMV-seropositive mothers.

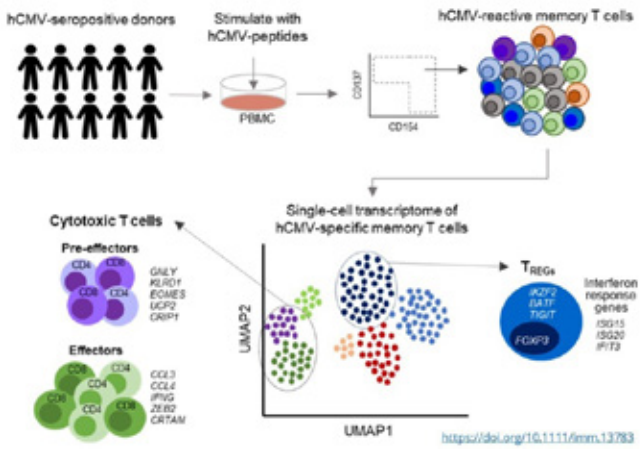


Figure 10.15: *Schematics showing the study overview for isolating and single-cell RNA-seq of hCMV-specific T cells using 10X Genomics platform*

Helical domain of hGBP3 cannot stimulate the second phosphate cleavage of GTP: Human guanylate binding proteins, hGBPs, are interferon-gamma-inducible large GTPases that play an important role in innate immunity. These proteins contain two domains: an N-terminal catalytic domain and a C-terminal helical domain, connected by an intermediate region. In a study published in the Journal of Biological Chemistry, researchers at NII demonstrated that hGBP3 has a unique ability to hydrolyze GTP into both GDP and GMP, where

GMP is the minor product of 30% (unlike 85% in hGBP1). The group also reported that the helical domain of this protein plays no role in substrate hydrolysis. Using wild-type and truncated proteins, the study indicated that the helical domain cannot establish specific interdomain contacts with the catalytic domain. As a result, the regulatory residue W79, present in the catalytic domain does not move toward the solvent after the gamma phosphate cleavage of GTP, thereby preventing efficient GMP formation (only 30%). Thus, this work provides an overview of the function of each hGBP3 domain in the hydrolysis of GTP and presents a possible molecular basis for the lower GMP formation by this protein. The study also offers insight that, despite the conservation of the key regulatory residue, the hGBP homologs show variation in the product ratio, which may be associated with the difference in their antiviral activity.

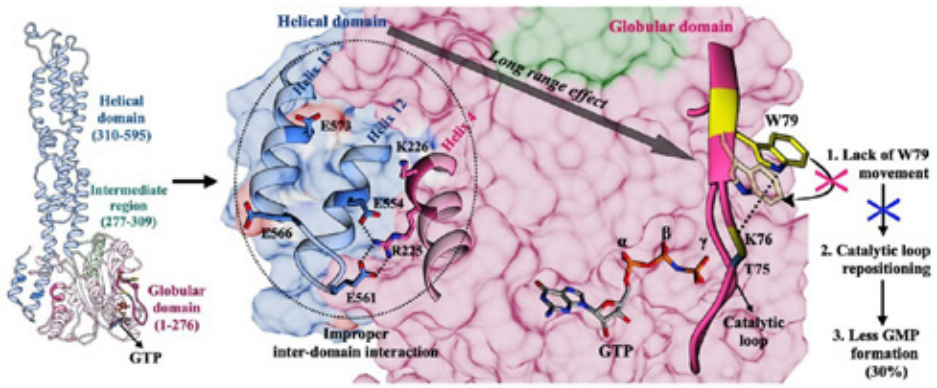


Figure 10.16: *Helical domain of hGBP3 cannot stimulate the second phosphate cleavage of GTP*

Societal Impact

The relevance of research impact extends beyond academia. Thus, NII has greatly increased its engagement with society. Under the Science Setu program, NII opens its labs and research facilities to students and educators. NII conducted one-day lab visits for thirteen schools and colleges during the year. The scientists of NII visited schools and colleges for interactions, talks, and hands-on workshops. NII conducted three open days on campus. Overall, around 800 students have visited NII in the past year. Further, NII actively participated in the Government's public outreach events like National Technology Day 2023, Global Bio India 2023, and India International Science Festival 2023.

NII acknowledges that building research ecosystems that yield high-quality research necessitates capacity-building activities. We have invited prominent national and international researchers to NII for seminars aimed at promoting understanding of the frontiers of biomedical research. These visits facilitate interactions between students and faculty and the visiting researchers, leading to the sharing of resources and knowledge, as well as the potential for future collaborations. Additionally, NII offers training to both undergraduate and postgraduate science students through various programs, which focus on the process of scientific inquiry and provide hands-on experience in advanced biotechnological tools and techniques.

BRIC-NATIONAL INSTITUTE OF PLANT GENOME RESEARCH (NIPGR), NEW DELHI, DELHI

The National Institute of Plant Genome Research (NIPGR), an autonomous institute of the Department of Biotechnology (DBT) starting from its inception in 1998, has focused scientific

programs both in basic science and translational work with a mission to undertake research of high caliber in plant molecular biology to generate new knowledge, assimilate it with current knowledge, and to seek applications of the same for genetic enhancement of plants for social benefits. 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.

Major Initiatives

The institute is continuously upgrading its research infrastructure to effectively pursue the twin goals of conducting high-quality basic research and seeking its application for product development. Towards this, full utilization of the newly created platforms, strengthening of the existing facilities, and functionalization of the National Genomics and Genotyping Facility (NGGF) in PPP mode has been done. A Memorandum of Understanding (MoU) was signed by NIPGR with Imperial Life Sciences (ILS) to run the NGGF facility in a Public Private Partnership (PPP), Mode. The "National Plant Computational Biology & Bioinformatics Facility" at NIPGR has been established and inaugurated by Dr. Jitendra Singh, Hon'ble Minister of State (IC), Ministry of Science & Technology.

Under the Mission mode program Mainstreaming rice landraces diversity in varietal development through genome-wide association studies has been taken by the Institute. A high-throughput method for efficient field phenotyping of photosynthetic traits has been established. Integrated genomic strategy for accelerating the domestication of rice bean (*Vigna umbellata*) has been taken up by the Institute.

Low glucosinolate gene-edited mustard lines with mutations in 10 glucosinolate transporter genes have been developed at the Institute. The regulatory approval for the open field trial is in progress. Further, biochemical and yield parameters were found to be comparable to the check cultivar, Varuna. This paves the way for the development of nutritionally improved Canola quality lines in Indian oilseed mustard cultivars.

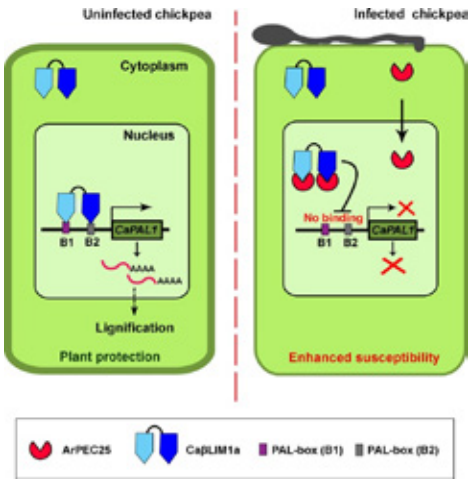
The Institute in collaboration with the Inter-Academy Panel (IAP), of the three Science Academies of India, has launched the national database/Portal on "Women in Science: viz. SWATI (Science for Women-A Technology & Innovation). This portal was developed and is being maintained by NIPGR, as a public interactive online resource, serving as a gateway to the expertise and contributions of Indian Women in STEMM.

Indicators	Number
No. of projects completed	20
Number of Publications	158
Technologies Developed	05
Number of patents filed	05
Number of patents obtained	05
Number of Human Resources trained	427

Scientific Achievements

A NIPGR study revealed that the fungal pathogen *Ascochyta rabiei*, the causal agent of Ascochyta blight disease in chickpea, secretes *Ascochyta rabiei* PEXEL-like effector Candidate 25 (ArPEC25) during infection. ArPEC25 targets the host LIM transcription factor CaβLIM1a. CaβLIM1a is a transcriptional

regulator of CaPAL1, which encodes phenylalanine ammonia-lyase (PAL). ArPEC25 inhibits CaβLIM1a by interfering with its DNA-binding ability, thus suppressing the phenylpropanoid pathway and decreasing the levels of intermediates in lignin biosynthesis, hence reducing lignin production. The study demonstrates the role of fungal effectors in governing virulence by targeting the biosynthesis of various secondary metabolites and antifungal compounds.



The study describes the role of ArPEC25 in promoting mediated disease susceptibility in chickpea. **Singh et al. 2023. The plant cell.**

Figure 10.17: *ArPEC25 from the necrotrophic fungus Ascochyta rabiei targets the chickpea transcription factor CaβLIM1a for increasing host susceptibility.*

The recently concluded study at NIPGR provides new insight into the mechanism of seed desiccation tolerance, seed vigor, and viability. The study reports that SKIP31, an F box protein, targets JAZ proteins for proteasomal degradation in a JA-Ile-independent manner to alleviate the inhibition imposed by JAZ proteins on ABI5. ABA-mediated downstream signalling thus becomes activated, which is essential for seed maturation, desiccation tolerance, and establishment of seed vigor and viability.

Using molecular breeding strategy, NIPGR researchers have delineated a bHLH (basic helix–loop–helix) transcription factor, CabHLH10 (*Cicer arietinum* bHLH10) underlying a major QTL,

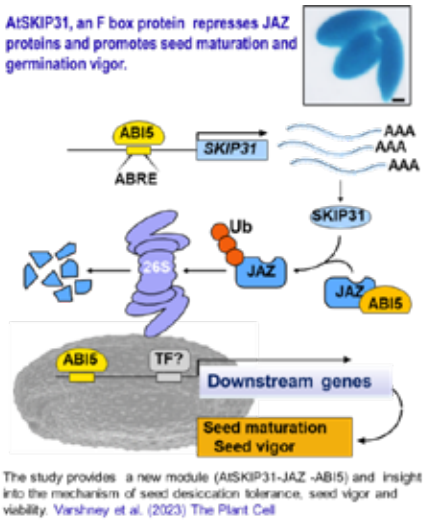


Figure 10.18: *AtSKIP31 represses JAZ proteins and promotes seed maturation and germination vigor*

along with its derived natural alleles/haplotypes governing yield traits under drought stress in chickpea. CabHLH10 binds to a cis-regulatory G-box promoter element to modulate the expression of RD22 (responsive to desiccation 22), a drought/abscisic acid (ABA)-responsive gene (via a trans-expression QTL), and two strong yield-enhancement photosynthetic efficiency (PE) genes. A superior allele of CabHLH10 was identified and introgressed into the NILs for improved root and shoot biomass and PE, thereby enhancing yield and productivity during drought without compromising agronomic performance.

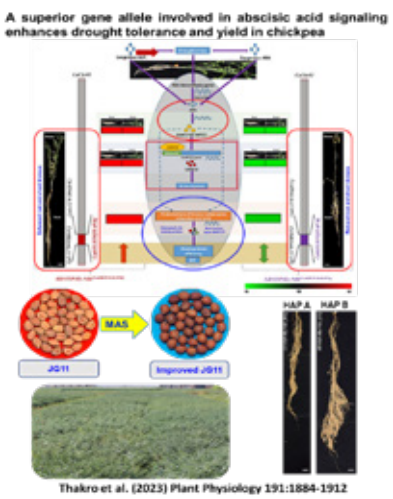


Figure 10.19: *A superior allele of CabHLH10 introgressed into the NILs improved root and shoot biomass.*

Indian oilseed mustard, *B. juncea*, accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop. *B. juncea* varieties grown in India contain high amounts of glucosinolates (>100 µmol/g of seed dry seed). Using an improved genome editing strategy of the CRISPR/Cas9 system, targeted and precise editing of 10 glucosinolate transporter (*GTR*) genes was performed to generate the 'ideal oilseed mustard lines' with reduced seed glucosinolate content while maintaining high-glucosinolate in leaves and silique walls for achieving enhanced defense and uncompromised defense traits. The transgene-free lines have been tested for trait stability under the containment net-house conditions for two generations. The transgene-free lines now need to be tested in open-field conditions.

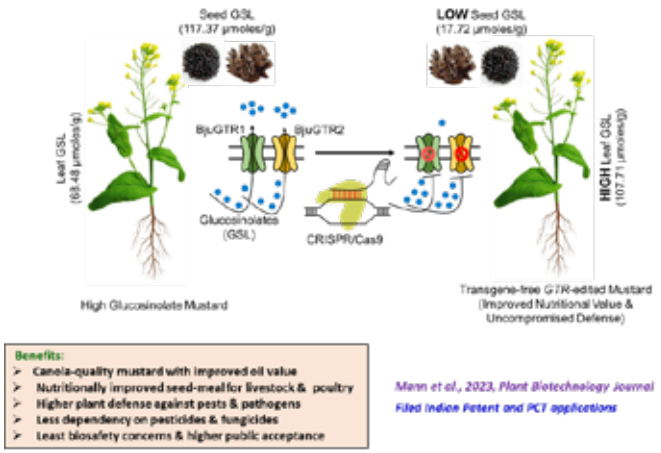


Figure 10.20: *Targeted editing of multiple homologs of GTR1 and GTR2 genes for mustard improvement.*

Dr. Jitendra Singh, Hon'ble Minister of State (IC), Ministry of Science & Technology, has announced the release of a new superior climate smart chickpea variety "ADVIKA" developed at DBT-NIPGR. Using a rapid, integrated, genomics-assisted breeding and functional genomics strategy involving GWAS, QTL/ fine mapping, map-based cloning, and molecular haplotyping delineated superior alleles of ABC transporter gene (CaABCC3) for chickpea genetic improvement program. Through marker-assisted selection large seed character has been transferred into a commercially important desi chickpea variety, JG11 (ICCV 93954). The Improved JG1 variety has a 15-20% increase in yield under drought over the parent.

Societal Impact

Under NIPGR flagship project, DBT-NIPGR, New Delhi and ICAR-IIRR, Hyderabad, have jointly identified a genetic locus for sheath blight tolerance. Developed rice lines are under 2nd year multi-locational trial. Once introduced to cultivation, these lines may save about 50% of loss (~Rs.1500 crore) caused by sheath blight every year. Two sheath blight-resistant rice donor lines have been developed by molecular breeding. The registration of the resistant donor lines is in progress.

Fruvetech a Startup established by the Institute is one of the 4 Indian Startups that won award in the Agriculture sector with a potential to fuel the spirit of Atmanirbhar Bharat. The technology was also recognized by the Department for Promotion of Industry and Internal Trade (DPIIT), a central government department under the Ministry of Commerce and Industry in India.

Under the mission program 'Integrated genomic strategy for accelerating domestication of rice bean (*Vigna umbellata*)' after two years of field trial, five ricebean accessions have been selected having high nutritional, low anti-nutritional contents, and high yield. These lines are now under pilot-scale field trials in Shimla, Uttarakhand, and Delhi for state-level registration before release.

A genetic module has been identified for leaf growth plasticity in response to temperature fluctuations that can be used to optimize leaf size under changing temperatures. The current efforts to investigate the variation in leaf photosynthesis rate across the Indian rice landraces would provide the genes/loci that can be used in crop improvement program for increasing photosynthetic efficiency.

BRIC-RAJIV GANDHI CENTRE FOR BIOTECHNOLOGY (RGCB), THIRUVANANTHAPURAM, KERALA

The RGCB operates with a clear vision, mission, mandate, and objectives that guide its strategic direction and activities. The vision of RGCB encompasses the prevention of illness and the enhancement of public health, embodying a commitment to disseminating research findings and fostering scientific knowledge. Its mission focuses on advancing disease biology research, technology development, translational science, training and education, and effective communication to positively impact human health and the broader community. The mandate of RGCB is to leverage innovative research, technology innovation, and trans-disciplinary approaches to address complex problems in disease biology, translating scientific knowledge into policy, education, and outreach. The institute's objectives, include fundamental research, technology development, translational science, training and education, and communications and engagement strategies to drive advancements in biotechnology and public health.

Major Initiatives

Biosafety level III: A new Biosafety level III (BSL III) facility established and commissioned to tackle existing and emerging infectious diseases.

National Facility for Mass Spectrometry-based Proteomics, Metabolomics and Lipidomics platforms: Established National Facility for Mass Spectrometry-based Proteomics, Metabolomics and Lipidomics platforms supported by DBT-SAHAJ.

RGCB-Science Museum at the Aspirational District Wayanad: To commemorate the 75 years of Independence and as part of the Prime Minister's ambitious program 'Jan- Bhagidari', RGCB established a science museum in the aspirational district – Wayanad, to inculcate science awareness among the students, teachers and the public. The museum was handed over to the school by Prof. Chandrabhas Narayana, RGCB's Director, on January 18, 2023.

Approved agency for evaluation of the In-vitro Diagnostics Medical Device: RGCB's Laboratory Medicine and Molecular Diagnostics (LMMD), is included in the list of conducting performance evaluation of the In-vitro Diagnostics Medical Device by Central Drugs Standard Control Organisation (CDSCO).

Livelihoods for tribal communities: Technology Interventions were done for the protection of tribal heritage and established 13 tribal community enterprises, which are directly benefiting to 319 tribal families in Kerala.

Centre of Excellence (CoE) in Microbiome: The Government of Kerala in Collaboration with RGCB establishing a CoE in Microbiome aims to leverage emerging technologies, cross-domain collaborations, and innovative product development to address microbiome-related challenges. RGCB is serving as the main partnering research agency for the CoE. RGCB provides indispensable scientific mentoring, research facilities, and structured training for the research staff, while also facilitating the identification of potential research projects and product development. This partnership underscores the critical scientific support necessary for the successful establishment and operation of the CoE in Microbiome.

Indicators	Number
Number of Publications	154
Technologies Developed	12
Technology Transferred to User Agency/ Industry/ Stakeholders	01
Process/Product/Technology Commercialized	01
Number of patents filed	02
Number of patents obtained	06
Number of Human Resources trained	600

Scientific Achievements

New insights in breast cancer treatment: βhCG in BRCA1mutated/deficient TNBC is explored by researchers at RGCB. The study will help develop new immunotherapeutic approaches for treating BRCA1 defective TNBC.

Engineered cancer cells for cancer drug research: An innovative cell engineering approach whereby cancer cells change its colour has been developed at RGCB. This technique will help scientists to develop precision medicine for cancer patients.

Self-assembled alpha-helical pores as nanopore sensors: Synthetic Transmembrane Peptide Pores for the Single-Molecule Sensing has been developed. This technique will open up new markets in personalized diagnosis with portable devices for nucleic acid sequencing.

Unlocking Therapeutic Potential: Star-PAP's Role in Rewriting Breast Cancer Genetics: The findings of this study could lead to the development of targeted therapies that specifically modulate the interaction between Star-PAP, miRNAs, and cancer-causing genes, offering a potential avenue for innovative breast cancer treatments. Additionally, the research provides a deeper understanding of non-canonical pathways in cancer gene regulation, paving the way for the exploration of novel therapeutic approaches to combat breast cancer.

Empowering Hope: FTY720's Quest Against Severe Dengue: The findings suggest that repurposing FTY720 to target S1P receptors can effectively mitigate endothelial hyperpermeability induced by Dengue virus infection, offering a potential therapeutic strategy to reduce vascular leakage and shock in severe dengue cases. By specifically targeting barrier-protective S1P receptors while avoiding S1PR2, FTY720 demonstrates promise as a targeted intervention to enhance endothelial barrier integrity and combat the detrimental effects of severe Dengue infections.

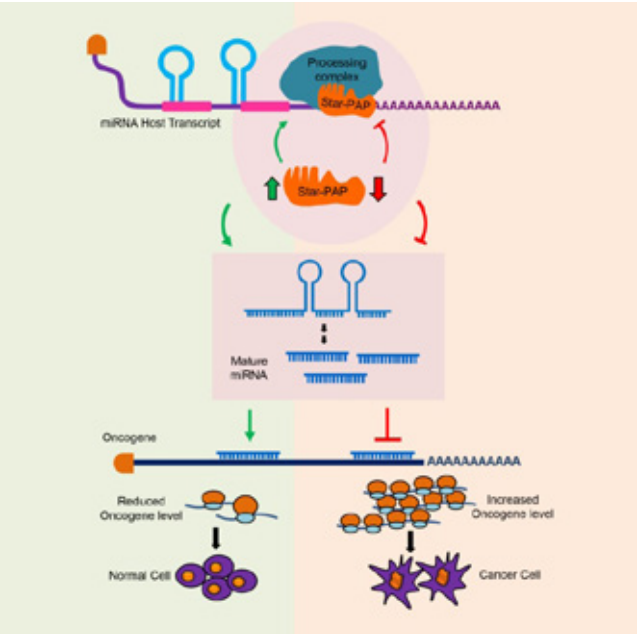


Figure 10.21: *Star-PAP's Impact on Breast Cancer Gene Regulation.*

Decoding Apoptosis-Autophagy Dynamics in Real Time: This study holds significance in unraveling the complex interplay between apoptosis and autophagy at a single-cell level, providing valuable insights into the cellular dynamics under stress conditions. The development of the sensor cells and their adaptability to 3D culture conditions offer a powerful platform for high-throughput screening of compounds that modulate caspase activation, autophagy, or both, thus holding immense potential for drug discovery and therapeutic intervention.

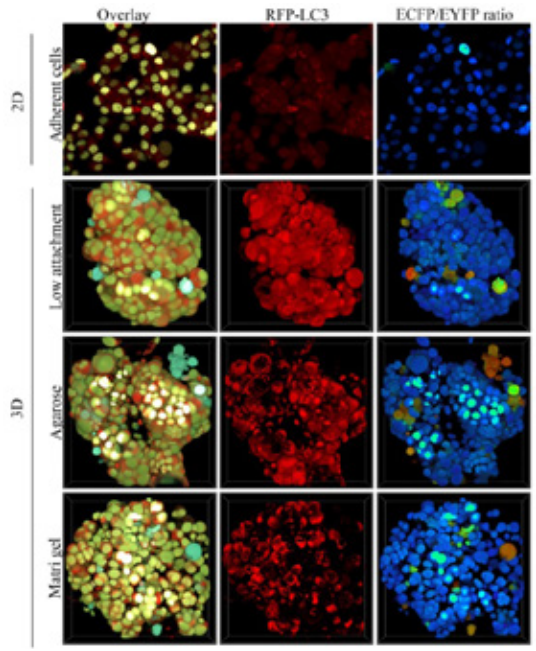


Figure 10.22: 3D culture enhances basal level autophagy and apoptosis: *MCF7 cells expressing both RFP-LC3 and SCAT3-NLS were subjected to 2D culture and 3D culture in low adherent plate, embedded with agarose gel and Matrigel, imaged after 48 hours of incubation (Ratio scale range 0-2).*

Urolithin A: Paving the Way for Novel Therapeutic Horizons in Breast Cancer Management: This study sheds light on Urolithin A (UA) as a promising selective estrogen receptor modulator (SERM) and attenuator of 27-hydroxycholesterol (27-HC) in breast cancer, offering insights into novel therapeutic approaches for estrogen receptor-mediated breast cancer. The identification of UA's SERM-like properties and its potential benefits in estrogen-responsive tissues present exciting avenues for further research into targeted breast cancer treatments.

RGCB has developed recombinant cell lines expressing fluorescent protein based sensors for screening compounds that can interfere with key cancer targets such as cell death, cell cycle, growth factor and proteasomes. These cell lines were validated using multiple platforms such as fluorescent microscopy, flow cytometry and high-throughput imagers. In addition, panel of cell lines expressing ACE2 EGFP to be used for COVID 19 viral propagation and pseudovirion assay has also developed. Final negotiations are progressing with the global non-profit business unit of Cancer Research, UK, Ximbio for making these drug discovery tools available to all researchers and drug discovery companies.

During the reporting period, RGCB secured 3 more patents for the invention, "Uttroside B and derivatives thereof as therapeutics for hepatocellular carcinoma" (USPTO No. 11,607,422,B2 dated 21-03-2023, USPTO No. 11,738,036 dated 29-08-2023 and European Patent No. EP3463382 dated 30-o8-2023). Notably, Uttroside B, a molecule demonstrating therapeutic promise against liver cancer, was extracted from the medicinal plant Solanum nigrum and characterized. The compound is presently undergoing clinical trials and has obtained orphan drug designation from the FDA. The compound has been previously licenced to multinational company Q-Biomed for further development in a joint initiative with RGCB and Oklahoma Medical Research Foundation (OMRF), USA.

Societal Impact

Rajiv Gandhi Centre for Biotechnology (RGCB) has been a key player in advancing biotechnology through its extensive research in genomics, proteomics, structural biology, and bioinformatics, contributing to the development of innovative tools and techniques in gene editing, protein engineering, and biomolecular analysis. Notably, RGCB's research has significantly influenced the biotechnology and healthcare sectors, leading to the creation of new drugs, diagnostic tools, treatment methods, and healthcare solutions, including diagnostics for various diseases, potential therapeutic interventions, and the discovery of drug targets for diseases like cancer, infectious diseases,

and genetic disorders. Furthermore, the center has played a vital role in capacity building, training a new generation of scientists, researchers, and healthcare professionals, and has actively promoted scientific awareness and encouraged students to pursue careers in research and biotechnology. Moreover, RGCB's efforts have fostered a culture of innovation and entrepreneurship, giving rise to spin-off companies and start-ups focused on biotechnology and healthcare solutions. Additionally, through extensive collaborations with industry partners, academic institutions, and healthcare organizations, RGCB has facilitated the exchange of knowledge, expertise, and resources, contributing to advancements in biotechnology and healthcare sectors regionally and globally. In conclusion, RGCB's impact on biotechnology and healthcare extends across scientific research, technological innovation, translational applications, and educational initiatives, with the potential to shape the future of healthcare and biotechnology on a multidimensional scale.

BRIC-TRANSLATIONAL HEALTH SCIENCE AND TECHNOLOGY INSTITUTE (THSTI), FARIDABAD, HARYANA

Translational Health Science and Technology Institute (THSTI), a premier institute of Department of Biotechnology, is a leading research institute dedicated to bridging the gap between scientific discoveries and real-world healthcare solutions. THSTI fosters a dynamic and collaborative research environment, bringing together diverse scientific minds - physicians, biologists, mathematicians, and more - to translate innovative concepts into tangible healthcare products. THSTI operates a network of specialized research centres addressing various healthcare areas. These centres are augmented by state-of-the-art facilities of THSTI.

THSTI is further expanding its infrastructure with the construction of a Medical Research Centre (MRC) and Translational Research Facility (TRF). The MRC, a 50-bedded hospital, will provide facilities for clinical observation studies, clinical trials, and potentially even human challenge studies in the future. The TRL will focus on vaccine development, in vitro diagnostics, integrated facilities for various platform technologies, standardized assays, immunogen designing, and pilot scale GMP facility. Committed to capacity building in the healthcare research sector, THSTI offers educational programs like the Master of Science in Clinical Research and PhD programs. Additionally, THSTI contributes to skill development by providing certified GCPPCS training and collaborating with the Government of India's Swayam portal to host online courses on clinical trials.

Figure 10.23: *Foundation stone laying ceremony of Medical Research Centre and Translational Facility at NCR Biotech Science Cluster*

Major Initiatives

Hon'ble Union Minister, Dr Jitendra Singh Ji laid the foundation stone of the Medical Research Centre and Translational Facility at NCR Biotech Science Cluster on 22nd Feb 2023.

Vaccine Design and Development Centre inaugurated on 15th Feb 2023. BiomLife (product) launched on 15th Feb 2023. School of Innovation in Biodesign (SiB) inaugurated on 18th April 2023. First Advanced Vaccinology Course launched on 22nd May 2023. Advanced Nucleotide Sequencing Facility inaugurated on 29th May 2023. THSTI has also been selected as one of the World Health Organization's (WHO) Global CoronaVirus Network (CoViNet) reference laboratories as a part of its Epidemic & Pandemic Preparedness and Prevention program.

Indicators	Number
Number of Publications	95
Projects completed	31
Process/Product/ Technology Developed	10
Number of patents filed	09
Number of patents obtained	02
Number of Human Resources trained	606

Scientific Achievements

Translational Health Science and Technology Institute (THSTI) has been selected as one of the World Health Organization's (WHO) Global CoronaVirus Network (CoViNet) reference laboratories as a part of its Epidemic & Pandemic Preparedness and Prevention program.

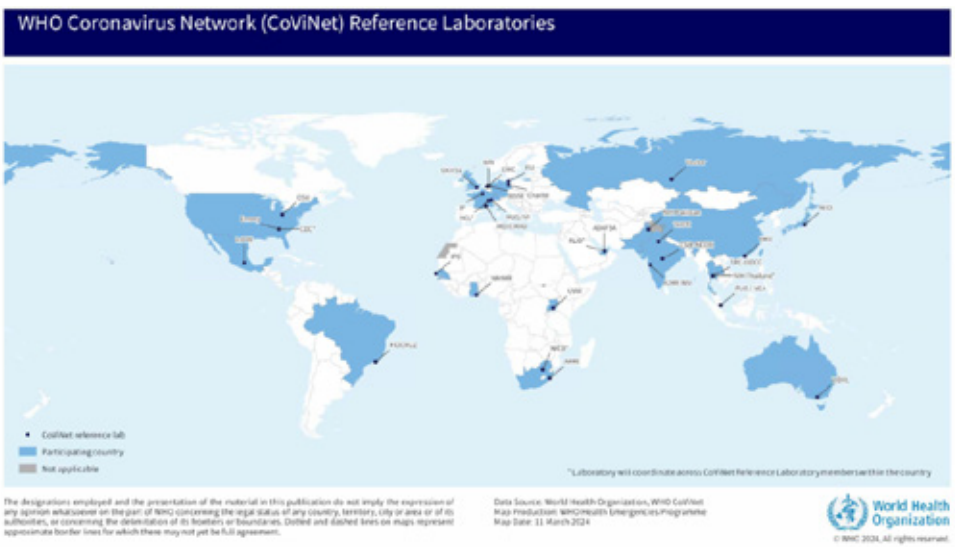


Figure 10.24: *World Health Organization's (WHO) Global CoronaVirus Network (CoViNet) reference laboratories*

Researchers from THSTI and IIT Madras have developed an Indian population-specific model for estimating GA in the late trimesters using data from GARBH-Ini, a pregnancy cohort in a North Indian district hospital. This study was conducted in partnership with Gurugram Civil Hospital, Gurugram, Safdarjung Hospital, New Delhi, Christian Medical College Vellore, and Pondicherry Institute of Medical Sciences, Puducherry.

Societal Impact

THSTI works in the area of translational research with a focus on developing indigenous solutions, like new products/interventions and healthcare policies to improve public health with a special focus on Indian population. Through its inter-disciplinary programs and state-of-the-art facilities, THSTI has been collaborating with various

academia and industries thereby contributing to develop products/interventions that are not only indigeneous and affordable but also have strong scientific evidence.

THSTI aligns with UN goals for good health and industry (SDG-3 & SDG-9). The facilities are open to researchers from academia and companies, fostering innovation and development of "Make in India" solutions for better societal health. Some of the key research programs at THSTI in the area of vaccines, therapeutics, diagnostics, Tuberculosis and Anti-microbial resistance work to address public health challenges and have developed indigenous technologies, some of which have been transferred to industries for further development. The centre of maternal and child health at THSTI has contributed to the WHO recommendation of immediate Kangaroo Mother care (iKMC) to reduce mortality in preterm and low birth weight infants.

REGIONAL CENTRE FOR BIOTECHNOLOGY (RCB), FARIDABAD, HARYANA

Regional Centre for Biotechnology (RCB) is an academic institution established by the Department of Biotechnology, Govt. of India, with regional and global partnerships synergising with the programmes of UNESCO as a Category II Centre. The primary focus of RCB is to provide world-class education and training, and conduct innovative research at the interface of multiple disciplines to create high-quality human resource in disciplinary and interdisciplinary areas of biotechnology in a globally competitive research milieu. In 2016, RCB was recognised as an Institution of National Importance.

Academic Programs:

RCB offers structured degree programs as well as short-term training programs in highly specialised areas of biotechnology and life sciences. Currently, 110 students are pursuing doctoral degree programs in Biotechnology, Bioinformatics, and Biostatistics in different RCB laboratories. So far, RCB has awarded 61 PhD degrees. RCB also has an integrated MS-PhD degree program where students with bachelor's degrees are admitted. A total of 48 students are currently registered for this programme.

The'i3C BRIC-RCB PhD Programme in Biosciences' has been launched by the Hon'ble Minister S&T on 5 February, 2024.

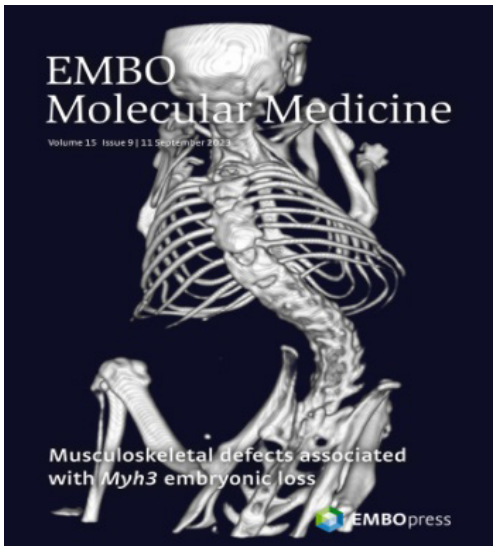
Figure 10.25: *Launch of 'i3C BRIC-RCB PhD Programme in Biosciences'*

The RCB Act 2016 empowers the Centre to recognise higher learning institutions for their various academic programs. In this direction, after the due diligence, RCB has granted recognition to academic programs of the following 14 Higher Education Institutes: CDFD, NIAB, NABI, ILS, RGCB, THSTI, NIBMG, CMC, NCCS, IBSD, ESIC. More than 500 students from these recognised centres are registered for their degrees with RCB.

Indicators	Number
Number of Publications	104
Projects completed	10
Number of patents filed	04
Number of Human Resources trained	~1000

Scientific Achievements:

RCB's scientific achievements in terms of the 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. 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. Our scientists published their research findings in the leading international scientific journals. Their work was supported by various competitive extra-mural grants. Provided below are some of the research highlights for this year.



Mutations in MYH3, the gene encoding the developmental myosin heavy chain-embryonic (MyHC-embryonic) skeletal muscle-specific contractile protein, cause several congenital contracture syndromes. Among these, recessive loss-of-function MYH3 mutations lead to spondylocarpotarsal synostosis (SCTS), characterised by vertebral fusions and scoliosis. The Molecular Medicine Research group at RCB found that Myh3 germline knockout adult mice display SCTS phenotypes such as scoliosis and vertebral fusion, besides exhibiting changes in muscle fiber type, altered satellite cell numbers and increased muscle fibrosis. A mass spectrometric analysis of embryonic skeletal muscle from Myh3 knockouts identified integrin signaling and cytoskeletal regulation as the most affected pathways, which are closely connected to the mechanosensing Yes-associated protein (YAP) transcriptional regulator, which was found to be significantly activated in the skeletal muscle of Myh3 knockout mice. Thus, increased YAP activation in this study underlies the musculoskeletal defects seen in Myh3 knockout mice, indicating its significance as a key pathway to target in SCTS and other MYH3-related congenital

syndromes. This work has been published in EMBO Molecular Medicine (IF 14.3).

The Cancer & Cell Biology Group deciphered that pigmentation is a complex physiological phenomenon that protects from UV-induced damage. Perturbations in pigmentation pathways lead to pigmentary disorders such as vitiligo, albinism and Darier's disease. The authors demonstrate that the functional mutation in TPC2 leads to its constitutive activation, thereby modulating cellular calcium dynamics and inducing changes in the lysosomal pH. Further, authors generated a knock in mice with homologous TPC2 mutation and corroborated a causative role for this mutation in albinism. It is an exciting study that reports a novel TPC2 mutation, which is responsible for albinism in an autosomal dominant inheritance fashion. Since TPC2 is localised on melanosomes as well, going forward, it would be interesting to investigate the role of this mutation on melanosomal calcium dynamics and alterations in melanosomal pH. This work has been published in Cell Calcium (IF: 6.8).

Another study from the Cancer & Cell Biology Group presents a hydrogel-mediated localised delivery of a combination of docetaxel (DTX) and carboplatin (CPT) (called DTX-CPT-Gel therapy) that ensured enhanced anticancer effect and tumor regression on multiple murine syngeneic and xenograft tumor models. DTX-CPT-Gel therapy modulated the TIME by an increase of antitumorigenic M1 macrophages, attenuation of myeloid-derived suppressor cells, and increase of granzyme B+CD8+ T cells. DTX-CPT-Gel therapy elevated ceramide levels in tumor tissues that activated the protein kinase R (PKR)-like endoplasmic reticulum kinase (PERK)-mediated unfolded protein response (UPR). This UPR-mediated activation of apoptotic cell death led to release of damage-associated molecular patterns, thereby activating the immunogenic cell death that could even clear the metastatic tumors. This multi-institutional study published in Science Advances (IF: 13.6) provides a promising hydrogel-mediated platform for DTX-CPT therapy that induces tumor regression and effective immune modulation and, therefore, can be explored further for treatment of TNBC.

RCB continued 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 small number of drug-like molecules showing antiviral activity against the Chikungunya virus in the cell culture and the mouse model. The mechanism of the antiviral activity of these compounds is being studied.

RCB has established a Bio-Incubator on its campus to foster innovation, research, and entrepreneurial activities in biotechnology-related areas. During the reporting period, twenty-four start-up companies were incubating at the Bio-Incubator. Through this mission, we contribute to spurring the economic growth in the region in the biotechnology sector. The Advance Technology Platform Centre (ATC) at RCB is open to all researchers from industry and academia across the country. It provides high-end equipment and technical support to scientists. The Biosafety Support Unit (BSU) at RCB continues to provide support to the Department of Biotechnology, Govt. of India in its regulatory activities. RCB continues to provide the 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 Human Resource

Development (HRD) Project Management Unit at RCB has been successfully managing the following HRD activities of the DBT.

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. Online Training was provided to about 100 students at the VelTech University, Chennai (Tamil Nadu) regarding submission of nucleotide data in IBDC. RCB in partnership with Nature India and DBT/ Wellcome Trust India Alliance hosted a Visualising science **workshop** on **November 27-28 2023**. This workshop brought together experts in science visualisation with young scientists interested in exploring the visual medium to communicate their science better. As a part of their Master's degree, students from other research institutes are being trained in various labs at RCB under 6 months training program.

Indian Biological Data Centre: The Indian Biological Data Centre (IBDC) is the national digital data repository mandated to archive all life science data generated from publicly funded research in India. It is supported by the Government of India (GOI) through the Department of Biotechnology (DBT). It enables the implementation of the "Biotech-PRIDE Guidelines" (Promotion of Research and Innovation through Data Exchange). Over 2.50 lakh SARS-CoV-2 genome sequences have been uploaded on IBDC. During the reporting period, more than 500 Covid-19 whole genome sequences have been submitted to the Indian Biological Data Center (https://ibdc.rcb.res.in) by 11 research institutes across the nation as part of the national level Covid-19 genomic surveillance effort. The entire data set is analyzed in real-time to identify the prevalent Covid-19 viral variant and reported back to INSACOG. Over 3000 different Covid-19 viral variants are regularly tracked for their prevalence across the nation. The entire data set, including the analyzed data is also made available to the general public via a specialized web portal (https://ibdc.rcb.res.in/insacog/statisticsinsacog). The real-time distribution of different Covid-19 viral variants in different parts of India can be tracked at: https://ibdc.rcb.res.in/insacog/statreportzonelineagegraph .

Currently, the Genome India archive has 11655 files accounting to ~263TB, including different file types of Fastq, UBAM and Gvcf, which is being accessed by 11 Institutes of Genome India Consortium across India. Around 3514 samples from 08 institutes were uploaded on the Controlled access portal of Indian Nucleotide Data Archive (INDA-CA). Eighty-eight samples from 08 institutes have been submitted to the open Access nucleotide data portal of the Indian Nucleotide Data Archive (INDA).

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 catalysing 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 has a flagship program on the development of antivirals against Japanese encephalitis and Chikungunya viruses. RCB has set up a collaboration with the CDRI, Lucknow, that allows them to access the vast collection of drugs-like molecules that CDRI has synthesised over the years. Until now, 12560 compounds were screened using the high-throughput assay. Withaferin, Emitine Dihydrochloride (EmD), Niclosamide, Celastrol and Gambogic acid inhibited CHIKV replication in cell culture. Withaferin and EmD showed significant anti-CHIKV activity in mice. Additionally, a total of 53 potential ligands of NS5 (RdRP) & NS3 (helicase)

from JEV and nsp4 (RdRP), nsp2 (helicase) and nsp1 (Mtase) from CHIKV were identified through virtual screening.

INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY (ICGEB), NEW DELHI, DELHI

The International Centre for Genetic Engineering and Biotechnology (ICGEB) is an international intergovernmental organization that receives extensive cooperation from 68 member states on themes of common interest. As a host country, the Government of India provides substantial funding to the New Delhi component of ICGEB. ICGEB, New Delhi is involved in various DBT programs and contributes actively to the science diplomacy efforts of the Government of India. ICGEB, New Delhi conducts pioneering research in life sciences with the objective of addressing challenges faced by developing countries. Furthermore, ICGEB plays a significant role in capacity building for biotechnology in developing nations. It strengthens the research capability of its Members through training, funding programs and advisory services and works to achieve following key functions:

- To conduct research in the field of Biotechnology and Genetic Engineering to address the issues relevant to Member countries which are mostly Developing Countries
- Impart Scientific long and short term training for Scientist and Students from Member countries such as Ph. D. Programmes & Advanced Training Programmes
- Develop and Transfer cost effective technologies for Member countries.

Indicators	Number
Number of Publications	154
Technologies Developed	02
Number of patents filed	04 (National) + 01 (International)
Number of patents granted	01 (International)
Number of Human Resources trained	514

Scientific Achievements:

Severe disease during both primary and secondary dengue virus infections in pediatric populations: The study shows that contrary to the current paradigm, which suggests that primary dengue infections are typically less severe compared to secondary infections, the results reveal that children in India constitute a large proportion of primary infections, and these primary infections actually constitute more than half of severe dengue cases (112 of 202) and fatalities (5 of 7). This finding is significant as most dengue vaccine research and policies focus on protecting against secondary infection. The study highlights the need to address primary infections as well.

A *Plasmodium falciparum* lysophospholipase regulates host fatty acid flux via parasite lipid storage to enable controlled asexual schizogony: PfLPL3, a *P. falciparum* lysophospholipase, has been characterized to reveal its key role in parasite propagation during asexual blood stages. PfLPL3 displays a dynamic localization throughout asexual stages, mainly localizing in the host-parasite interface. Inducible knockdown of PfLPL3 disrupts parasite development from trophozoites to schizont, inducing a drastic reduction in merozoite progenies. Detailed lipidomic analyses show that PfLPL3 generates fatty acids from scavenged host lipids to generate neutral lipids. These are then timely mobilized to allow schizogony and merozoite formation. Inhibitors of PfLPL3 have been identified with potent antimalarial activity, which could also serve as pertinent chemical tools to study parasite lipid synthesis.

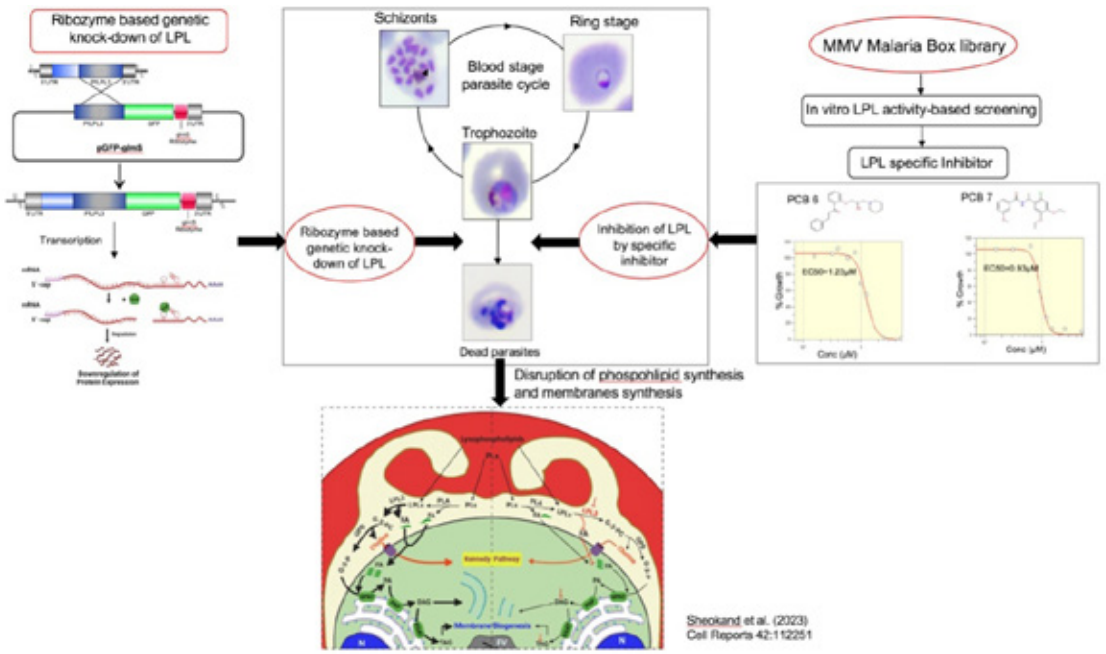
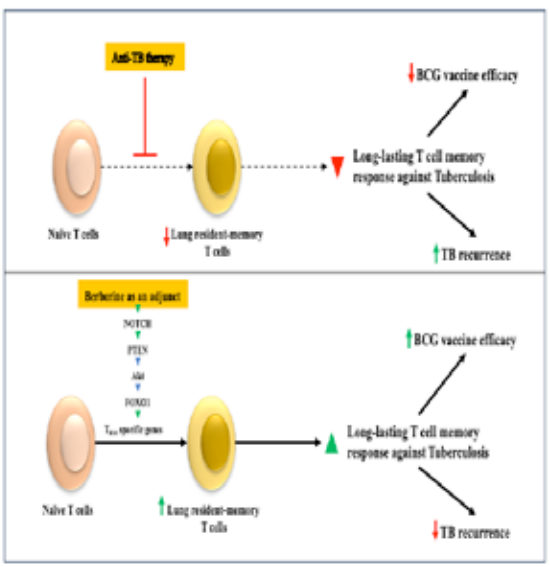


Figure 10.26: *A Plasmodium falciparum lysophospholipase regulates host fatty acid flux via parasite lipid storage to enable controlled asexual schizogony*

Berberine governs NOTCH3/AKT signaling to enrich lung-resident memory T cells during tuberculosis: Berberine (BBR) enhances innate defense mechanisms against M.tb and stimulates the differentiation of Th1/Th17 specific effector memory (TEM), central memory (TCM), and tissue-resident memory (TRM) responses leading to enhanced host protection against drug-sensitive and drug-resistant TB. The whole proteome analysis of human PBMCs derived from PPD+ healthy individuals, revealed that BBR modulated NOTCH3/PTEN/AKT/FOXO1 pathway as the central mechanism of elevated TEM and TRM responses in the human CD4+ T cells. Moreover, BBR-induced glycolysis resulted in enhanced effector functions leading to superior Th1/Th17 responses in human and murine T cells. This regulation of T cell memory by BBR remarkably enhanced the BCG-induced anti-tubercular immunity and lowered the rate of TB recurrence due to relapse and re-infection. These results thus suggest tuning immunological memory as a feasible approach to augment host resistance against TB and highlights the potential of BBR as an adjunct immunotherapeutic and immunoprophylactic against TB.



https://journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1011165

Figure 10.27: *Berberine governs NOTCH3/AKT signaling to enrich lung-resident memory T cells during tuberculosis*

Monoclonal Antibodies for Dengue and Chikungunya: ICGEB leads a BIRAC-funded Translational Research Consortium on Dengue

with an objective to identify human monoclonal antibodies that neutralize all four serotypes of Dengue. Through this support, ICGEB, New Delhi has made ~350 human monoclonal antibodies from either plasmablasts (effector B cells) or memory B cells from dengue acute or recovered individuals, respectively. The consortium is almost at the end of its goals and, within this year, will have a cocktail of human Mabs that potently neutralize all 4 serotypes of the dengue virus, allowing it to move further towards pre-clinical development. The lab has also made ~100 human monoclonals from Chikungunya patients and recovered individuals. Chikungunya, another arbovirus that has no anti-viral, or universal vaccine and thus will drastically benefit from a targeted therapeutic. Two of the Mabs from this panel potently neutralise Chikungunya virus and have been patented for further development by ICGEB.

New algal strain *Dysmorphococcus globosus*-HI for astaxanthin production: Astaxanthin (ASX), the "king of carotenoids", is used for anti-tumour therapies and preventive treatment of age-related neural damage like in Alzheimer's and Parkinson's diseases. Thus, the natural ASX has high commercial value. ICGEB recently isolated a new algal strain of *Dysmorphococcus globosus* from the Himalayan region of Northern India and optimised its growth conditions in the laboratory to achieve maximum growth and production of ASX. D. globosus shows the high carotenoid accumulation of ASX (391 mg/L) as compared to the other available species for commercialization.

Figure 10.28: *New algal strain Dysmorphococcus globosus-HI for astaxanthin production*

Some of international capacity building initiatives and partnerships of ICGEB New Delhi during the reporting period include:

- Collaboration with Instituto Nacional de Tecnología Industrial (INTI), Argentina for setting up a laboratory for research on industrial biotechnology.
- ICGEB New Delhi has provided technical advice to Egerton University, Njoro, Kenya where an ICGEB Regional Centre for East Africa is being established with a focus on Crop Biotechnology
- ICGEB New Delhi provided advanced training in Crop Biotechnology to researchers in the field of agricultural biotechnology in Bangladesh

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 an enabler aims to strengthen and empower the emergingBiotechnology ecosystem to undertake strategic translational research & development and create innovative, globally competitive products/ technologies addressing unmet needs.

To showcase the strengths of Indian biotech innovation ecosystem, BIRAC spearheads National and International events that bring together stakeholders for showcasing India's growing strength in the sector, creating opportunities to connect, co-develop, co-create and co-scale. Global Bio India 2023 is one such marquee event hosted annually by BIRAC that has successfully created an internationally recognized platform. GBI 2023 was held from 4-6 December, 2023 at Bharat Mandapam, Pragati Maidan, New Delhi and was attended by over 5500 delegates.

BIRAC has established national and international strategic partnerships, networks and platforms that help to bridge the existing gaps in the industry-academia innovation research and facilitate novel, high quality affordable product development through cutting edge technologies.

BIRAC integrates with and contributes to various National Missions such as Make in India, Startup India, Swachh Bharat, Ayushman Bharat. BIRAC has formed international alliances with reputed global organizations such as the World Bank for National Biopharma Mission, and with Bill & Melinda Gates Foundation, Wellcome Trust and USAID for Grand Challenges India Programme. Additionally, BIRAC aligns with policy initiatives and engages in G2G and Multilateral collaborations for International Ecosystem Connect to scale the Biotechnology Innovation Ecosystem across India.

BIRAC has successfully created an ecosystem comprising 95 Bio-incubators across 21 States and 4 UTs across the country. More than 4800 beneficiaries have been supported by BIRAC. This has enabled over 1300 IP filings, 800+ biotech products/technologies reaching the market. INR 5500 Cr follow-on funding have also been generated by supported startups and companies.

BIRAC SCHEMES AND THEIR OUTCOME:

- **BIRAC through its flagship programmes BioNEST** (**B**ioincubators **N**urturing **E**ntrepreneurship for **S**caling **T**echnologies) and **E-YUVA** (**E**mpowering **Y**outh for **U**ndertaking **V**alue-**A**dded Innovation Translational Research) have supported 95 bioincubation facilities in 25 States/UTs across the country contributing to a cumulative incubation space of 9,00,000+ sq. ft. and supporting 2500+ entrepreneurs &Startups. These incubators provide nurturing grounds to nascent startup ideas by providing access to high end infrastructure, specialized and advanced equipment, business mentorship, IP, legal and regulatory guidance, and networking opportunities. These facilities are located within Universities, Research Institutes, Research Hospitals, or as stand-alone centres.
- **E-YUVA** (**E**mpowering **Y**outh for **U**ndertaking **V**alue-**A**dded 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. The scheme is implemented through pre-incubation centres called E-YUVA Centres (EYCs), housed within the University/ Institution setup. The E-YUVA network has expanded from 10 EYCs to 20 EYCs nationwide, establishing its footprint in 15 states and union territories. 500 UG students and 60 PG/PhD fellows have been supported through EYUVA as EYUVA and Innovation fellows respectively.

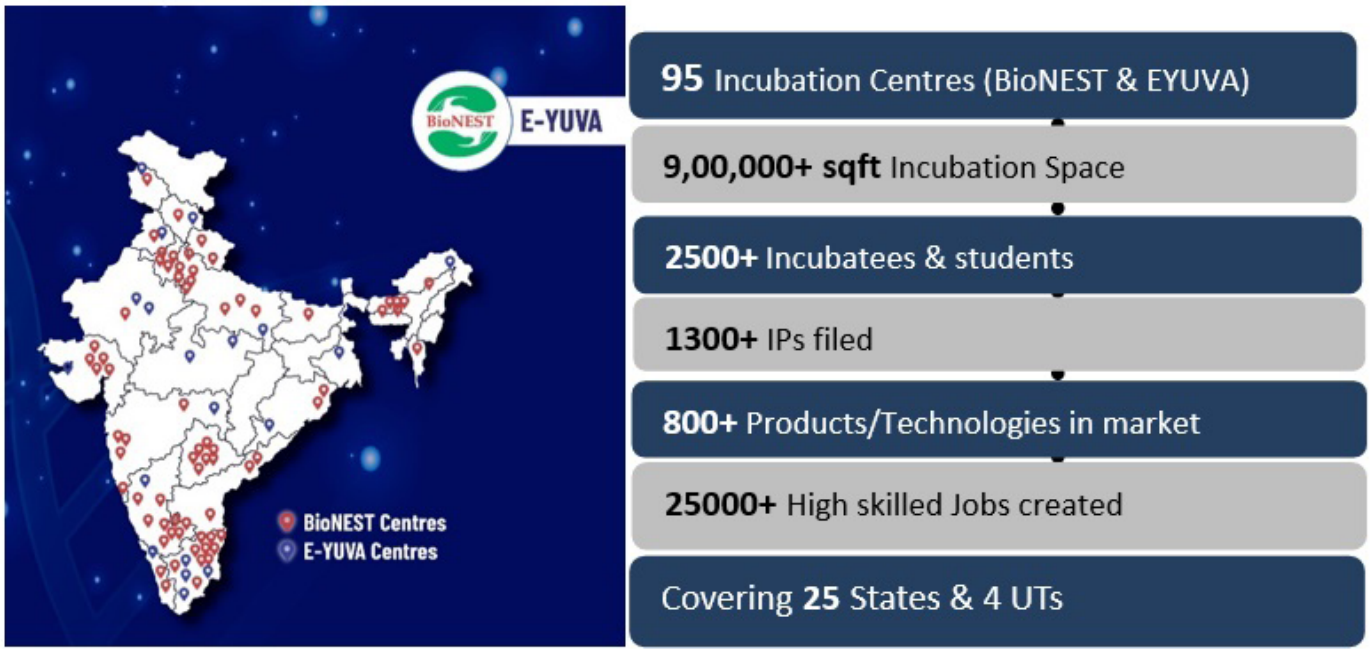


Figure 10.29: *Network of Incubation Centres & Pre-incubation Centres across the country and its impact*

- **Biotechnology Ignition Grant (BIG)** scheme provides support up to INR 50 lakhs for a period of 18 months and enabling support to young startups and individual entrepreneurs for incubation, team building, startup incorporation, equipment, operations, mentoring, training, etc. The scheme is implemented through 8 BIG Partners to expand the outreach and local mentoring in deeper pockets of the country especially Tier 2, Tier 3 cities and aspirational districts. Approx 1000 innovations have been supported through BIG so far with a total commitment of INR 500 Cr.
- **S**ustainable **E**ntrepreneurship and **E**nterprise **D**evelopment **(SEED)** Fund is the first equity exposure of up to INR 30 lakhs providing Capital assistance to post-PoCStartups with new and meritorious ideas, innovations and technologies. It is positioned to act as a bridge between promoters' investment and Venture/ Angel investment. 142 startups have been supported through SEED Fund.
- **L**aunching **E**ntrepreneurial **D**riven **A**ffordable **P**roducts **(LEAP)** Fund provides equity funding support of up to INR 100 lakhs/ Startup that has reached the pre-commercialization stage in order to reduce its gestation period. 60 startups have been supported through the LEAP Fund.
- **BioAngels** platform is an association of BIRAC and Indian Angel Network (IAN) to create India's single largest horizontal seed and early-stage investing platform. This platform will lead to creation of a consortium of Angels, HNIs, and early-stage VCs. It is focused on supporting Biotech, Medtech, Healthtech, Pharma, Agritech& Cleantech startups to raise their angel round from Investors who also bring deep domain expertise.
- **Accelerating Entrepreneurs (AcE) Fund** is a "Fund of Funds" which aims to foster R&D and innovation in Biotechnology by plugging the gap of the "Valley of Death" encountered by Biotech start-ups during their 'product development cycle' and 'growth phase'. AcE Fund invests and partners with SEBI- registered AIFs (Venture Funds and Angel Funds), which are professionally managed and desirous of investing in the biotech sector. The Daughter

Funds are committed to invest 2x of BIRAC's investment amount from fund corpus in Biotech start-ups. AcE Fund provides equity investment of up to INR 7 Crores per startup with an additional INR 3.5 Cr in follow on round. A small corpus of Rs. 149.50 Cr deployed through 16 daughter funds has seen more than INR 1172 Cr private funds investment into Biotech Startups and SMEsSo far, 88 Companies have been provided investment through AcE Fund.

National & International Partnerships:

- **BIRAC-TiE:** BIRAC TiEWInER (Women In Entrepreneurial Research) Fellowship Award is a dedicated award to reward and recognize women entrepreneurs in the Biotech sector. So far, 60 awardees have been felicitated through 4 successful editions of WInER Award. BIRAC and TiE also conduct nationwide Entrepreneurship Awareness Workshops especially for non-metros, tier 2 cities that has seen participation from thousands of students.
- **जनCARE Innovation Challenge-Reimagining the Healthcare Delivery in Low Resource Settings:** BIRAC and NASSCOM in collaboration with Grand Challenges India (GCI) launched "जनCARE" Innovation Challenge to discover, design and scale health-tech innovations that can work in low resource-settings especially in the areas of Cardiovascular Diseases, Maternal & Childcare, Diabetes, COPD, Cancer care, Eye care, and other NCDs. 14 winners were provided unique opportunity to carry out field deployment studies in PHC, CHCs, hospitals and at the last mile in 11 states. 9 products supported under the जनCARE Innovation Challenge were launched during the Global Bio-India 2023.
- **"Amrit Grand Challenge–जनCARE-Reimagining the Healthcare Delivery - Touching a billion lives":** 89 startups and entrepreneurs working on DigitalHealthtech Innovations in the area of Telemedicine, Digital Health, mHealth with Big Data, AI ML, blockchain etc. have been supported under the Amrit Grand Challenge program. The innovators are selected under different categories i.e., Stage-1: Early-Ideation and Testing, Stage-2: Late- Pivotal validation studies and field testing and Stage-3: Advanced-Multi-centric Product Deployment to receive financial assistance of INR upto 10 lakhs (as grant-in-aid), 20 Lakhs (as equity) and 50 lakhs (as equity) respectively. This public private partnership involves DBT/ BIRAC, GCI, India Health Fund, Stryker, and others.
- **New Partnerships during the year:** BIRAC entered into new international & national partnerships with the following during the year: Foreign, Commonwealth and Development Office (FCDO, UK); Takeda Pharmaceuticals International AG; MiltenyiBiotec; India Health Fund (IHF, Tata trusts)
- **Intensifying the Impact of Industrial Innovation (i4)**: i4 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):
  i. **Small Business Innovation Research Initiative (SBIRI)**: SBIRI scheme supports development and initial validation of products/technologies (up to TRL6).
  ii. **Biotechnology Industry Partnership Programme (BIPP)**: BIPP scheme supports validation, demonstration and pre-commercialization of products/ technologies (TRL7 and above).

  In both the schemes start-ups/companies/ LLPs can collaborate with another start-ups/

companies/LLPs or any recognized academic institute. During January 2023 to March 2024, a total of 31 projects, including 11 new ones were supported. 7 projects completed in this period.

- **Promoting Academic Research Conversion to Enterprise (PACE- AIR and CRS):** PACE supports academia to develop technology/ product (up to PoC stage) of societal/ national importance and its subsequent validation by an industrial partner, BIRAC had launched Promoting Academia Research Conversion to Enterprise (PACE) Program on 15th June, 2017. The Programme has two components as below:
  i. **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.
  ii. **Contract Research Scheme (CRS):** CRS aims at validation of a process or prototype (developed by the academia) by the industrial partner/LLP.

Major achievements: Since inception of the scheme,31 calls have been launched and 169 projects have been supported.10 technologies/ products have achieved TRL7 and above and 26 IPs have been filed. More than 75% projects funded underAIR have achievedTRL3.During January 2023-March 2024, 49 projects involving 62academic institutions, 15companies and 24 collaborations were supported.

- **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. Promising transgenic banana events having high PVA and iron (higher than the control) content in ripe-fruit- pulp have been identified and have been subjected to event selection trials. For BBTV resistance, agronomy and yield analysis data along with proper molecular data with control plants is being generated.
- **BIRAC and USAID supported wheat project:** Under the project entitled "Development of heat tolerant, high yielding and climate resilient wheat cultivars by utilizing genomics, molecular and physiological information and resources" the heat-tolerant varieties are being developed by building upon the available resources and breeding materials by utilizing information from model systems and currently available modern breeding, genetic, genomic, physiological, and biochemical tools.
- **BIRAC – IKP Grand Challenges in Agri-technology Translation for Boosting Farmers' Income:** BIRAC in partnership with IKP Knowledge Park has conducted a Grand Challenge in "Agri-technology Translation to Boost Farmers' Income" with the mandate to identify 'ready to deploy' and 'scalable innovations' in agriculture that will help in increasing the incomes of farming households. A series of innovative technologies, practices, products, services, business model and/or integrated solutions that have been piloted at a small scale in India are to be identified, funded, monitored for field testing over a period of 30 months through a 2-stage process in this program. The focus of the Challenge will be to demonstrate increased incomes through deployment of selected technologies. Ten start-ups were funded successfully to demonstrate their technologies in the test beds.
- **Global Bio India2023**: The Department of Biotechnology (DBT) along with its Public Sector Undertaking, Biotechnology Industry Research Assistance Council (BIRAC) organized

Global Bio-India 2023 from 4th- 6th December, 2023 at Bharat Mandapam, Pragati Maidan, New Delhi, with the theme "Transforming Lives-Biosciences to Bioeconomy" with focus on 'Biotech Innovation Ecosystem' and 'Biomanufacturing'. The Mega event saw participation of 500+ exhibitors, 7000+ delegates, 25+ countries, 8 States representation promoting their Biotech policies; 200+ Universities and Research Institutions, 1200+ Biotech start-ups, 100+ bioincubators, 300+ Industry representation from Biopharma, Medtech, Diagnostics, Industrial Biotech, Bio-Agri; Stakeholder discussion on National and Global Regulatory Trends; Industry Academia interactions; Representation from Major Industry Associations, Investor Associations, Global Entrepreneurship Organizations, 750+ B2B business meetings. There were 40+ sessions, 7 super sessions, CEO Roundtables, policy dialogues, Startup pitches; launch of 30 new products by Startups.

Publications released:

- India BioEconomy Report 2023
- https://www.birac.nic.in/webcontent/India_BioEconomy_Report_2023.pdf
- CARE Healthcare Innovation Challenge Field Deployment Report: https://www.birac.nic.in/webcontent/1701942506_Deplyoment__Jancare_Report.pdf
- BioincubationCentres Exhibitors Directory https://www.birac.nic.in/webcontent/Bioincubation_Centres_Exhibitors_Directory.pdf
- Exhibitor Compendium
- https://heyzine.com/flip-book/9ee3d34fa3.html
- Scientific Chronicles During COVID Times-DBT-BIRAC Efforts
- https://www.birac.nic.in/webcontent/DBT_Coffee_tablebook_New_1.pdf
- BIRAC Compendium: Start-UP
- https://www.birac.nic.in/webcontent/start_up_compendium_2023.pdf

Announcements:

- Grand Challenges India, BIRAC and Women Lift Health announced a leadership development program titled "Women Leadership in STEM" that aims at mid-career women working in STEM
- BIRAC's "Global Bioincubators Network" initiative
- BIRAC promoting Private Public Partnerships announced MOUs - BIRAC-Foreign, Commonwealth and Development Office (FCDO, UK); BIRAC-Takeda; BIRAC-MiltenyiBiotec and BIRAC-India Health Fund (IHF).
- DBT's Resource of Indian Vaccine Epidemiology Network (DRIVEN) Monograph on 'Setting Up Demographic Development and Environmental Surveillance Sites (DDESS)'.

Felicitation of the awardees:

- BIRAC's Innovators Award
- Exhibitor awards for Incubators and Startups
- Women Biotech WInER Fellowship Awards
- Top WInER Fellows under BIRAC-TiEWInER Fellowship Programme
- SPARSH Awards

Startup Product Launch

- 29 Products of Startups were launched

- JanCAREhealthtech innovations for Low resource settings deployed in PHCs, CHCs & last mile across 12 States bringing together State Government, Industry & other stakeholders.
- **Startup Expo at DBT Biotech Park, Kathua:** BIRAC along with CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM), Jammu organized Startup Expo on "Emerging Startup Trends in North India" at DBT Biotech Park, Kathua on 4th Jan, 2024. Twenty-five biotech startups from North India (including Jammu and Kashmir, Himachal Pradesh, Punjab and Delhi) showcased their innovations and products in the areas of agriculture, industrial biotechnology, medical & diagnostic devices, food technology, nutraceuticals, aroma and space etc during the expo. The Expo was inaugurated by Hon'ble Vice President of India, Shri Jagdeep Dhankhar in the presence of Dr. Jitendra Singh, Union Minister of State (Independent Charge) Science & Technology; MoS PMO, Personnel, Public Grievances, Pensions, Atomic Energy and Space.
- **IP & Technology Management (IPTEM) Group** at BIRAC carries out IP evaluation for grant proposals that it receives under different programmes such as BIPP, PACE, SBIRI, National Bio-Pharma Mission, BIG etc. The group also provides guidance on IP and licensing issues in collaborative research projects including the international projects. Under BIRAC-PATH, around 30 Patent applications have been supported for Provisional, Complete filing in India, PCT filing as well as National Phase filing. In FY-2023-2024, 5 patent applications were supported for National Phase filing and Provisional filing.

Grand Challenges India (GCI)

Grand Challenges India (GCI) is the Indian arm of Global Grand Challenges, launched in 2012 and is the flagship program managed by the Project Management Unit (PMU) at BIRAC, and is collaboratively funded by the Department of Biotechnology (DBT), Bill & Melinda Gates Foundation (BMGF), and the WellcomeTrust, which is a program-based partner.

Major achievements

i. Validation of Cost-Effective **Indigenous HPV Diagnostics Program**: Considering that India is signatory to WHO global initiative for cervical cancer, Grand Challenges India (GCI) has initiated a specialized initiative for developing and validation cost-effective indigenous HPV diagnostics tests not only for India but also for other low- and middle-income countries (LMICs). The first Scientific Advisory Committee for the program was convened on May 24, 2023. The committee took stock of various commercially available diagnostics for HPV diagnosis study plans to validate and anticipated outcome of the study. Keeping in view the necessity of an indigenous, point-of-care solution for universal HPV screening at national level, the committee in principle recommended the program for funding support under GCI ambit. A kick-off meeting for the project was held on March 6, 2024. The agenda included a discussion of the program's goals, schedule, milestones, test kit protocols, methodology, and deliverables. Additionally, the meeting also ensured that research teams and companies were aligned on roles and responsibilities related to the current project.

ii. The Grand Challenges Meeting 2023 aimed to build momentum for global health and development innovation and foster scientific collaboration among international groups and researchers. A three-member delegation from GCI-BIRAC participated in the annual meeting. GCI-BIRAC highlighted the efforts undertaken in India to advance and improve women's health in the Funder's Forum Meeting. Key themes of the meeting included artificial intelligence, climate change, genomics in public health, drug development, and best practices for grand challenge implementation and partnership. It featured parallel scientific

tracks, plenary sessions, and side meetings. GCI-BIRAC engaged in productive discussions with Grand Challenges Canada, the UK Department of Health and Social Care, and Aidsfonds - Soa Aids Nederland for potential future collaborations.

Eight upcoming open calls for proposals in India were announced during the Grand Challenges Partner for Impact event, covering AI, climate change, women leadership in STEM, TB, cachexia, one health, and faecal sludge management. More than 3000 delegates from over 75 countries attended this conference, which essentially gave attendees a forum to network, learn about the opinions and ideas of the international scientific community, and establish new collaborations. The meeting provided the vision to shape science's direction and address the most pressing global health and development issues for the benefit of the people of India and other developing

National Biopharma Mission (NBM)

The National Biopharma Mission (NBM), is an Industry-academia Collaborative Mission for Accelerating Discovery Research to Early Development for Biopharmaceuticals – An "Innovative in India for Inclusiveness (I3)" project. The National Biopharma Mission of Department of Biotechnology, Government of India, was approved by the Union Cabinet with a total budget outlay of INR 1500 Cr, of which 50% is to be co-funded by the World Bank. The program is being implemented by Biotechnology Industry Research Assistance Council (BIRAC) Program Management Unit and is aligned with the national mission of ''Make-in India' and "Aatma Nirbhar Bharat". The mandate of National Biopharma Mission is to enable and nurture an ecosystem to advance India's technological and product development capabilities in biopharmaceuticals, to a level that will be globally competitive over the next decade, and transform the health standards of India's population through affordable product development.

Under the NBM mandate a total of 39 Request for Proposals (RFPs) were published. From these 143 projects are being supported under National Biopharma Mission, and 65 projects have been completed. The projects include 215 grantees across the country. Of these 215 grantees, 135 are in private sector (88 of them are from Industry and 47 are academic institutions) and 80 in public sector (73 from academics and 7 from PSUs).

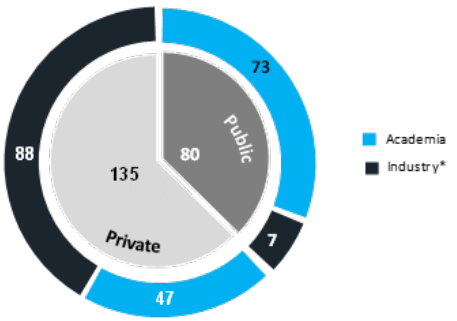
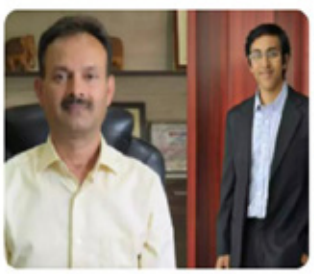


Figure 10.30: *Distribution of the grantees across Public & Private Sector and within Academia & Industry*

Lirafit (Liraglutide Biosimilar) article published in ET Health World

Rashmi Mabiyan · ETHealthWorld
Updated On May 6, 2024 at 01:03 PM IST
Read by: 629 Industry Professionals



Glenmark Pharmaceuticals recently launched a biosimilar of the popular antidiabetic drug, Liraglutide in India. Marketed under the brand name Lirafit, the drug is priced at around Rs 100 for a standard dose of 1.2mg (per day).

In the development and commercialization process for Lirafit, a active project management team was put in place from the beginning, and the review and advice from the scientific committees of NBM BIRAC and techno-commercial team at Glenmark was also instrumental in commercializing Lirafit.

Figure 10.31: *Market Authorisation Approval Received and Indigenously Developed Products and Technologies*

Major Outcomes: A total of 143 projects have been supported till now. The projects supported are spread across different areas, including, vaccines (20), Biosimilars (21), Devices and Diagnostics (29), Shared research Facilities (23), Clinical Trial Networks (45), Trainings (6), Technology Transfer offices (7) and Scientific research (17).

In the Vaccine vertical, the Mission's mandate was to bring 2-3 vaccines closer to market which has been successfully achieved.

- Two vaccines for Covid-19, ZyCOV-D®, (Zydus Lifesciences) and Corbevax® (Biological E), were identified and supported from Proof of Concept (PoC) studies till Phase I and Phase 2 clinical trial respectively, under NBM and with subsequent support from MCS, these vaccines received Emergency Use Authorisation (EUA), and were launched in the market
- Supported Pneumococcal vaccine candidate (Pneuteger 15®) Phase 1 to Phase 3 Clinical trials. The candidate received Market Authorization approval from the regulator.
- Indigenously developed Chikungunya vaccine candidate in Phase - 2/3 Trial.
- A dengue vaccine candidate by Indian Immunologicals Ltd. completed Phase I clinical trial.

In The Biotherapeutics vertical, a range of products were supported under the biotherapeutics vertical for indications ranging from Diabetes. Cancer (including CAR-T therapy), Age related Macular Disease, Immune diseases, Rabies and COVID-19. The mandate of bringing 2-3 Biotherapeutics closer to market has been achieved.

- NBM supported Pegylated Interferon for COVID-19 management launched in market for moderate Covid patients. Biosimilar of Liraglutide was launched under the brand name Lirafit in January 2024. The drug is priced at around Rs 100 for a 1.2 mg (per day); about 60% lesser than Innovator's price.
- 03 projects supported for developing biosimilar clones, of which 02 candidates have successfully developed high yielding clones of Ramucirumab and Golimumab. Golimumab clone has been supported further for the next stage of preclinical development of the biosimilar.
- Biosimilar Aflibercept development has progressed to Phase -3 clinical trial in India and Russia, the trial is expected to complete by March 2025.
- Indigenously developed anti-CD19 CAR-T Phase -2 trial ongoing in 50 paediatric lymphoma patients.
- 05 successful NBM and BIRAC projects supported for further development for next stage under the call "Follow-on Funding for Biotherapeutics and related infrastructure".

Support has also been extended to 18 medical devices and 11 diagnostics distributed along the product development cycle. The portfolio includes innovative products such as implants, defibrillators, next generation MRI scanners, heart valves, and different types of endoscopes supported for various stages.

The Mission supported establishment of high-end facilities to provide end-to-end services. Below is the list of facilities supported. These have provided services to more than 400 different clients in total from various academia, start-ups, MSMEs and Industries. Out of 22, 17 facilities had initiated services. 03 new facilities have been short listed for support under the "Follow-on Funding for Biotherapeutics and related infrastructure", including 01 from previously NBM supported project and 03 from BIRAC.

Product vertical supported	Facility Type	No. of Facilities	Providing services
Vaccines	GCLP compliant clinical immunogenicity labs for supporting Vaccine clinical trials	02	Yes
Biotherapeutics	GLP compliant facilities for analytical characterization of biotherapeutics	03	Yes
	PDL-GMP manufacturing facilities for biotherapeutics (Mammalian & Microbial)	03	2 Providing services
	Cell line repositories (Mammalian & Microbial)	02	Yet to provide services.
	Lentivirus Manufacturing Facility	02	01 Facility project closed .2nd facility ready, services will be initiated by June 2024
	Facility for Media	01	yes
Medical Devices and Diagnostics	Medical Device and diagnostics rapid prototyping facilities	04	Yes
	Large animal facility for preclinical testing	01	Yes
	EMI/EMC safety testing facilities	02	1 Facility providing services
	Large scale manufacturing of ventilators and diagnostic kits – DBT-AMTZ CoMMAND strategy.	01	Yes
	Large scale production of reagents for molecular diagnostics kits	01	Yes

The Mission supported establishment of Translational Research Consortia to support and nurture the translational research ecosystem to stimulate, standardize, and provide support for advancing the development and evaluation of vaccines and monoclonal antibodies. Multiple scientific and clinical challenges obstruct the development of novel preventive and therapeutics solutions. Challenges in evaluation of novel vaccines are the inability to predict immunogenicity, efficacy, reactogenicity or safety and identification of the factors that would enable generation of long-lived protective immune responses. Based on selected R&D areas, collaborative networks/ consortia were established for Dengue, Chikungunya, Hepatitis E virus and Malaria.

Outcomes for the Consortia: Translational Research Consortia for Dengue and Chikungunya have established serum biobanks and virus repositories with sequenced and characterized isolates of Dengue and Chikungunya. The consortia have established assays that are ready for transfer to industry/ academia and disease models as fee-for-service. Translational Research Consortium for Hepatitis E virus is developing a candidate vaccine for HEV. Phase -2 trial is completed and data analysis is ongoing to submit to regulators.

Technology Transfer Offices: NBM has championed the establishment of 07 Technology Transfer Offices (TTOs) to create an efficient technology transfer network in the country. As on date, **~7000 participants** have been trained

under different trainings and workshops under the National Biopharma Mission including **3039 female participants**.A series of webinars conducted for **promoting Clinical Research Ethics framework in India** on 'Good Clinical Practice' (**GCP**), 'Good Clinical Lab Practice' (**GCLP**) and '**Bioethics**'. These TTOs have transferred around 30 technologies, forged ~ 80 partnerships with various institutes, Start-ups, SMES, MSMEs from within their allocated regions, and about 40 transactions or agreements have been executed for services like patent filing, post licensing activities support, patent consultation etc.

INDIAN VACCINES CORPORATION LIMITED (IVCOL), NEW DELHI

Indian Vaccines Corporation Ltd. (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 (WHO). 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 (RIL) 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. Based on the Audit Report submitted by the statutory auditor, Profit/Loss for the last three year for the company is as under:

(Rs. In Thousands)

Year	Profit/Loss	Accumulated Losses
2020-2021 (As on 31St March, 2021)	(371)	(1,24,535)
2021-2022 (As on 31St March, 2022)	(36,986)	(1,61,521)
2022-2023 (As on 31St March, 2023)	15,733	(1,45,787)

BHARAT IMMUNOLGICALS AND BIOLOGICALS CORPORATION LIMITED (BIBCOL), BULANDSHAHR, UTTAR PRADESH

Bharat Immunolgicals and Biologicals Corporation Limited (BIBCOL) is a Central Public Sector Unit (PSU) in India, promoted by DBT, with primary objective of eradication of Polio from the country. In addition, 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. 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.

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11. ADMINISTRATION AND FINANCE

11 ADMINISTRATION AND FINANCE

General Administrative Matters

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 procurement, booking of domestic and international flight tickets, issuance of Identity cards/CGHS cards, 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 Inquiry system are also processed in Administration branch.

Administration branch also provides care taking 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

A total number of 1796 new e-files were opened from 1st April, 2023 till March, 2024. 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 ebill system and Admin Section is dedicatedly working towards achieving the paperless work goal. New and renewed Digital Signature Certificates were provided to the employees.

Government e-Marketplace

As per Government directives, all procurement of such goods and services from Government e-Marketplace (GeM) as are available on GeM. Administration branch endeavors to make all procurement of goods and services through GeM as are available in it, thereby complying with government instructions and maintaining the transparency under such procurement. As per Government directives, during this Financial Year, a total procurement of Rs.70.42 lakh was done during the financial year 2023-24 through Government eMarketplace (GeM).

Swachh Bharat Abhiyan

In its endeavour to maintain Swachhta in the office premises, sweeping and mopping of rooms, corridors, floors, bathrooms is done on daily basis and this is a year-round exercise. Sanitization is done on regular basis. As part of the Swachhta Pakhwada celebrations between 1st to 15th May, 2023, Department of Biotechnology observed Swachhta Diwas on Saturday, 13th May 2023 and a special cleanliness drive was organized. Secretary, DBT administered the Swachhta Pledge to all employees.

Waste Management

e-waste and other obsolete items were identified and segregated in the Department for auction as per Govt. Norms. Obsolete furniture items, IT equipment and other scrap items were disposed through e-auction.

Azadi Ka Amrit Mahotsav (AKAM)

Azadi Ka Amrit Mahotsav (AKAM) 'Har Ghar Tiranga' campaign was organized from 13th - 15th August 2023 to encourage the citizens to hoist the National Flag of India in their homes. All employees hoisted the Indian National Flag in their premises during the campaign and posted selfies with the Tiranga on the concerned website and social media.

Rights for Persons with Disability

Accessible toilets for Persons with Disability have been provided and are being optimally utilized.

Published Advertisement

Vacancy circulars, articles, periodical journals, annual report, Hindi Pakhwada Certificates, scientific schemes, etc. have been published by the Department in various newspapers through BOC.

International Day of Yoga 2023

Department of Biotechnology and BIRAC jointly organized International Day of Yoga on 21.6.2023 at Lodhi Gardens, New Delhi.

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 14-29th September 2023, 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 164 officers/employees participated in various competitions, out of which 103 officials won different prizes.

Successful participation in different competitions of Hindi fortnight was awarded in a prize distribution ceremony. The first prize of ₹5000/-, second prize of ₹3500/, third prize of ₹2500/- and 5 consolation prizes of ₹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.

Parliamentary Matters

The meeting of the Parliamentary Standing Committee on Science and Technology, Environment & Forests was held on 22.02.2023 in the Parliament House Annexe regarding detailed demand for grants of the Department of Biotechnology. Replies to about 25 Parliamentary Questions pertaining to the Department were duly replied within the prescribed time frame.

RTI Cell

RTI Cell is functioning in the Department and quarterly reports are filed timely on the RTI portal. A total of 217 RTI applications were received by the Department from 01.04.2023 to 31.03.2024, through the RTI portal, out of which 208 have been disposed off, similarly a total of 32 RTI appeals were received and disposed off by the Department respectively.

FINANCE

Budget details:

Department of Biotechnology (DBT) was allocated an amount of ₹2683.86 crores in the Budget Estimate (BE) for FY 2023-24. The allocation has, however, been reduced to ₹1607.32 crore at RE stage. The financial statement showing the stage details of Actual Expenditure during 2022-23, BE for 2023-24, RE 2023-24 and BE for 2024-25 in respect of various programmes/ Schemes/ autonomous institutions are given in Table below:

(₹ in crore)

SL No.	Name of the Programme/ Scheme	Actual 2022-23	BE 2023-24	RE 2023-24	BE 2024-25
1	2	3	4	5	6
	REVENUE SECTION				
1	Secretariat Economic Services				
1.01	Secretariat	32.74	46.39	44.25	71.04
2.01	BIRAC	32.59	40.00	52.00	40.00
2.02	Support to Autonomous R&D institutions*	848.68	902.47	911.07	940.66
3.01	Biotechnology Research and Development	968.95	1345.00	500.00	1100.00
4.01	Industrial and Entrepreneurship Development	238.46	300.00	50.00	74.00
5.01	International Centre for Genetic Engineering and Biotechnology (ICGEB)	0.00	50.00	50.00	50.00
	Total	2121.42	2683.86	1607.32	2275.70

* Institute includes 15 Autonomous Bodies namely National Institute for Plant Genome Research, New Delhi, Institute of Life Sciences, Bhuvaneswar, Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram,

National Institute of Biomedical Genomics, Kalyani, National Institute of Immunology, New Delhi, National Centre for Cell Science, Pune, Centre for DNA Finger Printing & Diagnostics, Hyderabad, National Brain Research Centre, Gurgaon, Institute of Bioresources & Sustainable Development, Imphal, Translational Health Science & Technology, Faridabad, Regional Centre for Biotechnology, Faridabad, National Agri-Food Biotechnology Institute, Mohali, Institute for Stem Cell Research and Regenerative Medicine, Bengaluru, National Institute of Animal Biotechnology, Hyderabad, Centre of Innovative and Applied Bioprocessing, Mohali.

The Budget Estimates and Revised Estimates for last five years is given below:

Amount in Crores of Rupees

Year	Budget Estimates	Revised Estimates
2018-19	2411.53	2411.53
2019-20	2580.34	2371.21
2020-21	2786.76	2300.00
2021-22	3502.37	2961.00
2022-23	2581.00	2192.92

Updated Audit para information for Annual Report 2023-24 is as under:

C&AG Audit Para Number	Present position
Para No. 4.2 of Report No. 2 of 2018 / Chapter IV	Regarding Irregular grant of promotion and entitlement – The para pertains to NCCS-Pune. O/o C&AG has vetted on 15.03.24 the ATN submitted on 09.02.24. While in case of most of the sub-paras O/o C&AG has agreed to reply submitted. in case of two paras vetted comments of O/o C&AG are as below - 4.2.2.(i) & (ii) – Newly formed BRIC needs to ensure that while forming new RR DBT to ensure all directives and OMs issued by GoI for AIs be complied with. For Para 4.2.3.2 – asked for taking waiver of excess TA paid to 3 officials from MoF and for submission of documents thereof. AI&PSU Division have been apprised about the above action points.Reply will be submitted as soon as received from AIPSU.
Para No. 14.2 of Report No. 6 of 2020 / Chapter 14	Regarding Extra Expenditure towards grants of allowances to employees -The para pertains to NBRC, Manesar. The first ATN was uploaded in APMS portal on 02.01.24. But O/o C&AG has returned the same on 11.01.24 stating that the reply is inconclusive and devoid of verifiable action as most of the matter is under examination. Concerned Section AIPSU has informed that they are pursuing with NBRC for the relevant information. Reply will be submitted as soon as received from AIPSU.

C&AG Audit Para Number	Present position
Para No. 3.1-Report No. 21 of 2022/ Chapter 3	Regarding Management of Projects under Medical Biotechnology Programme – The para pertains to various Divisions dealing with medical biotechnology programmes. O/o C&AG has vetted the revised ATN of DBT sent on 04.03.24. In their vetting comments dated 18.04.24 O/o C&AG sought some documents in case of some sub-paras. In case of other sub-paras O/o C&AG has commented that since the para has been selected by PAC for detailed examination final decision on the para would be taken after recommendation of the PAC. Incidentally, the para was selected by PAC Branch, Lok Sabha Secretariat (vide their Letter No. LAFEAS-PAC014(14)/1/2023-PAC/2023-24 dated 1st June, 2023 and DBT was asked to submit Background Note on the para for detailed examination by PAC. Accordingly, O/o Lok Sabha Secretariat (PAC Branch) was sent Background Note on this para vide e-mails dated 11.07.23 and 19.07.23 as directed by them. After receiving some more additional information (on specific projects), updated status was again provided to PAC on 21.05.2024.
Para 3.1 of Report No. 24 of 2023 / Chapter 3	Regarding Inadmissible payment of Rs.67.48 lakh on Travelling Allowance - The para pertains to ten Autonomous Institutes (AI) of DBT. The para has been uploaded in APMS portal on 09.02.24. Out of ten AIs, reply has been received from seven AIs till date. Three AIs of whom reply is awaited, have been asked to expedite reply so that ATN can be submitted at the earliest.
Para No. 2.1 (i) of Report No. 26 of 2022 Chapter 2	Regarding deficiencies in internal control in Central Autonomous Bodies - Internal audit of **one** CABs for the years 2019-20 & 2020-21 was not conducted - The para pertains to Regional Centre for Biotechnology, Faridabad. The Final ATN submitted by DBT on 26.09.23 was vetted by Audit Department on 03.10.23. **As per APMS portal the para stands settled on 03.10.23.**
Para No. 2.1 (ii) of Report No. 26 of 2022 Chapter 2	Regarding Deficiencies in internal control in Central Autonomous Bodies - Physical verification of the fixed assets of **one** CABs for the year 2019-20 was not conducted - The para pertains to Regional Centre for Biotechnology, Faridabad. The Final ATN submitted by DBT on 26.09.23 was vetted by Audit Department on 03.10.23. **As per APMS portal the para stands settled on 03.10.23.**

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Abbreviations

ATL	Accredited Test Laboratory
AI	Artificial Insemination
AI	Artificial Intelligence
AI-DARDS	Acute Respiratory Distress Syndrome
AIIMS	All India Institute of Medical Sciences
AIR	Academia Innovation Research
AKAM	Azadi Ka Amrit Mahotsav
AM	Arbuscular Mycorrhiza
AMR	Antimicrobial Resistance
AMRflows	Antimicrobials and resistance from manufacturing flows
ANN	Artificial Neural Networks
ARGs	Antibiotic Resistance Genes
BAA	Bone age assessment
BBSRC	Biotechnology and Biological Sciences Research Council
BIBCOL	Bharat Immunolgicals and Biologicals Corporation Limited
BioRRAP	Biological Research Regulatory Approval Portal
Biotech-KISAN	Biotech-Krishi Innovation Science Application Network
BIPP	Biotechnology Industry Partnership Programme
BIRAC	Biotechnology Industry Research Assistance Council
BITP	Biotech Industrial Training Programme
BMGF	Bill & Melinda Gates Foundation
BRCP	Biomedical Research Career Programme
BRD	Biotechnology Research and Development
BRIC	Biotechnology Research and Innovation Council
BSL	Bio Safety Level
BSS	Bernard-Soulier syndrome
BTIS-Network	Biotechnology Information Systems Network
CCMP	Cyber Crisis Management Plan
CDFD	Centre for DNA Fingerprinting and Diagnostics
CFP	Common Fellowship Portal
CIBA	Central Institute of Brackishwater Aquaculture
CKD	Chronic Kidney Disease
CMIAR	Ceramic membrane integrated anaerobic bioreactor

CRC	Colorectal Cancer
CRCN	Canine Research Centre & Networks
CRS	Contract Research Scheme
CRUK	Cancer Research UK
CSGE	Conformation sensitive gel electrophoresis
CTEP	Conference, Travel, Exhibition and Popular Lectures
DBT-BUILDER	DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research Programme
DBT-PG	Department of Biotechnology- Post Graduate
DBT-RA	DBT- Research Assistant
DBT-SAHAJ	DBT - Scientific Infrastructure Access for Harnessing Academia University Research Joint Collaboration
DCL	Dear Colleague Letter
DGFT	Directorate General of Foreign Trade
DGQI	Data Governance Quality Index
DMEO	Development Monitoring and Evaluation Office
DPIIT	Department for Promotion of Industry and Internal Trade
DST	Department of Science and Technology
EMBO	European Molecular Biology Organization
EPA	Environment (Protection) Act
eProMIS	Electronic Project Management System
ER	Endoplasmatic reticulum
FADH	Farmed Animal Diseases and Health
Fib. Def.	Fibrinogen Deficiency.
FIGs	Farmer Interest Groups
FITM2	Fat storage-inducing transmembrane
FIX	Coagulation Factor IX
FLD	Frontline Demonstrations
FOA	Funding Opportunity Announcement
FPOs	Farmer Producer Organizations
FVIII	Coagulation Factor VIII
GCI	Grand Challenges India
GE	Genetically Engineered
GRB	Gender Responsive Budgeting
GSH	Glutathione

GSU	Genetic Services Unit
GT	Glanzmann thrombasthenia
HBM	Himalayan Bioresource Mission
HFSPO	Human Frontier Science Programme Organization
HRMS	High- Resolution Mass Spectrometer
HTS	High- throughput Sequencing
IA	Implementation Arrangement
IABF	Indo-Australian Biotechnology Fund
IBDC	the Indian Biological Data Centre
IBKP	Indian Biosafety Knowledge Portal
IBSC	Institutional Biosafety Committee
IBTP	Industrial Biotechnology Parks
ICE	Integrated Computing Environment
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICKD	Indian Chronic Kidney Disease
ICMR	Indian Council of Medical Research
ICPD	Indian Crop Phenome Database
IED	Industrial and Entrepreneurship Development
IHIP	Integrated Health Information Platform
IMDA	Indian Metabolome Data Achieve
IMTA	Integrated Multitropic Aquaculture
INCENTIVE	Indo- European Consortium for Next Generation Influenza Vaccine Innovation
INDA	Indian Nucleotide Data Archive
INDA-CA	Indian Nucleotide Data Archive-Controlled Access
INSACOG	Indian SARS-Cov-2 Genomics Consortium
IP	Intellectual Property
IRRI- ISARC	International Rice Research Institute - South Asia Regional Centre
ISDA	Indian Structural Data Archive
IUSSTF	Indo-U.S. Science and Technology Forum
IVCOL	Indian Vaccines Corporation Ltd.
IYBF	Innovative Young Biotechnologist Fellowship
JRF	Junior Research Fellowship
LAD	Leukocyte Adhesion Deficiency

LDH	Lactic acid dehydrogenase
LDs	Lipid Droplets
MAC	Mucinous Adenocarcinoma
MAECI	Ministry of Foreign Affairs and International Cooperation
MBD	Metabolic Bone Diseases
MCFDs	Multiple Coagulation Factor Deficiencies
MEDIC	Medical Engineering, Design and Innovation Centre
MI	Mission Innovation
MoA	Memorandum of Association
MP/SC	Mother Plants/Stock Cultures
MS	Mass Spectrometry
MSI	Microsatellite Instability
MSS	Microsatellite Stable
MYH	May-Hegglin anomaly
NABI	National Agri-Food Biotechnology Institute
NBM	National Biopharma Mission
NBRC	National Brain Research Centre
NBTs	New Breeding Technologies
NCCS	BRIC-National Centre for Cell Science
NCS-TCP	National Certification System for Tissue Culture Raised Plants
NCTB	Neurocognitive Toolbox
NECAB	North East Centre for Agricultural Biotechnology
NECBH	North East Centre for Biological Sciences and Healthcare Engineering
NER	North East Region
NGO	Non-Governmental Organization
NGS	Next Generation Sequencing
NIAB	National Institute of Animal Biotechnology
NIAID	National Institute of Allergy and Infectious Diseases
NIAID	National Institute of Allergy and Infectious Diseases
NIH	National Institutes of Health
NIPGR	National Institute of Plant Genome Research
NL	Neutral lipids
NLDB	National Liver Disease Biobank
NNP	National Network Projects
NSAC	National Strategic Advisory Committee

NSAC	National Strategic Advisory Committee
NSF	National Science Foundation
NTFP	Non-Timber Forest Produce
NWFP	Non Wood Forest Produce
OOMF	Output- Outcome Monitoring Framework
PDX	Patient Derived Xenograft
PFDs	Platelet Function Disorders
PGPR	Plant Growth-Promoting Rhizobacteria
PHC	Primary Health Centers
PLF	Panchayat level federations
PRaGeD	Pediatric Rare Genetic Disorders
PSA	Principal Scientific Adviser
PSUs	Public Sector Undertakings
RCB	Regional Centre for Biotechnology
RCFDs	Red Cell Fragmentation Disorders
RCGM	The Review Committee on Genetic Manipulation
RIIG	G20 Research and Innovation Initiative Gathering
RRSFP	Research Resource Service Facility and Platform
RTS	Ready to Serve
SBIRI	Small Business Innovation Research Initiative
SCOMET	Special Chemicals, Organisms, Materials, Equipment and Technologies
SDG	Sustainable development Goals
SHGs	Self help groups
SIB	School of International Biodesign
SIBDS-IIBC	School of Innovations in Biomedical Devices and Systems and Inter-institutional Biodesign Center
SMES	Small and Medium sized Enterprises
SOP	Standard Operating Procedures
SPV	Special Purpose Vehicles
SRCC	Signet-ring Cell Carcinoma
STE	Stery esters
TAG	Triacylglycerol
TBS	Trabecular Bone Score
TCP	Tissue Culture raised Plants

TCPF	Tissue Culture Production Facilities
TCPFs	Tissue Culture Propagation Facilities
TFF	Traditional Fermented Foods
THSTI	Translational Health Science and Technology Institute
TRL	Technology Readiness Level
TRPVB	Translational Research Platform for Veterinary Biologicals
TWAS	UNESCO-The World Academy of Science
UAV	Unmanned Aerial Vehicle
UGC	University Grant Commission
UMMID	Unique Methods of Management of Inherited Disorders
UUV	Unmanned Underwater Vehicles
VAP	Indo-U.S. Vaccine Action Program
Vet-AMR	Veterinary antimicrobial resistance
VNCI	Virtual National Cancer Institute
VWD	Von Willebrand disease
WHO	World Health Oraganization
WIPO	World Intellectual Property Organization
WT	Wellcome Trust

Annexure: Details of Grant-in-Aid assigned to private institutions/NGOs in FY 2023-24:

S. No.	NAME OF AGENCIES	GIA-CAPITAL (NON-RECURRING) (A)	GIA-GENERAL (RECURRING) (B)	TOTAL (A+B)
1	A. VEERIYA VANDAYAR MEMORIAL SRI PUSHPAM COLLEGE(AUTONOMOUS), POONDI, THANJAVUR, TAMIL NADU	2913213	1050000	3963213
2	AARUPADAI VEEDU MEDICAL COLLEGE AND HOSPITAL, PUDUCHERRY, TAMILNADU	0	830590	830590
3	AHMEDABAD UNIVERSITY, GUJARAT	0	478557	478557
4	AJEENKYA D Y PATIL SCHOOL OF ENGINEERING (FORMERLY DR D Y PATIL SCHOOL OF ENGINEERING, PUNE, MAHARASHTRA	150000	1241770	1391770
5	AMITY UNIVERSITY HARYANA	856585	3964849	4821434
6	AMITY UNIVERSITY,NOIDA, UTTAR PRADESH	1080000	4180482	5260482
7	AMRITA INSTITUTE OF MEDICAL SCIENCE & CENTRE, AMRITA VISHWA VIDYAPEETHAM UNIVERSITY, KOCHI	0	5869752	5869752
8	ARTEMIS HOSPITAL, ARTEMIS EDUCATION & RESEARCH FOUNDATION GURUGRAM	1999510	823400	2822910
9	ARTS, COMMERCE AND SCIENCE COLLEGE, PALUS, SANGLI	0	800000	800000
10	ARYA VIDYAPEETH COLLEGE, GUWAHATI, ASSAM	432438	829960	1262398
11	ASHOKA TRUST FOR RESEARCH IN ECOLOGY AND THE ENVIRONMENT, BENGALURU, KARNATAKA	541571	3433845	3975416
12	ASHOKA UNIVERSITY, RAJIV GANDHI EDUCATION CITY, SONIPAT, HARYANA	0	1501760	1501760
13	AVANTHA CENTRE FOR INDUSTRIAL RESEARCH AND DEVELOPMENT, PATIALA, PUNJAB	0	512130	512130
14	AVINASHILINAM INSTITUTE FOR HOME SCIENCE & HIGHER EDUCATION FOR WOMEN COIMBATORE	0	501000	501000
15	AYURVET RESEARCH FOUNDATION, GHAZIABAD, UP	476000	1283580	1759580
16	AZIM PREMJI UNIVERSITY, BANGALORE	0	1242182	1242182
17	B S ABDUR RAHMAN UNIVERSITY, BSA CRESCENT INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI, TAMIL	0	1005888	1005888

	NADU			
18	BAIF DEVELOPMENT & RESEARCH FOUNDATION, PUNE	0	1934000	1934000
19	BALASAHEB DESAI COLLEGE PATAN, SATARA, MAHARASHTRA (KOYANA EDUCATION SOCIETY PATAN)	0	800000	800000
20	BANASTHALI VIDYAPITH, TONK. RAJASTHAN	500000	978101	1478101
21	BENNETT UNIVERSITY	458700	736280	1194980
22	BHARATA MATA COLLEGE, THRIKKAKARA, KOCHI, KERALA	3865008	1400000	5265008
23	BHARATI VIDYAPEETH (DEEMED TO BE UNIVERSITY), INTERACTIVE RESEARCH SCHOOL FOR HEALTH AFFAIRS, PUNE, MAHARASHTRA	2870186	8200975	11071161
24	BHARATI VIDYAPEETH (DEEMED TO BE UNIVERSITY), RAJIV GANDHI INSTITUTE OF INFORMATION TECHNOLOGY AND BIOTECHNOLOGY, PUNE, MAHARASHTRA	130	1682879	1683009
25	BHAVAN'S VIVEKANANDA COLLEGE OF SCIENCE, HUMANITIES AND COMMERCE, BHARATIYA VIDYA BHAVAN, SAINIKPURI, SECUNDERBAD, TELANGANA	0	2100000	2100000
26	BIOTECH CONSORTIUM INDIA LIMITED	0	67934069	67934069
27	BIRLA INSTITUE OF TECHNOLOGY & SCIENCES PILANI, RAJASTHAN	365253	8605120	8970373
28	BIRLA INSTITUE OF TECHNOLOGY & SCIENCES, GOA	2000000	35182185	37182185
29	BISHOP MOORE COLLEGE MAVELIKARA, KERALA	0	246960	246960
30	BITS, PILANI, HYDERABAD CAMPUS	2218000	3426848	5644848
31	C. ABDUL HAKEEM COLLEGE, TAMIL NADU	0	2380245	2380245
32	CBCI SOCIETY FOR MEDICAL EDUCATION (St. John's Research Institute, Bengaluru, Karnataka)	1262099	23257784	24519883
33	CENTER FOR NATURAL BILOGICAL RESOURCES AND COMMUNITY DEVELOPMENT, KARNATAKA	0	323800	323800
34	CENTRE FOR CELLULAR AND MOLECULAR PLATFORMS (C-CAMP), BANGALORE	0	500000	500000
35	CENTRE FOR HEALTH RESEARCH AND DEVELOPMENT, SCOETY FOR APPLIED STUDIES	0	2524400	2524400

36	CENTRE FOR STEM CELL RESEARCH, CHRISTIAN MEDICAL COLLEGE VELLORE ASSOCIATION, BAGAYAM, VELLORE, TAMIL NADU	12523400	81483045	94006445
37	CHANDIGARH COLLEGE OF PHARMACY, SHRI GURU RAM DASS EDUCATIONAL SOCIETY MOHALI, PUNJAB	0	250000	250000
38	CHENNAI DENTAL RESEARCH FOUNDATION (CDRF), CHENNAI, TAMIL NADU	0	364560	364560
39	CHETTINAD ACADEMY OF RESEARCH AND EDUCATION, KANCHIPURAM, TAMIL NADU	0	948999.78	948999.78
40	DADASAHEB BALPANDE COLLEGE OF PHARMACY, NAGPUR	0	406310	406310
41	DATTA MEGHE COLLEGE OF PHARMACY, WARDHA, MAHARASHTRA	952350	425000	1377350
42	DBT WELLCOME TRUST INDIA ALLIANCE, NEW DELHI	0	857800000	857800000
43	DCT'S DHEMPE COLLEGE OF ARTS AND SCIENCE, DEMPO CHARITIES TRUSTS DHEMPE COLLEGE OF ARTS AND SCIENCE,GOA	5741263	2100000	7841263
44	DEPARTMENT OF ANIMAL HUSBANDRY AND VETERINARY SERVICES (DAH7VS), KOHIMA, NAGALAND	584452	1110560	1695012
45	DR NGP ARTS AND SCIENCE COLLEGE, COIMBATORE	1498859	1849971	3348830
46	EGRA SARADA SHASHI BHUSAN COLLEGE, PURBA MEDINIPUR, WEST BENGAL	2000000	700000	2700000
47	ELIXIIR ECOBIOTEK, BHIMAVARAM, ANDHRA PRADESH	400000	1154300	1554300
48	ENTERPRENEURSHIP DEVELOPMENT CENTER, VENTURE CENTER, PUNE	0	1880600	1880600
49	FOUNDATION FOR RESEARCH IN MEDICAL GENETICS AND ENDOCRINOLOGY (FRIGE), AHMEDABAD	0	1908880	1908880
50	GEORGE INSTITUE FOR GLOBAL HEALTH, NEW DELHI	0	14273040	14273040
51	GNRC HOSPITALS, DISPUR, GUWAHATI, ASSAM (GNRC LTD)	0	635510	635510
52	GTN ARTS COLLEGE, DINDIGUL, SEELAPADI, TAMILNADU	0	1400000	1400000
53	GUJARAT GRASSROOTS INNOVATION AUGMENTATION NETWORK GIAN HIMALAYAN BIORESOURCE, GUJRAT	560560	2387421	2947981

54	HIMALAYAN ENVIRONMENTAL STUDIES & CONSERVATION ORGANIZATION (HESCO)	0	789988	789988
55	HIMALAYAN PHARMACY INSTITUTE, MAJITAR, SIKKIM	0	61156.34	61156.34
56	HIMALAYAN RESEARCH GROUP, HIMACHAL PRADESH	0	1817555	1817555
57	HIRABAI COWASJI JEHANGIR MEDICAL RESEARCH INSTITUTE, PUNE	0	350000	350000
58	IISC, BANGALORE (FOR MYNVAX PVT. LTD.)	0	1833960	1833960
59	INDIAN OIL CORPORATION LTD, FARIDABAD	0	3157040	3157040
60	INDIAN SPINAL INJURIES CENTRE, NEW DELHI	0	1673760	1673760
61	INSTITUTE FOR RESOURCE ANALYSIS AND POLICY, HYDERABAD, TELANGANA	0	1049025	1049025
62	INSTITUTE FOR SOCIAL AND ECONOMIC CHANGE, BANGALORE	0	2017167	2017167
63	INSTITUTE OF BIOINFORMATICS AND APPLIED BIOTECHNOLOGY	4000000	4543360	8543360
64	INSTITUTE OF BIOINFORMATICS TRUST, BANGALORE	0	461280	461280
65	INSTITUTE OF CHEMICAL TECHNOLOGY (FORMERLEY UDCT), MUMBAI	2500000	2642142	5142142
66	INSTITUTE OF HORTICULTURE TECHNOLOGY (AKHIL BHARTIYA GRAMEEN VIKAS SANSTHA), MANDIRA, KAMRUP DISTRICT, ASSAM	0	2574872	2574872
67	INSTITUTE OF INTEGRATED RESOURCE MANAGEMENT, SONITPUR, ASSAM	480000	1699200	2179200
68	INSTITUTE OF SCIENCE, NIRMA UNIVERSITY, GUJARAT	0	1519220	1519220
69	INTERNATIONAL CROP RESEARCH INSTITUTE FOR THE SEMI ARID TROPICS, HYDERABAD	3134599	35135178	38269777
70	INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY, HYDERABAD	177225	554840	732065
71	INTERNATIONAL RICE RESEARCH INSTITUTE-BRD SCHEME	9000000	82059923	91059923
72	JAGANNATH BAROOAH COLLEGE	500000	1610960	2110960
73	JAMIA HAMDARD, NEW DELHI	0	513469	513469
74	JAYPEE INSTITUTE OF INFORMATION TECHNOLOGY, NOIDA, UTTAR PRADESH	642952	2395909	3038861
75	JAYSINGPUR COLLEGE, MAHARASHTRA	1500000	550000	2050000

76	JOHN WILSON EDUCATION SOCIETY'S WILSON COLLEGE, BRD, MUMBAI	0	2100000	2100000
77	JSS ACADEMY OF HIGHER EDUCATION AND RESEARCH, KARNATAKA	600000	4717220	5317220
78	JSS COLLEGE OF PHARMACY, OOTCAMUND, JSS ACADEMY OF HIGHER EDUCATION AND RESEARCH, KARNATAKA	0	698927	698927
79	JUSTICE BASHEER AHMED SAYEED COLLEGE FOR WOMEN, TEYNAMPET, CHENNAI, TAMIL NADU	3750000	1400000	5150000
80	K J SOMAIYA COLLEGE OF SCIENCE AND COMMERCE, VIDYAVIHAR, MUMBAI	0	3780199	3780199
81	KALASALINGAM ACADEMY OF RESEARCH AND EDUCATION, KRISHNANKOIL, TAMIL NADU	1700000	2128800	3828800
82	KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY, ODISHA, BHUBNESHWAR	0	2700000	2700000
83	KARPAGAM ACADEMY OF HIGHER EDUCATION, COIMBATORE, TAMIL NADU	0	1539000	1539000
84	KASTURBA MEDICAL COLLEGE, MANIPAL ACADEMY OF HIGHER EDUCATION, MANIPAL, KARNATAKA	0	3380491	3380491
85	KAVIKRISHNA, GUWAHATI	0	2098996	2098996
86	KMCH RESEARCH FOUNDATION, COIMBATORE, TAMIL NADU	0	1518600	1518600
87	KONGU ARTS AND SCIENCE COLLEGE, NANJANAPURAM, TAMIL NADU	0	1800000	1800000
88	KRISHNA CHANDRA COLLEGE , HETAMPUR RAJBATI, BIRBHUM	0	565574	565574
89	KRT ARTS BH COMMERCE AND AM SCIENCE COLLEGE	0	2696529	2696529
90	LAYA (SOCIETY REG. NO. 667/89) CHENNAI	0	1748400	1748400
91	M S RAMAIAH COLLEGE OF ARTS SCIENCE AND COMMERCE, BANGALURU	620501	263044	883545
92	M S RAMAIAH INSTITUTE OF TECHNOLOGY, BENGALURU, KARNATAKA	150480	736780	887260
93	MADRAS DIABETES RESEARCH FOUNDATION, CHENNAI	257	789650	789907
94	MAHARISHI MARKANDESHWAR (DEEMED TO BE UNIVERSITY), MULLANA, HARYANA	440000	867620	1307620
95	MAHATMA PHULE ARTS SCIENCE AND COMMERCE COLLEGE PANVEL, MAHARASHTRA	0	1100000	1100000

96	MAHINDRA UNIVERSITY, HYDERABAD	600000	818600	1418600
97	MANIPAL ACADEMY OF HIGHER EDUCATION, MANIPAL, KARNATAKA	476934	207380	684314
98	MANIPAL INSTITUTE OF REGENERATIVE MEDICINE (MANIPAL ACADEMY OF HIGHER EDUCATION), BANGALORE KARNATAKA	1726450	4959840	6686290
99	MANTHAN GRAMIN EVAM SAMAJ SEWASAMITI (MANTHAN BIOTECH KISAN HUB)	0	13570000	13570000
100	MATA GUJRI COLLEGE, FATEHGARH SAHIB, PUNJAB	0	292562	292562
101	MAZUMDAR SHAW MEDICAL FOUNDATION, BENGALURU	0	22452	22452
102	MODERN COLLEGE OF ARTS, SCIENCE & COMMERCE, GANESHKHIND, PUNE, MAHARASHTRA	0	2301863	2301863
103	MS SWAMINATHAN RESEARCH FOUNDATION, CHENNAI, TAMIL NADU	0	4829760	4829760
104	MULTANI MAL MODI COLLEGE, PATIALA, PUNJAB	0	1400000	1400000
105	N.E.S. RATNAM COLLEGE OF ARTS, SCIENCE AND COMMERCE, BHANDUP	0	2800000	2800000
106	NAMRUP COLLEGE, NAMRUP, ASSAM	199983	471240	671223
107	NAZARETH HOSPITAL, SHILLONG, MEGHALAYA	57001	1395760	1452761
108	NB INSTITUTE FOR RURAL TECHNOLOGY, WEST TRIPURA, TRIPURA	2263391	1396256	3659647
109	NEW ARTS, COMMERCE & SCIENCE COLLEGE, AHMEDNAGAR, MAHARASHTRA	0	982800	982800
110	NEW EDUCATION SOCIETY'S ARTS, COMMERCE AND SCIENCE COLLEGE, LANGA MAHRASHTRA	1991742	700000	2691742
111	NEWMAN COLLEGE, THODUPUZHA, IDUKKI, KERALA	0	1100000	1100000
112	NIRMALA COLLEGE, RANCHI	0	687883	687883
113	NITTE UNIVERSITY CENTRE FOR SCIENCE EDUCATION AND RESEARCH, NITTE (DEEMED TO BE UNIVERSITY), MANGALURU	0	92900	92900
114	NMRKV COLLEGE FOR WOMEN, BANGALORE, KARNATAKA	704418	454376	1158794
115	NOIDA INSTITUTE OF ENGINEERING & TECHNOLOGY, GREATER NOIDA	98000	241476	339476
116	NORTH EAST INITIATIVE DEVELOPMENT AGENCY, NAGALAND	0	556576	556576
117	NOWGONG COLLEGE, NAGON, ASSAM	500000	1610960	2110960

118	P.D. HINDUJA NATIONAL HOSPITAL & MRC, NATIONAL HEALTH & EDUCATION SOCIETY BRD, MUMBAI	407824	10767282	11175106
119	PACHHUNGA UNIVERSITY COLLEGE	0	2403500	2403500
120	PALAVI TRUST, PUNE, MAHARASHTRA	0	1292800	1292800
121	PANDIT DEENDAYAL ENERGY UNIVERSITY, GANDHINAGAR, GUJARAT	11078677	6812737	17891414
122	POULTRY DIAGNOSTIC AND RESEARCH CENTRE DIVISION OF VENKATESHWARA HATCHERIES PRIVATE LIMITED, PUNE, LONI-KALBHOR	1075400	1355320	2430720
123	PRAVABATI COLLEGE, MAYANG, IMPHAL	199936	204597	404533
124	PRESIDENCY UNIVERSITY, KOLKATA	1666160	4616327	6282487
125	PRINCIPAL DAV COLLEGE BATHINDA, PUNJAB	0	700000	700000
126	PRINCIPAL GURU NANAK COLLEGE, SRI MUKTSAR SAHIB, PUNJAB	0	1100000	1100000
127	PRINCIPAL, JAWAHARLAL NEHRU COLLEGE, PASIGHAT, EAST SIANG DISTRICT, ARUNACHAL PRADESH	200000	1268400	1468400
128	PROF RAMKRISHNA MORE ARTS, COMMERCE AND SCIENCE COLLEGE, PUNE, MAHARASHTRA	1000000	500000	1500000
129	PROF. M VISHWANATHAN DIABETES RESEARCH CENTRE	0	5034688	5034688
130	PROGRESSIVE EDUCATION SOCIETY'S, MODERN COLLEGE OF ARTS, SCIENCE & COMMERCE, PUNE, MAHARASHTRA	17421	40937	58358
131	PUBLIC HEALTH FOUNDATION OF INDIA, GURUGRAM HARYANA	1090415	14711118	15801533
132	PUSHPAGIRI INSTITUTE OF MEDICAL SCIENCES AND RESEARCH CENTRE, THIRUVALLA, KERALA	0	133075	133075
133	RAJIV GANDHI CANCER INSTITUTE AND RESEARCH CENTER, NEW DELHI	0	48557	48557
134	RAMAKRISHNA MISSION VIDYAMANDIRA,HOWRAH	2999238	1100000	4099238
135	RATHNAVEL SUBRAMANIAM COLLEGE OF ARTS AND SCIENCE, SULUR, COIMBATORE, TAMIL NADU	0	1800000	1800000
136	RISHI DAYARAM AND SETH HASSARAM NATIONAL COLLEGE AND SETH WASSIAMULL SCIENCE COLLEGE, MUMBAI	4160467	1652614	5813081
137	RV COLLEGE OF ENGINEERING, BENGALURU, KARNATAKA	0	902798.47	902798.47

138	SAGI RAMA KARISHNAM RAJU ENGINEERING COLLAGE ASSOCIATION SPRING, BHIMAVARAM, ANDHRA PRADESH	200000	2509039	2709039
139	SD COLLEGE, BARNALA, PUNJAB	0	1098161	1098161
140	SETH GS MEDICAL COLLEGE & KEM HOSPITAL DIAMOND JUBILEE SOCIETY TRUST, MUMBAI	0	25359050	25359050
141	SHANMUGA ARTS SCIENCE TECHNOLOGY AND RESEARCH ACADEMY, THANJAVUR, TAMIL NADU	0	3569513	3569513
142	SHANMUKHA INNOVATIONS PVT LTD	0	606260	606260
143	SHIV NADAR UNIVERSITY, DADRI	1180000	1248720	2428720
144	SHOOLINI UNIVERSITY OF BIOTECHNOLOGY AND MANAGEMENT SCIENCE C/O FOUNDATION FOR LIFE SCIENCES AND BUSINESS MANAGEMENT, SOLAN HP	2265000	2891676	5156676
145	SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMKUR, KARNATAKA	8045534	2020680	10066214
146	SIKSHA O ANUSANDHAN UNIVERSITY, BHUBANESHWAR, ODISHA (SIKSHA O ANUSANDHAN DBT QUALITY ENHANCEMENT OF TURMERIC)	12580800	4457989	17038789
147	SIR GANGA RAM HOSPITAL, NEW DELHI	222000	7076120	7298120
148	SOCIETY FOR HEALTH ALLIED RESEARCH AND EDUCATION INDIA, (SHARE INDIA), HYDERABAD, TELANGANA	0	1413784	1413784
149	SOPHIA COLLEGE FOR WOMEN, MUMBAI, MAHARASHTRA	5505580	1620990	7126570
150	SOUTH ASIA BAMBOO FOUNDATION, GUWAHATI	0	100000	100000
151	SOUTH ASIA BIOTECHNOLOGY CENTRE, DELHI	0	3800000	3800000
152	SREE NARAYANA COLLEGE, KOLLAM, KERALA	5000000	1438792	6438792
153	SREE NARAYANA COLLEGE, NATTIKA, THRIPRAYAR, KERALA	2000000	700000	2700000
154	SRI GVG VISALAKSHI COLLEGE FOR WOMEN, UDUMALPET, TIRUPPUR, TAMIL NADU	2988356	1100000	4088356
155	SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING, ANDHRA PRADESH	0	1263190	1263190
156	SRI VENKATESWARA COLLEGE, UNIVERSITY OF DELHI, DELHI	0	3086320	3086320
157	SRM INSTITUTE FOR MEDICAL SCIENCE, CHENNAI	0	1360560	1360560
158	SRM UNIVERSITY AP, AMARAVATI GUNTUR	0	2033973	2033973

159	SRM UNIVERSITY, KATTANKULATHUR, CHENNAI	498850	1327036	1825886
160	ST. FRANCIS COLLEGE FOR WOMEN, UMA NAGAR, BEGUMPET	3875500	1350000	5225500
161	ST. MARY'S COLLEGE AUTONOMOUS THOOTHUKUDI BRD SCHEME	0	1399960	1399960
162	ST. XAVIER'S COLLEGE (AUTONOMOUS), MAHAPALIKA MARG, MUMBAI, MAHARASHTRA	0	1847840	1847840
163	ST. XAVIER'S COLLEGE, KOLKATA	0	2198734	2198734
164	SYMBOSIS SCHOOL OF BIOLOGICAL SCIENCES, SYMBIOSIS INTERNATIONAL (DEEMED UNIVERSTY)MAHARASHTRA	0	917751	917751
165	TEA RESEARCH ASSOCIATION, TOCKLAI, TEA RESEARCH INSTITUTE, JORHAT, ASSAM	0	6737710	6737710
166	THAPAR INSTITUTE OF ENGINEERING AND TECHNOLOGY, PATIALA, PUNJAB	43250	1824877	1868127
167	THE COCHIN COLLEGE, COCHIN, KERALA	4000000	1201642	5201642
168	THE ENERGY AND RESOURCE INSTITUTE (TERI), NEW DELHI	0	5237729	5237729
169	THE INCLEN TRUST INTERNATIONAL, DELHI	0	45333339	45333339
170	THE VOLUNTARY HEALTH SERVICES HOSPITAL, CHENNAI, TAMIL NADU	0	3301660	3301660
171	VEL TECH RANGARAJAN DR. SAGUNTHALA R&D INSTITUTE OF SCIENCE AND TECHNOLOGY, DBT 2	0	6386763	6386763
172	VELLORE INSTITUTE OF TECHNOLOGY, TAMIL NADU	0	1266800	1266800
173	VIMALA COLLEGE	0	2100000	2100000
174	VIRUDHUNAGAR HINDU NADARS SENTIKUMARA NADAR COLLEGE, VIRUDHUNAGAR, TAMIL NADU	0	1784049	1784049
175	VISION RESEARCH FOUNDATION, CHENNAI TAMIL NADU	0	3065963	3065963
176	VIVEKANANDA COLLEGE, TIRUVEDAKAM, TAMILNADU	0	1375016	1375016
177	YENEPOYA (DEEMED TO BE UNIVERSITY), MANGALORE, KARNATAKA	5841755	5552320	11394075
178	ZANDU FOUNDATION FOR HEALTH CARE, AMBACH, GUJARAT	0	772704	772704

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