



# ANNUAL REPORT

## 2020-2021



**Department of Biotechnology**  
**Ministry of Science & Technology**  
**Government of India**

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# Contents

<b>1. Overview</b>	<b>06</b>
<b>2. Building Capacities:</b>	
- Human Resource Development, Training and Workshops	35
- Research Resources, Service Facilities and Platforms	45
<b>3. Research and Development</b>	
- Agriculture and Allied areas	49
- Bioenergy, Bioresources, Environment & Forest	60
- Healthcare and Medical Biotechnology	78
- Knowledge Generation, Discovery Research, New Tools and Technologies	105
- Biotechnology Science Clusters	122
<b>4. Promoting Entrepreneurship and Industrial Growth</b>	
- Make in India	125
- Start up India	128
- Biodesign Programme	128
- Biotechnology Parks and Incubators Parks	131
<b>5. Building International Collaborations and Partnership</b>	<b>137</b>
<b>6. DBT Response to Covid-19 Pandemic</b>	<b>149</b>
<b>7. Societal Programs</b>	
- Programme of societal relevance- Rural SC/ST Population	171
- BIOTECH KISAN	174
<b>8. Promoting Biotechnology in North Eastern Region</b>	<b>181</b>
<b>9. DBT Autonomous Institutions and Public Sector Undertakings</b>	<b>189</b>
<b>10. Regulation, Intellectual Property and Legislations</b>	<b>236</b>
<b>11. Data Monitoring and Analysis</b>	<b>240</b>
<b>12. Administration and Finance</b>	<b>250</b>
<b>Abbreviations</b>	<b>254</b>





**01**

# **OVERVIEW**

## OVERVIEW

The Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India has the mandate of promoting and nurturing Biotechnology in the country. The focus of the Department is on creating a strong ecosystem for facilitating basic, early and late translational research and entrepreneurship and also formulation of policies/ guidelines/ legislations in all sectors of biotechnology. The

emphasis is on promotion of excellence; innovation and technology leading towards product development; building capacities, both human resource and infrastructure; establishing national and international partnerships/linkages. Innovation-driven research is being promoted by the Department through its various schemes such as center of excellence, grand challenges, international partnerships, public-private partnerships. Translational research platforms and Bio-clusters have also been established to facilitate

## Vision and Mission

## Vision

Harness the potential of Biotechnology as a premier precision tool for national development and well-being of society.

## Mission

To make India globally competitive in Biotechnology research, innovation, translation, entrepreneurship and industrial growth and be a US\$150 billion Bioeconomy by 2025.



## Goals and Objectives



To build and strengthen a strong education, research and translation ecosystem across the country.



To make India a global player for development and deployment of new and emerging technologies.



To build and nurture a vibrant start up, entrepreneurial and industry base in the country, connecting the academia and industry.



To position India as a strong Biomanufacturing hub for innovative, affordable and accessible products for the society and also for global markets.

translation of technologies for product development, their validation, testing and commercialization. DBT has also established 15 theme-based autonomous institutions across the country. One international institution namely the New Delhi centre of the International Centre for Genetic Engineering & Biotechnology and two Public Sector Undertakings BICOL and BIRAC have also been established for manufacturing of biologicals and fostering and nurturing

the start-up innovation ecosystem. Also, since the time the first report of the novel Corona Virus Disease (COVID-19) emerged, the Department of Biotechnology (DBT) has worked relentlessly to contribute, in all ways possible, for mitigating the crisis. The multi-pronged strategy adopted by the Department, coupled with the untiring efforts of the Autonomous Institutions and the Indian Biotechnology enterprises have begun to bear fruit and yield tangible results in addressing the issues related to the pandemic.



## BUILDING CAPACITIES - HUMAN RESOURCE DEVELOPMENT, TRAININGS, WORKSHOPS

Building a skilled workforce is the key for strong, sustainable and balanced growth of the biotechnology sector. This year, DBT has supported 15 new skill development courses for Post-Graduate Certificate/Diploma with an objective to provide quality hands on training in tools and techniques in Medical Biotechnology, Agricultural Biotechnology and Computational Biology. The department has also initiated the Skill Vigyan State Partnership Program with six States viz., Arunachal Pradesh, Himachal Pradesh, Meghalaya, Odisha, Punjab and Uttarakhand in partnership with State Science and Technology Councils of respective States.

The Department has a major emphasis on human resource development and an Integrated Human Resource

Development Programme in Biotechnology comprising of post graduate teaching programme, industrial training of students, skill development programme, fellowship for doctoral and post-doctoral research training in frontier areas of life sciences and biotechnology, short term training courses for upgradation of skills of mid-career scientists and faculty engaged in life science and biotechnology teaching and R&D. Department is also supporting a finishing school program for skill enhancement of biotechnology students and meetings for young investigators and students. The department is generating critical mass of trained and skilled manpower required for overall development of Biotechnology sector in the country. Special effort has been made to start Skill Vigyan programme in partnership with State and Union Territories for imparting skill training for entry level students. Under HRD program following activities are being supported:

<i>Post-graduate Teaching Programmes</i>	<i>The program helped in development of trained manpower in general biotechnology as well as in specific areas such as medical, agricultural, marine, veterinary, industrial biotechnology, computational biology, food and nutrition.</i>
<i>Skill Vigyan Program (Skill Development Programme) in Biotechnology</i>	<i>The program helped in generating skilled trained manpower for enhancing job well as in industries, hospitals, medical colleges, R&amp;D laboratories, diagnostic laboratories.</i>
<i>Star College Scheme</i>	<i>This program has helped in improving skills of teachers and students by organizing faculty training, improved curriculum for teachers and emphasis on practical training to students by providing access to specialized infrastructure and consumables.</i>
<i>Biotechnology Finishing School Programme</i>	<i>This helped in imparting skill training. Life Sciences Sector Skill Development Council (LSSSDC), New Delhi is also participating in development of national occupational standards for training modules as well certification of training programs.</i>
<i>DBT Junior Research Fellowship (DBT- JRF)</i>	<i>This has helped student's in pursuing doctoral research in universities and research institutions in the country.</i>
<i>DBT's Research Associateship (DBT- RA)</i>	<i>DBT Research Associateship program helped to improve post-doctoral research training in frontier areas of Biotechnology and Life sciences at premier institutions across the country.</i>
<i>Ramalingaswami Re-entry Fellowship</i>	<i>The programme has encouraged Indian scientists working overseas to return back to India and pursue their scientific research career in any recognized Indian Institutions.</i>
<i>DBT- Wellcome Trust Fellowship</i>	<i>It aims to improve the biomedical research landscape in India through mechanisms supports exceptional researchers at Indian institutions, and facilitate the recruitment</i>

	<i>that of highly trained and qualified scientists from overseas. This is done through Fellowship Programme with three types of fellowships early, intermediate and senior fellowships.</i>
<i>DBT-TWAS Fellowship</i>	<i>The Department and The World Academy of Sciences (TWAS) provide Biotechnology fellowships to foreign scholars from developing countries who wish to pursue research in emerging areas in biotechnology for which facilities are available in the Laboratories/ Institutes in India.</i>
<i>DBT - Energy Biosciences Overseas Fellowships</i>	<i>DBT “Energy Biosciences Overseas Fellowships” is a flagship scheme of DBT for bringing back to scientists of Indian origin who are working outside the country in the field of Energy Biosciences.</i>
<i>Indo-U.S. Genome Engineering /Editing Technologies Initiative (GETin) Overseas Fellowship</i>	<i>The objective of this program is to provide opportunity to Indian students and scientists to have exposure and access to world class research facilities in leading US institutions for capacity building in frontline area of Genome Engineering/Editing Technologies and building long-term R&amp;D linkages and collaborations with US institutions/ researchers.</i>
<i>Newton Bhabha PhD Placement Programme</i>	<i>The department partners with British Council to enable participation of UK and Indian PhD scholars in international intellectual networks, building cultural understanding, and fostering long-term sustainable research collaborations.</i>
<i>Khorana Programme for Scholars</i>	<i>The Department is collaborating with University of Wisconsin (UW) Madison, USA the Indo-US Science and Technology Forum (IUSSTF) to nurture contacts between and students of biotechnology and biomedical sciences from India and the US, through a joint training programme in biotechnology and allied areas.</i>
<i>Building Bharat-Boston Biosciences (B4) Programme</i>	<i>This program aims at linking up Institutions in India and Boston to promote research and creation of new knowledge in Biosciences through collaboration between the two countries, in the emerging areas of Biosciences.</i>
<i>DBT-Heidelberg Graduate Program on Big Data Research</i>	<i>Department has implemented a joint graduate programme on Big Data Research with Heidelberg University, Germany for human resource development. The programme is designed toward a joint doctoral research training from Heidelberg University and one of the Indian partner institutions.</i>
<i>IIT-B Monash (Indian Institute of Technology, Bombay-Monash University) PhD Programme</i>	<i>The broad scope of the Programme is to enable joint PhD degree from IIT Bombay and Monash University. Students do get a good exposure to Industry Academia Partnership and new areas of research under the program</i>
<i>Indo-Australian Career Boosting Gold Fellowships (IACBG-Fellowships)</i>	<i>It is an initiative to fund researchers from India to undertake a collaborative research project at a leading science institute or university in Australia.</i>
<i>Short Term Training Programme for Mid-Career Scientists and UG &amp; PG Teachers Biotech</i>	<i>Department is supporting short term training programmes for upgrading skills of mid-career scientists from R &amp; D institutions and UG &amp; PG faculty from universities and colleges involved in teaching in multidisciplinary areas of biotechnology and life sciences.</i>

<i>Industrial Training Programme (DBT-BITP Apprenticeship)</i>	<i>DBT is supporting Biotech Industrial Training Programme (BITP) for providing hands-on training for six months to fresh B.E./B.Tech./M.Sc./M.Tech. biotechnology students. The programme is mutually beneficial to the students as well as industry as it not only provides industrial exposure to the students but also an opportunity to industry to select suitable manpower as per their requirement.</i>
<i>Tata Innovation Fellowship</i>	<i>The programme has recognized and rewarded several outstanding scientists for their excellent research contributions towards knowledge generation and technology development in Biotechnology including health care, agriculture, environment biotech, veterinary sciences and other areas related to Life sciences and Biotechnology.</i>
<i>Innovative Young Biotechnologist Award</i>	<i>A vast pool of talented young minds has been created through this program support who could work independently to generate innovative knowledge and develop technologies in frontier areas of Biotechnology.</i>
<i>National Bioscience Award for Career Development</i>	<i>The scheme has recognized and rewarded the outstanding scientists of the country for their significant research contributions and at the same time has catered support to these mid-career scientists to pursue their ongoing research for knowledge generation and/or technology development for further advancement in various fields of Biotechnology.</i>
<i>National Women Bioscientist Award</i>	<i>The scheme facilitates the outstanding young women scientists to pursue their research interests and also rewards the senior women scientists for their lifetime excellent scientific contributions.</i>
<i>Biotech Product, Process Development and Commercialization Award</i>	<i>This award scheme has awarded the scientists /innovators/ entrepreneurs or organization for development/ commercialization of a biotech product or a bioprocess in the areas of Biotechnology and Biological sciences.</i>
<i>Distinguished Biotechnology Research Professorship Award</i>	<i>Support to the Distinguished Professors have resulted in publications, mentoring students, and dissemination of key outcomes of their ongoing research work in various conferences, workshops etc leading to further advancements in areas of Biotechnology and related fields</i>
<i>Biotechnology Career Advancement and Re-orientation Programme (BioCARE)</i>	<i>The program aims to promote women in science and is an attempt to enhance the participation of Women Scientists in Biotechnology Research. The purpose of the scheme is to build capacities for women Scientists employed full time in Universities and small research laboratories or unemployed women scientists after a career break so as to help them undertake independent R&amp;D projects.</i>
<i>DBT-CTEP Program</i>	<i>To popularize Biotechnology activities in India, the Department provides financial assistance towards organizing Conference/ Seminar/ Symposium/ Workshop and Travel support to the researchers for presenting their papers in the conferences which are being organised outside the country.</i>
<i>Societal Development Awards</i>	<i>These awards are given to recognize the biotechnological work done for societal development and has made an impact on the community at large scale.</i>



## RESEARCH AND DEVELOPMENT, MISSION PROGRAMS, DEMONSTRATION AND TRANSLATION ACTIVITIES

### ATAL JAI ANUSANDHAN BIOTECH MISSION

Atal Jai Anusandhan Biotech Mission implemented by DBT with major focus on improved agriculture, affordable healthcare, clean energy and cutting-edge frontier science. Following mission programs are being implemented under this mission program:


- (i) **GARBH-ini (Interdisciplinary Group for Advanced Research in Birth outcomes- DBT India Initiative)** study aims to discover molecular risk-markers and generate a risk-prediction algorithm for preterm birth which will facilitate timely referral and care for at-risk mothers, thus saving children's lives and reducing morbidity.



- (ii) **AMR Mission:** With the aim to discover, develop and exploit new resources for antibiotics and alternatives to antibiotics, the Mission on Antimicrobial Resistance (AMR) focuses on the development of new antibiotics, development of alternatives to antibiotics and development of diagnostics.

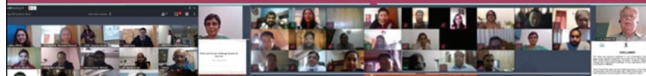


- (iii) **Ind-CEPI:** Ind-CEPI Mission aims to address not just the development of new vaccine candidates for outbreaks but also explore new ways of working to drive vaccine innovation to address public health threats like recent outbreaks – SARS, Ebola and Zika, Covid-19 in alignment with the WHO blueprint for R&D.



**Epidemic preparedness through rapid vaccine development: Support of Indian vaccine development**

Current Vaccine Portfolio:	Skill Development:
1. mRNA platform for SARS-CoV-2-Genova Biopharmaceuticals Ltd. 2. Inactivated Virus platform for Chikungunya-Bharat Biotech International Ltd.	E-course series "Strengthening Clinical Trial Research Capacity in Neighboring Countries"



- (iv) **Clean Technologies for Swachh Bharat:** DBT has already developed various technology platforms designed to convert different solid, liquid and gaseous wastes into renewable fuels, energy and useful products such as food, feed, polymers and chemicals. Promising clean technologies have been identified for demonstration with DBT support at different sites across India, in collaboration with local stakeholders such as municipalities and other urban local bodies. The identified technologies include biomethanation, constructed wetland, bio-toilets, chemical & membrane free water purification etc.

- (v) **Fortified Wheat Nutritional Improvement:** Anthocyanin rich biofortified coloured wheat lines have been developed by NABI, Mohali. NABI has signed MoU with ten companies from Punjab, Haryana, MP, UP, Bihar and Gujarat involved in contract farming and making food products. The program is addressing micronutrient malnutrition problem along with helping the progressive

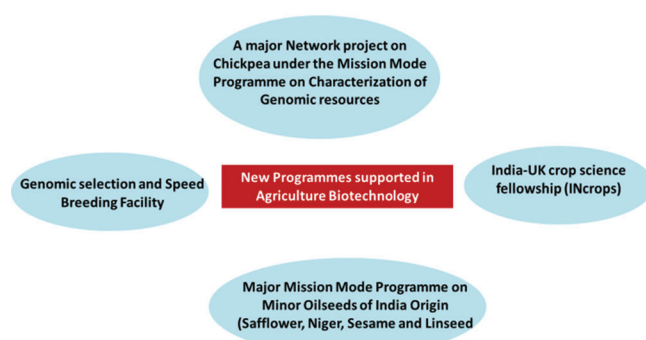
farmers to grow improved wheat lines and entrepreneurs and start-ups to start business in this new and specialized area of Agri-Biotechnology.

R&D Projects: Achievements at a glance	
Ongoing projects supported	2012
New R & D projects, Network programs, platforms, facilities supported	269
Human Resources trained in R & D projects	9401
New Facilities/Research Infrastructure established	28
Research publications emanated from R&D projects supported	2297
Products and Technologies developed from R&D projects	110
Products and Technologies Commercialized	18
Patents filed/granted	59

## AGRICULTURE AND ALLIED AREAS

The programme envisages use of cutting-edge technologies for developing animal breeds, crop varieties, vaccines and diagnostics in collaboration with publicly funded as well as private institutions/companies.

**Agriculture Biotechnology:** The mandate of Agriculture Biotechnology program is knowledge generation, technology and product development for productivity gains, enhanced nutrition and ensuring quality, resistance to drought salinity, high temperature, resistance to pests and diseases, input use efficiency, climate resilience and biosafety. Agriculture biotechnology programme deals with a wide range of economically important crops including rice, wheat, cotton, millets, oilseeds and pulses. A major mission mode programme has been supported by the Department on “Minor Oilseeds of India Origin”. The mission mode programme is aimed at sequencing/re-sequencing and phenotypic characterization of germplasm resources of Minor Oilseeds (Sesame, Linseed, Safflower and Niger). In the mission programme, the four (4) major Network projects in execution will provide information on new genes to combat biotic, abiotic stresses and nutrition.



Following are some of the notable achievements:

**Rice varieties released:** CR Dhan802 introgressed with drought resistance trait

### Rice varieties under trials:

- **Pusa Basmati 1847:** Three bacterial blight and blast resistant NILs (Pusa 1847-12-62-90-39-7-15, Pusa 1847-12-62-184-36-9-155 and Pusa1847-12-62-64-12-6-8) developed
- 249 advanced breeding lines for improved tolerance to biotic stresses (to bacterial leaf blight, brown plant hopper, blast, and gall midge) and abiotic stresses (drought, salinity, improved scent, reduced plant height and seedling stage cold tolerance).
- Pusa 44 –Pup1 promising agronomic performance and Phosphorus use efficiency.

### Oilseeds varieties developed:

- **Mustard:** white rust resistance varieties Varuna, Pusa bold, Pusa Jai Kisan and Rohini were developed are currently under AICRP trials and eight seed companies have procured these lines through signing a tripartite Technology Transfer Agreement (TTA) involving Delhi University-DBT (BIRAC) – Seed Companies.
- **Groundnut:** DBG4 a high yielding variety resistant to foliar disease is under trials.

### Vegetables varieties developed:

- **Tomato:** ArkaVikas and Pusa Ruby resistant to Tomato Spotted Wilt Virus (TSWV) developed.

- **Tomato:** “Punjab Chuhhara” breeding lines resistant for leaf curl virus; late blight; and root knot nematode resistance developed
- **Okra:** Punjab Padmini resistant to Yellow Vein Mosaic Virus (YVMV)
- **Bittergourd:** Punjab-14 cultivar resistant to Bittergourd Yellow Mosaic Virus were developed

**Animal Biotechnology:** The main aim of Animal Biotechnology program is sustainable growth of livestock and poultry for nutritional security and economic prosperity as well as to enhance production and productivity of livestock through biotechnological interventions. Animal Biotechnology programme of the department is focused towards improving animal health by developing newer vaccines and diagnostics as well as improving animal productivity by developing newer reproductive technologies, genomics and genetic characterization and production of biopharmaceuticals through transgenesis.

A program on development of novel semen extender to optimize post thaw quality for enhancement of productivity and multiplication of superior goat Germplasm has been supported. A Network Programme on Anthrax Diagnosis and Control in India has been initiated. Department has also taken a major initiative for the establishment of a Consortium for One Health to address Zoonotic and Transboundary Diseases in India.

#### BIOENERGY, BIO RESOURCE AND ENVIRONMENT

**Energy Bioscience (Biofuel):** Department of Biotechnology has been promoting R&D for Biofuel Technology development recognizing the need for clean and renewable energy. A total of twelve Waste to Energy projects initiated to develop/ demonstrate novel and viable technologies for sustainable utilization of municipal solid waste (MSW) for cleaner and pollution free environment as well as generation of the energy. DBT-BIRAC Clean Tech Demo Park at Barapullah drain site, near Sundial Park, Sarai Kale Khan, was inaugurated by the Hon'ble Minister for Science & Technology Health & Family Welfare, and Earth Sciences. The DBT-BIRAC Clean Tech Demo Park will be used to demonstrate innovative Waste-to-Value technologies with support from DBT and BIRAC.



Pic: Inauguration of “Clean Tech Demo Park” at Barapullah by Hon'ble Minister S&T, H&FW and ES, for demonstration of clean technologies for waste treatment and value addition.

**Environmental Biotechnology:** Environmental Biotechnology programme is one of the areas where impetus is on waste management and environmental improvement. Efforts have been made to generate/formulate consortia from the existing isolates as well as new isolates for site-specific remediation of xenobiotics from the environment etc. Department has also initiated R&D projects on remediation and reclamation of Hexa-Chloro-Cyclo-Hexane (HCH) dumpsite by using microbial bioremediation technology, bioconversion of CO<sub>2</sub> to platform chemicals through microbial catalysed electrochemical approaches. Mangrove restoration technology developed with DBT support was successfully demonstrated at approximately 5-acre scale at Sunderbans, West Bengal. The restored mangrove successfully survived cyclone Amphan. Based on this success, scale up R&D project has been initiated in 100 acres of land.

**Bioresources And Secondary Agriculture:** The aim of the programme is to support R&D programme in the area of Bioresources and Secondary Agriculture for biomass biotransformations, bioresource systems analysis, and technologies associated with conversion production of value added products and processes from natural resources. Brainstorming-cum-Consultation meetings were organized for prioritization of R&D areas based on available research leads. Department took an initiative towards development of network project on exploration, discovery, and utilization of biological resources for sustainable development in North East India. During this year, efforts are being continued to support the research for bioprospecting, inventorization and



characterization, value addition and sustainable utilization of bioresources along with relevant training, capacity building and awareness generation. Various Brainstorming-cum-Consultation meetings were organized for prioritization of R&D areas based on available research leads. The Department has taken an initiative towards creating a consortium programme/virtual centre of Marine Bioresource and Biotechnology Network. The network comprises of around 20 institutes (DBT, CSIR, ES, MoEF & CC and ICAR) and Indian universities which are looking towards the basic, applied, and translational research in the field of Marine Biology.

**Forest Biotechnology:** The Department has taken this initiative to facilitate research and development in emerging areas of forest biotechnology. Overall aim of the programme is to support forest biotechnology with the focus on mapping and technological intervention for forest conservation, resource utilization, scientific management of invasion, studying ecosystem services and climate change mitigation.

**Translational Research On Medicinal And Aromatic Plants:** Department is providing research support across the country towards development of products and processes from medicinal and aromatic plants following multi-disciplinary approach. The aim is to use rich traditional knowledge in the country under three available regulatory frameworks: (a) US-FDA-Botanical Drugs, (b) DCGI-Phytopharmaceutical Drugs, and (c) AYUSH mode. The aim is to develop a herbal drug pipeline. During this year, the Department has launched a 'Phytopharmaceutical Mission for North East Region of India' with a view to promote development of phytopharmaceuticals in North East Region. A QC and QA facility for medicinal plants has been already established and cGMP facility for pilot-scale extraction for phytopharmaceutical products from the medicinal Plants of NE India is being set up. Under the Inter-Ministerial Cooperation program of CSIR, DBT and ICMR on 'Phytopharmaceutical drug development', a pipeline of phytopharmaceutical drugs has been developed. The Department has signed a Memorandum of Understanding (MoU) with National Medicinal Plant Board, Ministry of AYUSH for Inter-Ministerial Cooperation on biotechnological intervention in AYUSH sector and to have a platform for exchange of information between the NMPB, Ministry of AYUSH and DBT.

### Phytopharmaceutical Mission for North East Region of India

- cGMP facility for pilot-scale extraction for phytopharmaceutical products from the medicinal plants of NE India is being set up.
- A pipeline of phytopharmaceutical drugs was developed in collaboration with CSIR and ICMR.



### Turmeric Mission programme

- To generate high-quality raw materials from turmeric for development of nutraceutical products / dietary supplements for the global market.
- Development of curcuminoids / curcumin-based therapeutics for various disease conditions.

**Silk Biotechnology:** The programme on application of biotechnology towards developing newer and emerging technologies in silk and its applications in biomaterials continued during the year. Major focus was on development of improved races of silkworm for enhanced productivity, development of disease and pests control measures, improvement of host plants, and utilization of by-products etc.

## HEALTH CARE AND MEDICAL BIOTECHNOLOGY

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

**Infectious Disease Biology:** Considering the tremendous impact of these emerging and re-emerging diseases in India at socioeconomic and public health levels, steps were taken by the Department to redefine the Infectious Diseases Biology research in the country to harness the maximum benefit of this discipline in the line with developed countries. Under the aegis of Infectious Disease Biology program, the Department is supporting basic and applied research to better understand and ultimately provide solutions in terms of therapeutics,

diagnostics and preventive measures to prevent 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; neglected tropical diseases such as Malaria, Leishmania, Dengue, host-pathogen interactions, antibody as immune-therapeutics and antibiotic-resistant microbes. The Department provides funding opportunities and a comprehensive set of resources for researchers that support discovery and interdisciplinary research, pre-clinical development, and clinical evaluation in the area of infectious diseases including COVID-19 conditions. In addition, conscious efforts are being undertaken for promoting the scientific advancements in its various identified areas and other emerging areas.

**Drug Development Program:** India is a leader in global generic pharmaceuticals manufacturing. However, many generics manufactured in India are at the end of their respective product life cycle, with limited new research and development taking place on new drugs. Furthermore, our country has a high burden of both communicable and non-communicable diseases and is vulnerable to epidemics. In order to keep pace with global innovation and to improve health outcomes, there is a need to foster R&D for new and cost-effective therapies. With the aim to take India at global map in terms of R&D innovations in the area of drug development in our country, the Department has initiated a new program on “Drug Development” with a vision to develop indigenous and cost-effective new drugs against diseases prevalent in our country.

**Next Generation Treatment For Snakebite (NGTS):** Considering snakebites as one of the well-known medical emergencies in many parts of the world, especially in rural setup, World Health Organisation (WHO) has included snakebite into Category A of neglected tropical diseases. The Department has initiated a major Mission program, **Mission- Next Generation Treatment for Snakebite (NGTS)** with a vision to develop an indigenous, cost-effective and globally accessible technology with the aim to cater the needs of the affected people and facilitate employment generation through training and skill development under Make-in-India and Skill India missions of the Government.

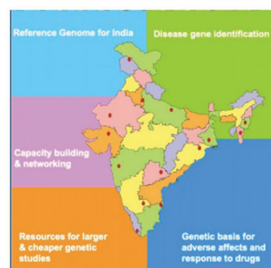
**Neurosciences:** Neuroscience program address a wide

spectrum of neurological disorders. A multi-centric program on Dementia involving eight sites across the country has been implemented. Long-term population-based and hospital-based cohorts of Dementia patients will be set-up and follow up of patients will provide reliable data regarding incidence, prevalence, biomarkers, risk and protective factors. DBT has supported a multi-institutional ‘Dementia Science Programme’ with National Brain Research Center (NBRC), Manesar as the nodal centre. The programme aims to arrive at reliable estimate of prevalence and incidence of dementia including Alzheimer’s disease in the country.

**Human Genetics & Genome Analysis:** The Human Genetics and Genome Analysis (HGGA) program addresses issues related to specific inherited diseases. Major steps have been taken by the Department towards improving the understanding of genetic disorders prevalent in our country in terms of new research on disease diagnosis and therapeutics. DBT- Unique Methods of Management of Inherited Disorders (UMMID), GenomeIndia and the Human Microbiome initiative, are a few of the major initiatives that have been initiated. Taken together, these will help in understanding the role of genetic and genomic components in human health and disease, and the crosstalk of these components with environmental factors, lifestyle, and cultural practices. The understanding thus acquired can be utilised for the improvement of human health by promoting development and dissemination of genomic methodologies and tools for prediction, diagnosis and prevention of disease, and for developing affordable therapeutic interventions. Efforts have also been made to formulate a National Mission on Health Genomics. Draft DPR has been prepared and circulated for expert comments and inter-ministerial consultation.

### GenomeIndia Project

Pan-India project to catalogue variation in Indians through whole-genome sequencing of 10,000 individuals across India.



### Human Microbiome Initiative

To map the influence of diet, lifestyle, geography and age on the gut microbiome in 17 different endogamous groups across India.

#### Objectives

- Generate baseline gut microbiome data.
- Understand diet and gut microbial community relation.
- Understand the association between Ayurvedic phenotype and microbiome.



**Maternal and Child Health:** Maternal & Child Health is an important priority area for the country's health to reduce maternal and child mortality. Several initiatives have been taken for advancing research and scientific knowledge in this area which encompasses research from preconception to adolescence. Under this program coordinated by an interdisciplinary research group christened as GARBH-Ini (interdisciplinary Group for Advanced Research on Birth outcomes), a unique pregnancy cohort comprising more than 8000 women has been established comprising methodologies of clinical, epidemiological, statistical, genetic, proteomic and imaging sciences to study Pre Term Birth (PTB).

**Public Health and Nutrition:** This program focuses on Research and Development Activities, oriented for addressal of food sufficiency and security. The areas under support includes addressal of micronutrient deficiencies including anemia, severe acute malnutrition, Protein and malnutrition, food fortification, probiotics for human health and well-being, food safety, Some of the recent R & D initiatives includes the "Food fortification and newer technologies to improve bioavailability of nutrients" and Geriatric Nutrition. The programme has a mandate to provide technological and clinical solutions for public health nutrition issues. Recently R&D programs on Agri Nutrition linkages has been undertaken to address the protein malnutrition prevalent across the country.

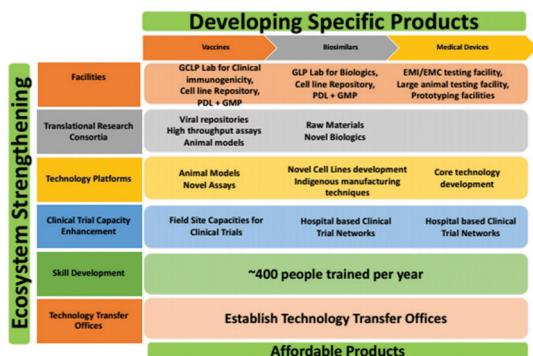
**Stem Cells and Regenerative Medicine:** The unique properties of stem cells to self-renew and give rise to subsequent generations with variable degrees of differentiation capacities, offers significant potential for generation of tissues that can potentially replace diseased and damaged areas in the body, with minimal risk of rejection and side effects. The Department continues to support basic, early and late translational research in the area of stem cells and regenerative medicine with emphasis on developing protocols for isolating and growing stem cells from various origins, advancing gene and cell therapy, creation of animal models for various human diseases and capacity building. The Department also played crucial role in formulation and release of guidelines particularly, 'The National Guidelines for Stem Cell Research' and 'The National Guidelines for Gene Therapy Product Development & Clinical Trials' jointly with ICMR.

**Biomedical Engineering:** Biomedical engineering is a highly interdisciplinary area of research involving cross disciplinary knowledge from engineering and other quantitative sciences for unravelling the complexities of biological systems and provide cost-effective solutions for improved quality of life. With a priority to study emerging diseases, to manipulate/engineer genomes, develop transgenic systems and develop genome-based diagnostics the department significantly contributes towards biomedical engineering field for development of affordable devices, diagnostics, bio composites, tissue engineering, biosensors etc. During the year PLUTO: A modular, portable, and compact robot for training different hand functions (for hand neurorehabilitation) and a technology for Sonography Training Simulator have been developed.

**Vaccine Research and Development:** Vaccines are one of the most cost-effective health interventions for combating infectious diseases. Hence, over the past three decades, the Department of Biotechnology (DBT) has made concerted efforts to strengthen the Indian vaccine R&D ecosystem, through adoption of pioneering strategies like fostering active partnerships with relevant global leaders and implementation of innovative funding mechanisms. The most significant international partnership that contributed immensely towards development of indigenous vaccine science is the Indo-US Vaccine Action Programme (VAP), a bilateral programme being jointly implemented by DBT, and the National Institutes of Health (NIH), since 1987. The programme demonstrated major achievements like the development of the low-cost Rotavirus vaccine which became part of the universal immunization programme and development of vaccines for diseases like Malaria, Dengue and Tuberculosis. Horizon 2020 Programme is another initiative, wherein the Union Government and European Union (EU) have collaborated to develop cost-effective and affordable universal Influenza vaccine. The Ind-CEPI Mission was initiated in 2019, in partnership with the global foundation, the Coalition for Epidemic Preparedness Innovations (CEPI), for supporting vaccine development for potential outbreak threats up to Phase II testing and enhancing inter-ministerial co-ordination for rapid vaccine development. Innovative funding mechanisms are being facilitated through the National Biopharma Mission (NBM) - an Industry-Academia collaborative Mission, being implemented by BIRAC, a Public Sector Undertaking of DBT.



## National Biopharma Mission: Accelerating Affordable Product Development



**Chronic Disease Biology:** The aim of the Program Division is to develop & support competitive R&D programs and generate new programmes from basic to clinical and translational research identified under non-infectious disease conditions. The areas cover chronic non-communicable diseases across lifespan. Diseases addressed in the program include but are not limited to Cancer, Diabetes, Hypertension, Cardiovascular Diseases, Lung Diseases, Kidney Disorders, Autoimmune Disorders, Eye Diseases, Osteoporosis & Bone Biology, Diseases of the Gastrointestinal System, Neurological Disorders etc. The International Cancer Genome Consortium (ICGC) was formed to obtain comprehensive catalogues of genomic abnormalities (somatic alterations, abnormal expression of genes, epigenetic modifications) in 50 different tumor types and/or subtypes which are of clinical and societal importance across the globe. India is a founding member of this consortium along with countries such as Australia, Canada, China, France, Japan, UK and USA. India has participated in ICGC to generate evidence of genomic alterations in oral cancer, which is of high prevalence in our country.

## KNOWLEDGE GENERATION AND DISCOVERY RESEARCH, NEW TOOLS AND TECHNOLOGIES

**Basic Research in Modern Biology:** Basic Research is the core strength in all disciplines of life-sciences to address various issues in modern biology. Integration of recombinant technology and process design, as well as *in-silico* modelling and process systems engineering for efficient bio-processes development and manipulation of Bio-systems through metabolic engineering techniques is being attempted to provide novel enzymes, pathways and cells. Basic research

in Biology is essential for nurturing the expansion of knowledge. The Department through Basic Research in Modern Biology has been funding basic research in a variety of biological science fields with a goal of generating new knowledge to enhance, transform and translate the new leads. The DBT-IISc partnership program has supported the collaborative activities between the faculty of the Division of Biological Sciences and the faculty from various other science and engineering divisions. These collaborative efforts have resulted in the development of newer drug options for the treatment of tuberculosis which continues to be a major societal problem in the country.

**Nanobiotechnology:** This program fosters innovations with an approach to found application/translation-oriented projects. Key objective of the programme is to advance research and promoting innovation through applications of nanobiotechnology to address issues in health, energy, agriculture and environment. Recent, initiatives under the programme area includes “Nanotechnology based tools to enhance agricultural productivity” and “Nanotechnology interventions in Dentistry and Bone diseases”. Some of the achievements include; release of the “Guidelines for evaluation of Nanopharmaceuticals in India” jointly formulated by Department of Biotechnology, ICMR and CDSCO and “Guidelines for evaluation of Nanobased Agri and Food Products in India” to push innovation and product development.

### Genome Editing Technologies and their Applications:

Genome editing techniques can be exploited to engineer genome by insertions, deletions, modifications or replacements of DNA segments in a site specific location in the genome of a living organism leading to development of genetically engineered organisms for biomedical and agricultural applications. RNAi, Transcription Activator-like Effector Nucleases (TALENs), and the Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR/Cas9) systems are the most widely used approaches in genome editing. Recognizing the importance of such technologies to study and manipulate the genome, the DBT has been engaged in promoting research and innovation in the area of genome engineering technologies, and their applications for addressing specific unmet needs in the areas of Human Health, Agriculture and Plant Productivity, Environment and Bioresources, and Animal Health. Genome editing tools have

been utilized to unravel the regulatory mechanism for the accumulation and degradation of  $\beta$ -carotene in fruit-pulp of Banana and to modify certain genes to develop pro-vitamin-A biofortified Banana variety. CRISPR-based technologies in combination with single-effector nucleases are being utilized for development of diagnostics for viral diseases, such as AIDS and Hepatitis, and experimental therapeutics for genetic and complex diseases

**Theoretical and Computational Biology (Bioinformatics, AI, and Big Data):** The major objective of the programme is development of Bioinformatics in the country through establishing the necessary infrastructure. Under the programme Department has implemented Biotechnology Information System Network (BTISNet) wherein 150 Bioinformatics Centres were supported in various Universities and Research Institutions spreading across the country and also the 'Supercomputer Facility' at one of the centres are supported. Department is currently revamping BTISNet Centres for establishment of Bioinformatics and Computational Biology Centres involving data driven research, applications of artificial intelligence, machine learning, high-throughput data related informatics etc. in various sectors of life sciences. R&D support in this area has emanated into significant technological advancement.

#### Key Technology/Process Developed

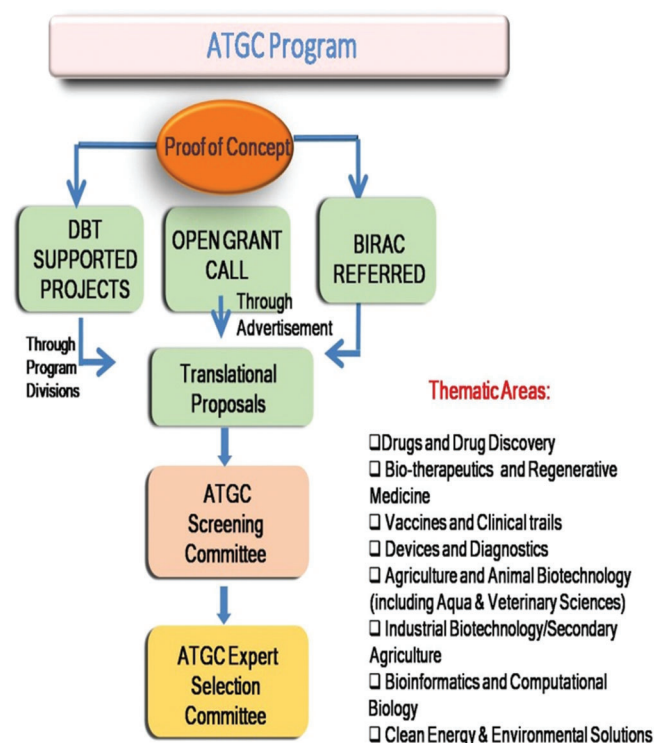
- i. **GenoVault:** A Cloud based Genomics Repository
- ii. **pPerturb:** Web-Server for Predicting Mutation Induced Destabilization of Buried Residues
- iii. **Universal Parser Library:** - A primary code of the framework for standards based input/output formats support for data interoperability.
- iv. **QuantWiz<sup>®</sup>:** - A robust quantitation tool for isobaric labeling methods like iTRAQ and TMT for proteomics data.
- v. **Search Integration Pipeline (SIP):** - Searches from multiple algorithms and statistical validation in one turn-key approach.
- vi. **Pluggable Score:** - Multiple scoring algorithms for time efficient data analysis.

Department is supporting the projects for application of AI in accordance with the NITI Aayog's Policies of **#AIforAll** wherein

proposals regarding applications of Artificial Intelligence Artificial Intelligence for Affordable and Accessible Healthcare. Some of the key research innovations being supported are in the area of cancer, tuberculosis and pulmonary diseases, diabetic & cardiovascular diseases, ophthalmological diseases, neurological disorders and methods/ drug development in the research institutes and Universities throughout the country for the development of predictive models and diagnostics and assistive devices.

#### ACCELERATED TRANSLATIONAL GRANT FOR COMMERCIALIZATION (ATGC)

A number of obstacles, scientific, institutional, cultural and policy have limited the opportunities for basic investigators to conduct translational science. Translational research is best conducted through multi and inter-disciplinary collaborations which can be difficult to establish and maintain in an academic environment that encourages domain expertise and rewards individual achievements and hypothesis-driven research. In addition, basic investigators face inadequate funding, resources, infrastructure for developing translational research programs. Furthermore, they often lack sufficient experience with essential methods and techniques and complex regulatory requirements to be effective in the realm.



To address these issues, DBT has developed a program entitled 'Accelerated Translational Grant for Commercialization' (ATGC) for academic researchers to take their fundamental research to next phase via translational research opportunities that launch their idea towards an end-use application.

## BUILDING A VIBRANT ECOSYSTEM – CONNECTING UNIVERSITY RESEARCH AND INDUSTRY

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

Over the years DBT has supported infrastructure development in DBT autonomous institutions and other organizations. Recently, department has initiated 'Scientific Infrastructure Access for Harnessing Academia University Research Joint Collaboration (SAHAJ)' program to give scientific infrastructure access to Research Institutes, Universities, Colleges and Start-ups / Entrepreneurs.

The DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research (DBT-BUILDER) has been an important sub-program under the RRSFP program through which DBT has supported the Life Science Departments of various Central and State universities thereby promoting interdepartmental cross-talk with the vision to nurture a large number of post-graduate students to nurture them and make them competent enough for globally competitive emerging bio-economy.

### DBT SAHAJ Portal

53,685 users  
Revenue Generated  
~ Rs. 2.00 crores

28 articles published in peer reviewed journals under DBT BUILDER

### 2 mega facilities established

Class 100,000 (ISO 8) Facility for *in vivo* biomedical research at Indian Institute of Science, Bangalore  
ESRF Phase III at RCB, Faridabad

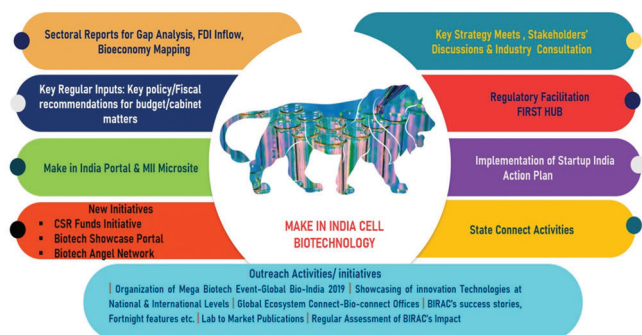
56 new proposals approved for funding under DBT BUILDER in PG colleges and Universities across 15 states and 1 Union Territory

**Biotechnology Science Cluster:** Research and development in the Biotechnology sector in a cluster format with core emphasis on innovation is critical for the growth of biotechnology entrepreneurship. The Department emphasized the need to establish Biotech Science Cluster in its National Biotechnology Development Strategy document in order to exploit biotech sciences towards accelerated technology and product development. Further the announcement for the same was made by the present government in its budget speech in 2014 following which, four Bioclusters were established since 2015 at Faridabad (Haryana), Bangalore (Karnataka), Kalyani (West Bengal) and Pune (Maharashtra). to spur innovative research and development and entrepreneurship activities. The significant achievements made under existing Biocluster includes establishment of high end facilities such as National structural biology facility with Electron Cryo-microscope; an Advanced Technology Platform Centre with a Bioincubator; a platform to study on a large data analysis on problems ranging from plant pathogen interactions to understanding neuronal circuits and establishment of a system medicine platform for generating required biological and medical evidence to accelerate systems medicine. These facilities are fully functional and are serving as National facilities catering to researchers across the country. The mechanism to access these facilities are in place with a peer-review mechanism in most of the cases.

## PROMOTING ENTREPRENEURSHIP AND INDUSTRIAL GROWTH

**Make in India and Startup India:** The DBT alongwith BIRAC is playing a crucial role in implementation and delivery of the flagship programs of the Government of India, such as 'Make-in-India' and 'Startup India'. DBT recognizes the

necessity for entrepreneurship development among the youth in the country and hence has taken initiatives to build, support and promote Indian biotech ecosystem in healthcare, agriculture and industrial biotechnology. The Make-in-India Cell ensures wider dissemination of the Government programs and other information relevant to the establishment and growth of startups, SMEs and companies in the country.



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

**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. Teams of SiB Fellows started to work on projects to address the underlying Covid situation. The projects entitled “Indigenous Production of Novel Personal Protective Equipment for Healthcare Personnel” and “A non-invasive ventilation device for patients with chronic obstructive pulmonary disease” were selected under the DBT-BIRAC COVID-19 Research Consortium Call.



Digital Microscope enabled with Artificial Intelligence



Ultrasound based therapy using low intensity pulsed ultrasound



Indigenous Production of Novel Personal Protective Equipment for Healthcare Personnel



Intraoral dental aerosol containment device

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

- Two technologies have been developed under SIB including Technology for a non-invasive ventilation device for patients with chronic obstructive pulmonary disease and Dual device for screening & Treatment of Pre-cancerous Lesions
- One Product, *Flexicast* - A breathable and customized cast for immobilization of fractured limb, has been commercialized from SIB.
- Finger-prick whole blood compatible rapid and affordable test for typhoid developed at CBD was transferred to Faculty-Start-up.
- A realistic model of the upper gastrointestinal track was developed by BBI for simulation of real-time endoscopy.
- HTIC and Helyxon, a healthcare startup have successfully deployed a jointly developed remote patient monitoring solutions for COVID-19. The device is a first-of-its-kind in the market that does clinically accurate continuous monitoring of four critical parameters – Temperature, Oxygen Saturation, Respiratory Rate and Heart Rate.
- *iQuant Analyser* - the country's first indigenous immunoanalyser instrument developed by HTIC in partnership with J Mitra. Rapid testing of multiple key blood markers for diabetes (HbA1C), vitamin deficiencies (Vitamin D), hormones (TSH, T3, T4, TSH), inflammations (cRP), infectious diseases (Dengue, Influenza) etc., at an affordable cost.



**Biotechnology Parks & Incubators:** The Department of Biotechnology has established Biotechnology Parks/ Incubators across the country to translate research into products and services by providing necessary infrastructure support. These Biotechnology Parks offer facilities to scientists, and Small and Medium sized Enterprises (SMEs) for technology incubation, technology demonstration and pilot plant studies for accelerated commercial development of biotechnology. The Department so far, has supported 9 Biotechnology Parks in various States. These are: i) Biotech Park, Lucknow, Uttar Pradesh; ii) Biotechnology Incubation Centre, Hyderabad, Telangana; iii) Tidco Centre For Life Sciences (TICEL) Biotech Park, Chennai, Tamil Nadu; iv) The Golden Jubilee Biotech Park For Women, Chennai, Tamil Nadu; v) Biotech Park Technology Incubation Centre, Guwahati, Assam; vi) Biotechnology Incubation Centre, Cochin, Kerala; vii) Biotechnology Park, Bangalore, Karnataka; viii) Industrial Biotechnology Parks (IBTPs), Jammu & Kashmir; and ix) Chhattisgarh Biotech Park, Naya Raipur, Chhattisgarh. These parks are successfully accelerating the commercialization of new technologies, nurturing and maintaining emerging ventures and assisting new enterprises to forge appropriate linkages with other stakeholders of biotechnology sector including academia and government.

## BUILDING INTERNATIONAL COLLABORATIONS AND PARTNERSHIP

The International Cooperation programme of the Department of Biotechnology (DBT) is an effort to bridge the technological and capacity gap in new and emerging areas of life sciences through collaborating with the best in science across the globe. The programme facilitates opportunities to interact, collaborate, and train with global-best in research, innovation, and technology interventions relevant to the Indian context; for enabling creation of new knowledge and fostering capacity building. Through these partnerships, the department endeavours to leapfrog scientific advancements in the country. Partners include Government S&T organizations, research/academic institutions, councils, philanthropic organizations, and NGO's. Currently, the department maintains active **Bilateral Partnerships** with Australia, Brazil, Canada, Denmark, European Union, Finland, Germany, Japan, Russia, Spain, Sweden, Switzerland, South Africa, U.K, USA and The Netherlands; and **Multilateral Partnerships**

with BRICS, HFSP, EMBO, TaSE, and Globalstars (EUREKA). Under the scheme Department also partnered with **Philanthropic Organizations** (Bill & Melinda Gates Foundation (BMGF)-the USA, Wellcome Trust (WT)-UK), Cancer Research UK (CRUK), Universities (Cambridge University UK, Monash University Australia, and Heidelberg University Germany), and other NGOs (Nobel Media, Prakashlabs).

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 extensive 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 Agriculture and allied sciences. Apart from these areas, during the year, various R&D initiatives under the programme were taken to address challenges of the COVID-19 pandemic including efforts related to understanding the pathophysiology, epidemiology, development of vaccine, diagnostics and therapeutics.



### DBT's Partnership with UK



#### Cancer Research UK (CRUK)



Seven thematic areas/core challenges:

- Prevention
- Early Detection
- Early Diagnosis
- Computational Approaches
- Small Molecule Treatment
- Affordable Treatment
- Children and Youth cancer prevalence

DBT and UKRI to address the challenge of antimicrobial resistance in India.

DBT and DFID-ESRC-MRC launched Phase II of the Global Research Programme for addressing the health needs of women and children in the most disadvantaged populations globally.

Joint Centre for Cancer Biology & Therapeutics with MRC in NCBS created several first-in-class lead compounds that modulate targets considered initially undruggable.

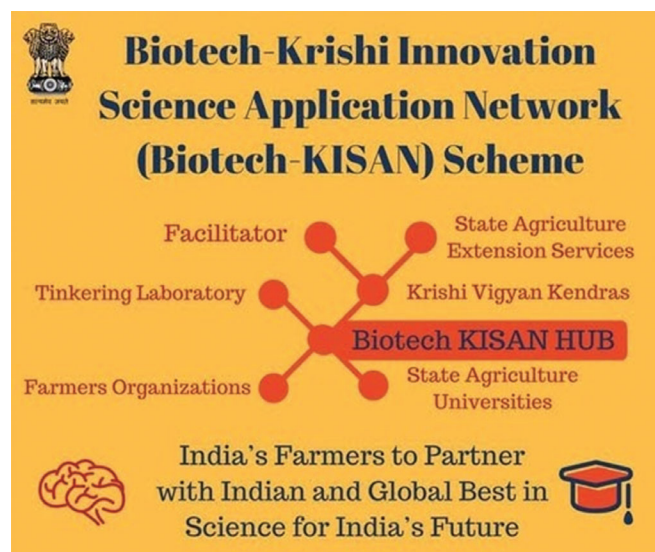
## SPECIAL PROGRAMMES

### Programmes of Societal Relevance – Rural, SC/ST Population:

Department has been supporting projects aiming to promote use of biotechnological processes and tools for the benefit of the women, rural and SC/ST population. The programme aims to create platform for self-employment generation among the target population by diffusion of proven and field-tested technologies through

demonstration, training and extension activities. The projects are being supported in agriculture and animal husbandry including fish farming, poultry farming, pig production, goat farming, value added products, floriculture, hybrid seed production, integrated farming system, entrepreneurship development, bio-resource utilization, women and child health, hygiene and nutrition. Many rural farmers including youth, SC/STs population and women have been benefited through implementation of the biotechnology-based programme for societal development.

**Biotech-KISAN:** DBT also has Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) program that empowers farmers, especially women farmers. It aims to understand the problems of water, soil, seed and market faced by the farmers and provide simple solutions to them. 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.



**Biotechnology Programme for North East Region:** The Department has been focussing on developing local capacities to address regional challenges and harness endemic bioresources for economic development of the North East Region. To effectively manage the programme, NER Biotechnology Management Cell (NER-BPMC) has been set up by at its Autonomous Institution, The Institute of Life Sciences (DBT-ILS), Bhubneshwar. The Department has proactively launched several region-specific programmes for

research and development, human resource development, establishment of research and training infrastructure, programmes for entrepreneurship development and specific network programmes targeting local problems.

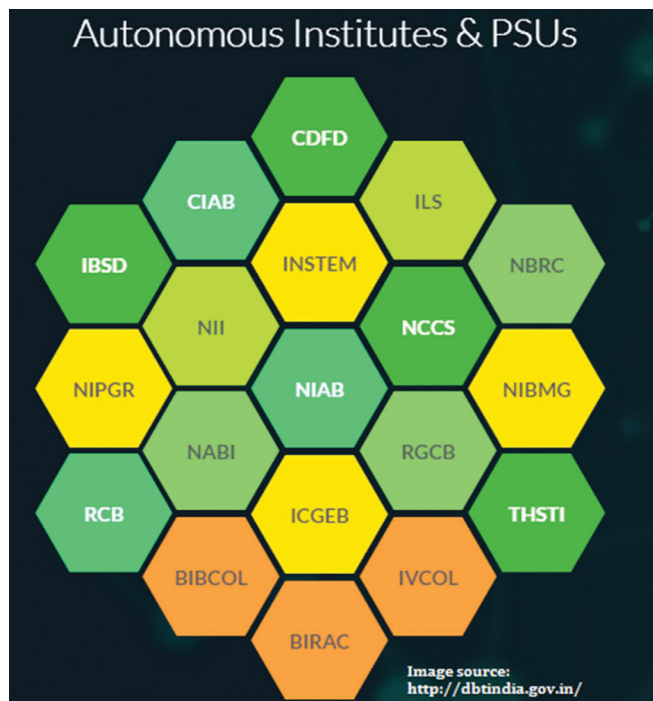
Three Centres of Excellence have been established in NER. North East Centre for Agriculture Biotechnology (NECAB) at AAU Jorhat focuses on improvement of local rice against regional challenges. The centre has also developed 5 bioformulations and signed MoUs with 3 companies. Satellite labs have been set up in KVKs of five different states of NER for onsite production of Bioinputs. Fisheries and Aquaculture Biotechnology (FAB-CoE) at College of Fisheries, CAU, Tripura has standardised protocols for mass-scale multiplication of 3 food and 3 ornamental fishes in NER. Demonstrations are being conducted in the farmer's field. A CoE on Bio-Resource and Sustainable Development is being set up by Arunachal Pradesh with focus on establishment of (i) State-of-the-Art Orchidarium at Kimin and (ii) Medicinal and Aromatic Plants Garden for ex-situ conservation of priority species along with establishing essential oil distillation units. The centre will work in close coordination with local farmers.

A State-of-the-Art Infrastructure Facility, the North East Centre for Biological Sciences and Healthcare Engineering (NECBH), has been established at IIT-Guwahati. The facility can be accessed by all researchers across NER. The facility has been utilised by 30 NER researchers and these researchers have published 2 patents and 20 research publications. Under the 2 training programmes conducted 98 researchers. As a component of the project 34 small joint R&D projects have also been initiated with researchers across NER.

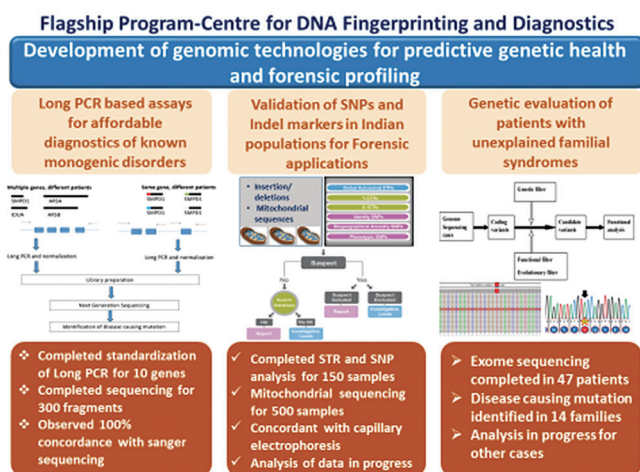
### AUTONOMOUS INSTITUTIONS:

DBT has established 16 theme-based institutions across the country. These institutions are pursuing basic, discovery and translational research in line with the National missions in the areas of agriculture biotechnology, animal biotechnology, medical biotechnology, clean energy and bioresources development, secondary agriculture, etc. The institutions also have a mandate of human resource development and societal outreach. During the year, apart from the R&D activities in various areas of Biotechnology and Modern Biology, the autonomous institutions have taken R&D initiatives to address the challenges due to COVID-19 pandemic including

efforts related to understanding the pathophysiology and epidemiology of the disease, and development of diagnostics, vaccine and therapeutics which are discussed in Chapter-7. Besides, during the year, all the autonomous institutes of DBT have initiated flagship programme based on their core competence in the respective areas.

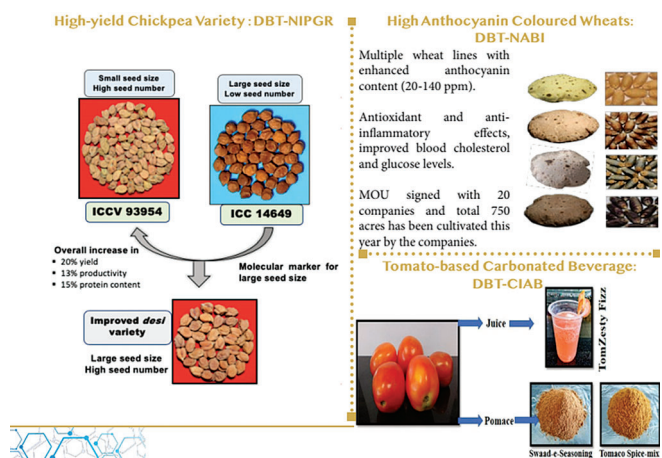


**Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad** provide specialized DNA fingerprinting services, medical diagnostics, and to carry out fundamental research in the frontier areas of modern biology. CDFD has initiated a flagship Programme “Development of genomic technologies for predictive genetic health and forensic profiling”.



**Institute of Life Sciences (ILS), Bhubaneswar** has a broad vision of carrying out high-quality multidisciplinary research in the area of life sciences. The goal is for overall development and betterment of human health, longevity, agriculture and environment. ILS has developed 27 useful plant expression vectors coupled to recombinant promoters for boosting agricultural production under stress conditions. A recombinant construct was also developed as a whole cell biosensor for the detection of arsenic in drinking water. One scientist has been given DBT product & process development award for development of antibodies against the non-structural proteins against chikungunya virus.

**National Agri-Food Biotechnology Institute (NABI), Mohali** has developed a novel edible coating formulation based on wheat straw polysaccharide and stearic acid esterified oat bran polysaccharide for the post-harvest shelf life improvement of perishable fruit crops (Apple, Peach and Banana). Further, a major research initiative in the form of institutional flagship program was initiated on nutritional biofortification of Wheat to enhance the traits such as micronutrient, protein etc along with six other co-partners. The research efforts yielded 65 high impact publications as well as filing of 7 patents. Furthermore, NABI has supported 121 research scholars and trained 84 young students.



**National Institute of Plant Genome Research (NIPGR)** undertakes research of high caliber in basic and applied areas of plant science and agricultural biology. Earlier Institute had elucidated the whole genome sequence of tomato and chickpea to be used in crop improvement through genomics assisted breeding. Several key genes, proteins and molecular markers have been identified from genomics and proteomics studies in crop plants and functionally characterized for



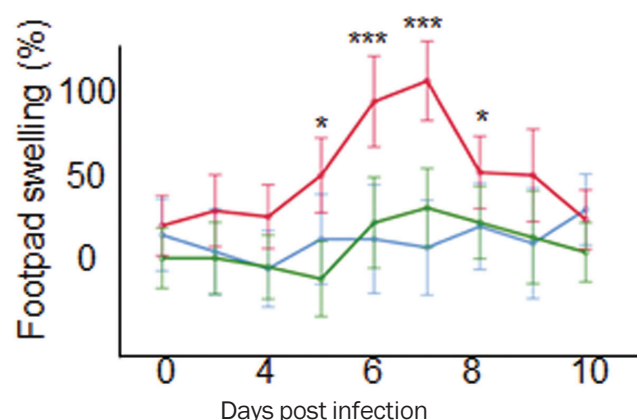
enhanced productivity, seed longevity, nutritional quality, tolerance to abiotic stress and disease mitigation. Nutritionally enriched food crops like potato and rice; anti-nutrient free tomatoes, soybean, mustard and lathyrus; and high yielding chickpea varieties have been developed. Cellular pathways for chitosan-triggered immunity, major QTLs and antifungal protein for fungal disease tolerance have also been identified and currently the knowledge generated is in use to develop disease resistant rice and chickpea cultivars. A state of the art “Advanced Research Platform for Crop Sciences” has been established for gene function analysis, metabolomics and proteomics studies.

**Center of Innovative and Applied Bioprocessing (CIAB)**, Mohali has licensed two technologies: (i) processes for development of tomato based seasoning/spice-mix and beverage and ii) iron fortified or iron added turmeric as a value added product for improving iron nutrition to M/s AamztofaamzTechnosolutionsPvt. Ltd, Mohali. DBT funded flagship programme on utilization of rice residues for value added product development was also initiated along with INST, Mohali. CIAB has filed seven patents have been granted and published 32 high impact research publications. CIAB also supported 49 research scholars.

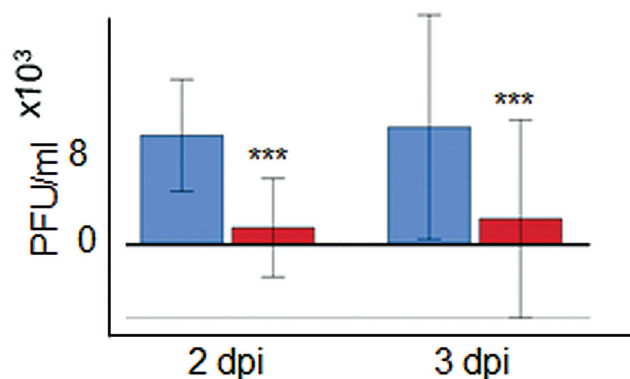
**National Institute of Animal Biotechnology (NIAB), Hyderabad** is aimed to harness novel and emerging biotechnologies and take up research in the cutting-edge areas for improving animal health and productivity. NIAB has developed a genomic CHIP for identification of indigenous breeds of cattle. It will help in conservation of pure breeds in various pockets of the country. The Brucella detection kit (lateral flow and ELISA) will be useful for the farmers to identify brucella infection in cow, buffalo, sheep and goat. It will also be able to differentiate between the Brucella infected animals from the vaccinated animals. The biosensor developed for detection of SARS-CoV-2 infection in human's beings can detect the virus in femto molar range.

**Regional Centre for Biotechnology (RCB), Faridabad** is an academic institution with regional and global partnerships synergizing with the programmes of UNESCO as a Category II Centre. The primary focus of RCB is to provide world class education, training and conduct innovative research at the interface of multiple disciplines to create high quality human resource in disciplinary and interdisciplinary areas of biotechnology. An interdisciplinary

PhD program in Biostatistics and Bioinformatics is also being conducted through a collaboration with the global pharmaceutical giant, GlaxoSmithKline Pharmaceuticals India Private Ltd. (GSK). RCB under its flagship program on development of small-molecule antivirals against Chikungunya and Japanese Encephalitis viruses identified some lead compounds that show significant inhibition of CHIK virus infection in three different cell types. One of these compounds was tested in the mouse model of CHIK virus infection where its antiviral activity could be clearly demonstrated. The compound is under further evaluation for its antiviral potential and development.



Antiviral activity seen in the mouse model



Antiviral activity seen in cell culture

**National Institute of Immunology (NII), Delhi** is committed to advanced research addressing the basic mechanisms involved in body's defence to identify modalities for manipulation of the immune system to provide protection against diseases and understand mechanisms that can be used to target disease processes for intervention. NII has identified novel di-isonitrile

lipopeptides from *Mycobacterium tuberculosis* named 'kupyaphores' – ('Kupya' in Sanskrit refers to metals other than gold & silver and 'phores' means carrier). These molecules are induced very early during infection and primarily required for bacterial zinc homeostasis and produced by a biosynthetic operon. Besides, Phase II clinical trials of a dendritic cell-based vaccine targeting SPAG9 (Sperm-associated antigen 9) protein are currently underway in patients of cervical cancer.

**Translational Health Science and Technology Institute (THSTI), Faridabad** is engaged in theme-based research programs each prioritizing public health problems unique to India identified to translate domain knowledge to usable products. THSTI started collaborative project with Bionees India Private Ltd. and NCCS, Pune for developing method of treatment of HIV infection and another collaborative project with Premium Serum for the development of aptamer based TB diagnostics.

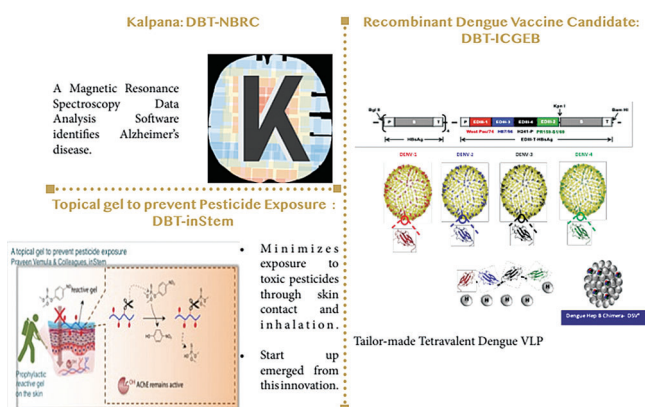
**National Brain Research Centre (NBRC), Manesar** is dedicated to provide infrastructural facilities and a coordinated multidisciplinary team to work at the frontiers of neuroscience research and network the existing groups and whenever required, create satellite units to catalyse the overall growth of this discipline in the country. NBRC has identified receptors (host protein) in neurons, which facilitates the entry of Japanese Encephalitis Virus into cells; the importance of inflammatory pathways in neurodegeneration which follows infection of the brain by the Chandipura virus; role of an ubiquitin ligase, Rnf2, that regulates synapse maturation via non-degradative function of protein ubiquitination that is linked to a neuro-developmental disorder known as Angelman Syndrome.

**Biotechnology (ICGEB), Delhi** is a unique, Intergovernmental Organisation, with biotech labs in Italy, India, and South Africa works in the area of Genetic Engineering and Biotechnology. ICGEB has developed high yielding rice through silencing of one of the specific cytokinin oxidases, making it possible to obtain "More grains per plant". Another breakthrough achieved lately is the development of multiple abiotic and biotic stress tolerant rice, through the manipulation of glyoxalase pathway, which show minimum yield penalty under stress conditions.

**Institute for Stem Cell Science & Regenerative Medicine (inStem), Bangalore** is a state-of-the-art research institute, dedicated to the study of stem cells and regenerative biology with translational emphasis. inSTEM established the National CryoEM Facility. The facility is equipped with a 300 kV Transmission Electron Microscope (TEM) that is capable of high-resolution structure determination of macromolecules in solution as well as *in situ* in cells by tomography.

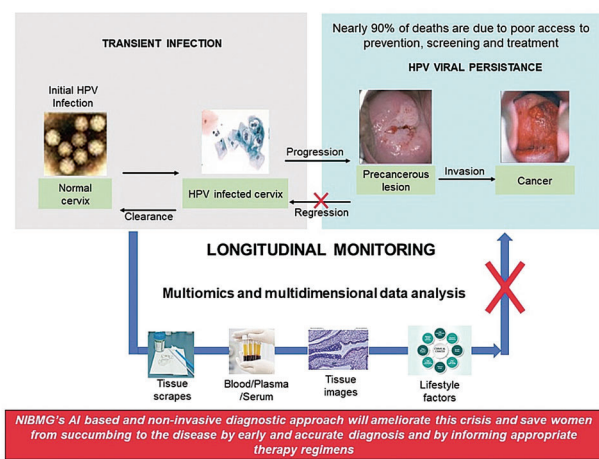
**Rajiv Gandhi Centre for Biotechnology (RGCB), Trivandrum** Is devoted to research in Molecular Biology and Biotechnology and working on different areas of biological sciences like Cancer Research, Cardiovascular Disease & Diabetes Biology, Pathogen Biology, Regenerative Biology, Plant Biotechnology & Disease Biology, Neurobiology, Reproduction Biology, and Transdisciplinary Biology. RGCB published the use of a single dose of HPV vaccine to prevent cervical cancer instead of the regular three doses, showed role of metformin in regression of vascular disease in patients with type 2 diabetes and demonstrated enhancement of cardiac mitochondrial functions in hypertrophy by Amalakirasayana, a traditional Indian Ayurvedic product. RGCB Bio-Nest facility, managed by Rajiv Gandhi Centre for Biotechnology and Kerala Start-Up Mission, Government of Kerala, provides incubation facility for young entrepreneurs and has state-of-the-art equipment to facilitate research and development.

**National Institute of Biomedical Genomics (NIBMG), Kalyani** is the first *institution* in India explicitly devoted to research, training, translation & service and capacity-building in *Biomedical Genomics*. launched Doctoral program on Biostatistics and Bioinformatics, jointly with Regional Centre

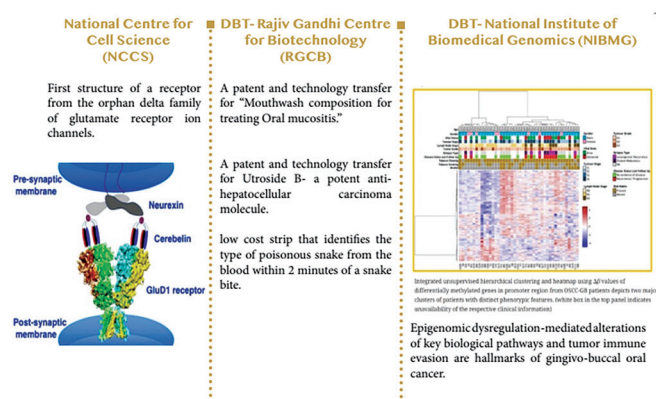


for Biotechnology (RCB) and GlaxoSmithKline Private limited (GSK). NIBMG has taken genomic laboratories and genetic testing to the doorsteps of clinicians by establishing a Unit in the largest tertiary care government hospital in Kolkata, the SSKM Hospital. About 800 patients have benefitted by getting genetic tests done for various disorders. NIBMG flagship program is on Integrating multi omics data using big data analytics to infer optimal wellness trajectories for management of non-communicable diseases.

#### FLAGSHIP PROJECT



**National Center for Cell Science (NCCS), Pune**, is one of the premier research centers in India, which works on cell-culture, cell-repository, immunology, chromatin-remodelling. During the year NCCS deciphered the 3D molecular structure of a key brain receptor protein called GluD1, which mediates critical nerve functions of the central nervous systems, such as memory, mobility, cognition, and growth, and could therefore help gain a better understanding of neuronal disorders. NCCS has reported the 1<sup>st</sup> cryo-EM structure of a eukaryotic membrane protein from India. NCCS is serving as a national repository of animal cell cultures and supplied almost three thousand five hundred cell cultures to research/academic organizations, including for the purpose of COVID-19 related work.



**Institute of Bioresources and Sustainable Development (IBSD), Imphal, Manipur:** Institute of Bioresources and Sustainable Development (IBSD) is carrying out research and development activities in the areas of plant resources, microorganisms, traditional foods, and animal resources for various applications in phytopharma drug development, nutraceuticals. Conservation, Propagation and Mass Multiplication of Selected Orchid species from North-East has been initiated and a pilot project has been sanctioned for developing bio-based entrepreneurship in North-East India. Total of 60 Orchids species have been collected so far. The construction of Orchidarium and auxiliary facilities for production, mass & post-harvest units are underway. Potential entrepreneurs are being identified.

**DBT AUTONOMOUS INSTITUTIONS FLAGSHIP PROGRAMS:** DBT AIs are implementing identified flagship projects that are strategically and scientifically defined and are of substantial size in terms of their scientific and financial volume, the number of project partners and the running time. These are expected to bring out good scientific and technical outcome of societal relevance:



National Brain Research Centre (NBRC), Manesar	NBRC flagship program on 'Comparative mapping of common mental disorders (CMD) over the lifespan aims to understand how information processing networks in the brain are affected in common mental disorders viz. anxiety, depression, obsessive-compulsive disorder and post-traumatic stress disorder.
National Institute of Plant Genome Research (NIPGR), New Delhi	NIPGR flagship program on 'Imparting sheath blight disease tolerance in rice' is focused at developing newer ways of managing sheath blight disease using a multi-pronged approach.
National Institute of Biomedical Genomics (NIBMG), Kalyani	NIBMG flagship program is on Integrating multi omics data using big data analytics to infer optimal wellness trajectories for management of non-communicable analytics.
National Institute of Animal Biotechnology (NIAB), Hyderabad	Genomics assisted pathobiology to identify novel targets for diagnosis and therapeutic intervention(s) of Japanese encephalitis and Leptospirosis
Institute of Life Sciences (ILS), Bhubaneswar	The major goal of the ILS flagship program on "Tribal Health and Nutrition" is to provide a comprehensive outcome through understanding genomic diversity and differentiation, linking immune-metabolic variations to prevalent diseases and understanding gut microbiome diversity and their contribution to and/or influence on human nutrition and diseases, in ethnically distinct, well-differentiated and geographically distributed 62 tribal communities of the state of Odisha.
National Institute of Immunology (NII), New Delhi	NII has recently initiated a Flagship Programme on Immuno Engineering. This umbrella project encompasses research on novel adjuvants and vaccines (for infectious diseases and cancer), immunotherapeutic strategies and artificial antigen presenting cells, scaffolds, and drug delivery devices, and on new methods and protocols for regenerative medicine.
Institute of Bioresources and Sustainable Development (IBSD), Imphal, Manipur	IBSD flagship programme, Conservation, Propagation and Mass Multiplication of Selected Orchid species from North-East has been initiated and a pilot project has been sanctioned for developing bio-based entrepreneurship in North-East India. This Flagship programme aimed at exploring the potential of few selected species of the North East region for improvement of natural products contributing to environment protection, health security and sustainable growth of the economy.
Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad	CDFD flagship program is focused on "Development of genomic technologies for predictive genetic health and forensic profiling".
Regional Centre for Biotechnology (RCB), Faridabad	RCB flagship program is focused on development of small-molecule antivirals against Chikungunya and Japanese Encephalitis viruses
Translational Health Science and Technology Institute (THSTI), Faridabad	THSTI flagship is a part of DBT Inter-Institutional program on maternal, neonatal, and infant sciences: GARBH-INI- interdisciplinary Group for Advanced Research on Birth outcomes.
Institute for Stem Cell Science & Regenerative Medicine (InStem), Bangalore	InStem, work on leveraging stem cell technologies to facilitate discovery for Human disease biology in India

National Agri-Food Biotechnology Institute (NABI), Mohali	NABI flagship project is focussed on development of Bio-fortified and Protein rich wheat
Center of Innovative and Applied Bioprocessing (CIAB), Mohali	CIAB flagship project is focussed towards utilization of rice residues for value added product development
National Center for Cell Science (NCCS), Pune	NCCS flagship project is focussed on study of Human Microbiome in Endogamous Populations of India

## PUBLIC SECTOR UNDERTAKINGS

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

### Bharat Immunologicals and Biologicals Corporation (BIBCOL)

182 million doses of the Bivalent oral poliovirus vaccine (bOPV) were produced and of these 161 million doses were supplied to Ministry of Health & Family Welfare for a total value of Rs 79.5 crores.

Introduced Hand sanitizer in April 2020 and started commercial production. So far 1,500 bottles have been distributed/sold.

Initiated development of the process for fractionation of albumin from plasma, in association with NIL.

Pilot scale facility for oral cholera vaccine being set up with technology transfer from International Vaccine Institute (IVI), Korea.



**Biotechnology Industry Research Assistance Council (BIRAC), New Delhi:** Biotechnology Industry Research Assistance Council (BIRAC) was set up by DBT as its public sector undertaking organization with the mandate to promote Public Private Partnership (PPP) to nurture the emerging biotech enterprises in our country. BIRAC promotes start ups and SMEs to undertake strategic research and innovation addressing the country specific needs. This started as a PPP model where innovation risks are shared both by the innovator company and the Government. Since its inception in 2012, it has launched several schemes to steam up the start up ecosystem for affordable product development in our country.

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

### BIRAC's Partnerships



#### Partnerships for Networks, Platforms and Market Access

WISH-BIRAC-Lords Education and Health Society (LEHS), through its WISH initiative; Scaling innovations through testing beds

BIRAC-TISS: Mentoring innovators and assessing impact

BIRAC-ICMR

BIRAC-AcE Fund Partners: Funding oxygen for the next level

BIRAC-TiE (The Indus Entrepreneurs): Platform for global networking

BioCubaFarma: Transfer of technologies and commercialisation of innovative healthcare products

BIRAC-ALEAP, BIRAC-TiE: Promote women entrepreneurship

### Intensifying the Impact of Industrial Innovation (i4)

BIRAC launched i4 scheme to support biotechnological product/technology development. It provides impetus for pulling the translational ideas past PoC and taking them further along the innovation chain for validation, scale-up, demonstration and pre-commercialization of products and technologies. The programme will be operated through Small Business Innovation Research Initiative (SBIRI) and Biotechnology Industry Partnership Programme (BIPP).

Small Business Innovation Research Initiative (SBIRI)	Biotechnology Industry Partnership Programme (BIPP)
<b>Scope</b> <ul style="list-style-type: none"> <li>- Supports development and initial validation of new products and technologies</li> <li>- The end point of the proposed study should be TRL6 or below</li> </ul>	<b>Scope</b> <ul style="list-style-type: none"> <li>- Supports validation, demonstration and pre-commercialization of products and technologies</li> <li>- The end point of the proposed study should be TRL7 or above</li> </ul>
<b>Funding</b> <ul style="list-style-type: none"> <li>- 100% Grant from BIRAC to primary + collaborating company (if any) upto Rs. 50 Lakhs</li> <li>- For projects more than Rs 50 Lakhs, BIRAC grant would be Rs. 50 Lakhs + 50% of the cost exceeding Rs 50 Lakhs</li> </ul>	<b>Funding</b> <ul style="list-style-type: none"> <li>- Irrespective of the amount, BIRAC contribution to the total project cost will not exceed 50%</li> </ul>

## REGULATION, IP AND LEGISLATIONS

**Regulation and Intellectual Property:** The programme on Biosafety Research and Regulations emphasizes on the implementation of the provisions of Rules, 1989 of Environment (Protection) Act, 1986 for the manufacture, use, import, export and storage of hazardous microorganisms, genetically engineered organisms or cells and products thereof in research and development. The Rules, 1989 delegated the Department to administer the functioning of i) Institutional Biosafety Committees (IBSCs) which operate directly from the premises of the institutions and ensures on-site assessment and monitoring of adherence to the biosafety guidelines with overall oversight of the regulatory process, at the institutional level and ii) Review Committee on Genetic Manipulation (RCGM) which monitors & reviews all ongoing research projects involving high risk category and confined field experiments and ensure the compliance of biosafety rules & regulations. Framing and implementation of safety measures and guidelines, while conducting research on high risk group microorganisms and GE organisms have also been entrusted upon RCGM.

**Biosafety Research:** During the year, 2020 12 RCGM meetings were held; wherein, 445 applications were assessed in the areas of agriculture, healthcare and industrial products. These include 173 COVID related applications, which were processed under Fast track mode. 284 IBSCs were registered during this period. Several steps for simplification and streamlining the biosafety regulation have been taken and following documents have been issued/notified:

- Handbook for Institutional Biosafety Committees (IBSCs), September, 2020.
- Streamlining of the regulation Procedure of Biopharma Drug Development, August, 2020.
- Rapid response regulatory framework for COVID 19 compilation of notification, June 2020.
- Revised Simplified Procedures/ Guidelines on Import, Export and Exchange of GE organisms and products thereof for R&D purpose, January 2020

**National Guidelines for Stem Cell Research:** “National Guidelines for Stem Cell Research” have been jointly

formulated by the DBT and ICMR to lay down standards for stem cell research and ensure that research with human stem cells is conducted in a responsible and ethically sensitive manner in the country. **National Guidelines for Gene Therapy Product Development and Clinical Trials:** The National Guidelines for Gene Therapy Product Development and Clinical Trials was jointly developed with ICMR.

## DBT RESPONSE TO COMBAT COVID-19

The Department of Biotechnology (DBT) and its PSU, Biotechnology Industry Research Assistance Council (BIRAC) together strategized both immediate and long-term research and development efforts for vaccine, diagnostics and drug development in addition to development and production of monitoring and assistive devices and other biomedical solutions through the DBT-BIRAC COVID-19 initiative. This consortia platform aimed at leveraging capacity and strengths established across the pyramid of academicians, researchers, innovators, large industries and MSMEs and to prioritize research and scientific interventions so as to deliver solutions for the pandemic.

Major efforts are ongoing under the National Biopharma Mission and Ind-CEPI. Some of notable scientific and technical achievements are as follows:

- The plasmid DNA vaccine (ZyCoV-D) from Cadila Healthcare has completed enrollment for Phase I trial and is poised to initiate recruitment for Phase II human clinical trials.
- The recombinant BCG candidate (VPM1002) from Serum Institute of India Pvt Ltd (SIIL), completed enrolment of 6000 high-risk subjects across 40 hospitals in the Phase III clinical trials
- The m-RNA vaccine candidate from Gennova Biopharma progressed well in the preclinical development and is expected to enter human clinical trials before the year end.
- Hyderabad based Virchow Biotech (P) Ltd is expected to enter into human clinical trials shortly for Immunoglobulin (antibody) therapy purified from the plasma of COVID-19 recovered patients.
- Pune-based Mylab Discovery Solutions has scaled its production and development of COVID-19 Pathodetect

testing kit. Currently, Mylab has a manufacturing capacity of 2,00,000 RT-PCR and 50,000 RNA tests.

- Ubio Biotechnology Systems Pvt Ltd received the manufacturing license for rapid antigen test.

The health-tech Start-ups were supported to scale-up the existing solutions relevant for COVID 19 and some of them being : Aarna Biomedical Products (Suraksha Full Body Coverage Kit), Alpha Corpuscles (Face shields), MicroGO (GO Assure- automated hand hygiene device), Cistron Systems (PSA medical oxygen generators), Ubiqare Health (Specialty mobility healthcare platform) and Ayu Devices (Bluetooth Enabled Digital Stethoscope for COVID-19). Additionally, BIRAC has also approved support to two Co-funding partners (IKP and C-CAMP) for in turn funding upto 25 Start-ups under the BIRAC's mandate to foster market deployment of innovative solutions addressing COVID-19 challenges.

DBT along with BIRAC is also working to facilitate regulatory support to startups through its FIRST HUB initiative. Representatives from ICMR, CDSCO, GeM etc join for special weekly sessions being run every Friday to address the queries of start-ups in wake of the COVID crisis. Regulatory facilitation of 250+ Startups was done through FIRST HUB and RIFC (Regulatory Information & Facilitations Centre).

**National Biomedical Resource Indigenization Consortium (NBRIC)** was launched to drive indigenous innovation in a Public Private Partnership with DBT, BIRAC, ABLE and C-CAMP. This make in India initiative is an important step towards building a self-reliant India. Over 40 companies have till now partnered to develop RT-PCR Kits and its associated reagents and consumables along with serological tests/lateral flow assays and its associated reagents and consumables under NBRIC.

## Potential COVID-19 Solutions

DBT-BIRAC are augmenting Startup space to address COVID-19 challenges through:

- 100+ solutions in market from our start-ups and incubator network
- Regulatory facilitation of 250+ Startups through FIRST HUB and RIFC



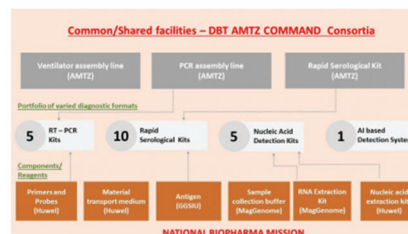
**DBT-BIRAC Technology Compendium:** The Department of Biotechnology (DBT) and its public sector undertaking Biotechnology Industry Research Assistance Council (BIRAC) have been relentlessly working to address the COVID-19 global health care crisis. DBT-BIRAC has prepared a compendium document that highlights DBT and BIRAC's science and technology efforts to fight against the pandemic, COVID-19. This compendium provides an overview of supported products and technologies under various heads: Products in Market, Products to be in market in 3-6 months, COVID-19 research pipeline and other additional facilitations. DBT and BIRAC are working with the start-ups to scale up their COVID-19 healthcare prevention and treatment solutions. BIRAC supported 20 start-ups have emerged as potential COVID-19 solution and the products are already available in the market to help the masses at large. BIRAC created a provision to fund COVID solutions that are ready for immediate deployment under a 'Fast Track Review Process'. Under this initiative, 6 Start-ups have been funded and two Co-funding partners selected for in turn funding up to 25 Start-ups. The compendium provides detail of various projects funded under DBT-BIRAC, COVID-19 Research Consortium Call, to support Diagnostics, Vaccines, Novel Therapeutics, Repurposing of Drugs or any other intervention for control of COVID-19. The compendium showcases the various innovations that are available and those that are in the pipeline. It offers a platform to the innovators to get connected with various stakeholders in the Indian healthcare ecosystem to work coherently towards tackling COVID-19 at local as well as the national level. The compendium was released on the occasion of National Technology Day on 11<sup>th</sup> May 2020 and is being updated regularly. It is available online at [https://birac.nic.in/webcontent/Birac\\_Compendium\\_2020.pdf](https://birac.nic.in/webcontent/Birac_Compendium_2020.pdf)

## COVID Diagnostic Efforts to Augment Indigenous Capacity

**First Indigenous kit** for diagnosis of COVID-19 developed by a DBT-BIRAC supported startup, MyLab is being scaled up.

DBT established a commonly shared facility to manufacture diagnostic kits and ventilators at Andhra Pradesh MedTech Zone (AMTZ) with an intent to provide scale-up of production capacity to different manufacturers.

DBT-AMTZ Command consortia aims to make 15,000 ventilators, 10 million Covid-19 diagnostic kits, 20,000 non-contact Thermometers, 5 Lakh N-95 Masks and 2 Lakh PPEs to achieve self-reliance.





## COVID-19 diagnostics and testing: *Enabling indigenous Manufacturing of diagnostic kits and allied reagents*

In keeping with the Hon'ble Prime Minister's vision of marching towards 'Atmanirbhar Bharat', DBT is supporting mobilization of indigenous resources and manufacturing. DBT-AMTZ (Andhra Med Tech Zone) CoMMAND (Covid MedTech Manufacturing & Development Strategy) Consortium, supported under National Biopharma Mission (NBM), enabled rapid scale-up of manufacturing of COVID-19 diagnostic kits effectively lowering import dependency. Nearly 5 lakh diagnostic testing kits per day inclusive of RT-PCR tests, antibody tests, and ELISA kits) are being manufactured. In a short span of two months, 100% indigenization has been achieved, with respect to production of COVID-19 diagnostic kits. Also, DBT extended support through NBM, to Mylab Discovery Solutions, Pune, for scaling up production of fully indigenous COVID-19 Pathodetect testing kit. Currently, Mylab has a manufacturing capacity of 2,00,000 RT-PCR tests and 50,000 RNA tests.

## COVID: Testing and Diagnostics

DBT City/Regional clusters for COVID-19 were established in a Hub and Spoke model to scale-up testing of COVID-19 samples in government institutions across the country.

**20 City /Regional clusters have been established** – Bengaluru, Delhi/NCR, Hyderabad, Thiruvananthapuram, Chandigarh/Mohali, Bhubaneswar, Nagpur, Pune, Mumbai, Lucknow, Chennai, Kolkata, North Eastern Region, J&K, Ahmedabad, MP, Rajasthan, Banaras, Palampur and Delhi city.

6 AIs of DBT i.e. ILS, THSTI, RGC, NCCS, inStem and CDFD are also actively involved to augment India's capacity for COVID-19 testing.

Over 100 institutions are at present doing the sample testing and **over 2,60,000 samples have been tested till date.**



National Biomedical Resource Indigenization Consortium (NBRIC), a PPP (Public Private Partnership) initiative of DBT in partnership with ABLE (Association of Biotechnology Led Enterprises) and CII (Confederation of Indian Industry), to foster indigenous innovation and biomanufacturing, became operational since May 1, 2020, with a focus on developing reagents, diagnostics and therapeutics for COVID-19. Nearly 40 manufacturers of RT-PCR and Serology kits are part of the Consortium, which is growing by the day.

## National Biomedical Resource Indigenization Consortium (NBRIC)

Launched in a PPP model in partnership with ABLE and CII and is being hosted by C-CAMP.



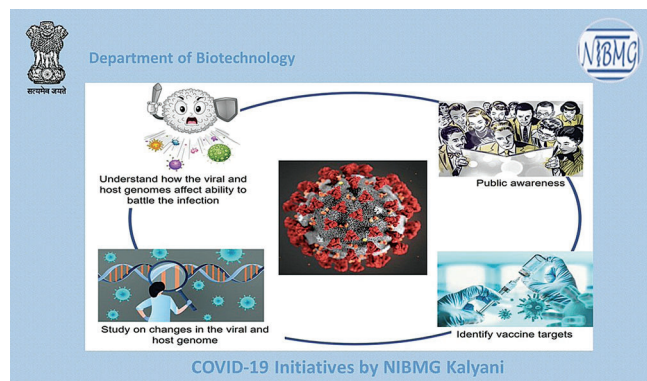
### Mission

- To be a nation-wide platform for the **convergence** of research and product resources, and technology services towards developing reagents, diagnostics, vaccines, and therapeutics across India for COVID-19 response.
- A **Make in India** initiative for Biomedical research and innovative products, towards import substitution and export.

This consortium aims to build 1-1.5 M COVID testing reagents within a month and exponentially scale-up then onwards.

**Mission COVID Suraksha- the Indian COVID-19 Vaccine Development Mission'** has been launched by the Government of India (GOI) to accelerate the development of at least 5-6 vaccine candidates and ensure that some of these are brought closer to licensure and introduction in the market for consideration of regulatory authorities and for introduction in public health systems. The Mission was announced as part of the third stimulus package with a provision of Rs. 900 Cr. to the Department of Biotechnology (DBT) for supporting the development of a comprehensive ecosystem for enabling the development of a safe, efficacious and affordable vaccine for COVID-19.

**SARS-CoV-2 genomics study:** DBT-NIBMG is coordinating the "PAN-India 1000 SARS-CoV-2 RNA Genome Consortium", a multi-institutional effort involving other DBT AIs, viz., CDFD, ILS, inStem-NCBS and NCCS, initiated to undertake research on host and viral genomics. The Consortium successfully completed sequencing of 1000 genomes from different geographical regions of India.



## Services and facilities offered by DBT Autonomous Institutes

- **Biorepositories:** DBT Autonomous Institutions THSTI, ILS, RCB, inStem have been chosen for establishment of biorepositories to enable equitable access to COVID-19 biospecimens and foster relevant research. The biorepository at THSTI holds around 4000 samples and has shared nearly 2500 samples till date. The biorepository at THSTI has also developed sample panels to aid diagnostics, including panels of sera for antibody testing, positive and negative controls for diagnostic assays, Standardized panels of nasopharyngeal/oropharyngeal samples for testing of antibodies, Viral strains, and inactivated viruses.
- **Antiviral testing:** Six DBT AIs, viz., THSTI, RGCB, ILS, RCB, IBSD, ICGEB identified for testing of investigational new products.
- **Validation of diagnostic kits:** Five AIs of DBT, RGCB, ILS, THSTI, inStem, ICGEB, recognized for validation. Validation of nearly 10 serology and RT PCR diagnostic kits completed by THSTI and RGCB.

**Other Interventions:** DBT-inStem is developing masks and surgical gowns coated with a disinfective chemical that can kill the virus on contact. DBT-inStem has designed COVID-Gyan website along with other institutions, to disseminate verified information and knowledge and create awareness about the disease and approaches for understanding and management.

DBT-IBSD is finalizing the draft of the monographs of NER medicinal plants with anti-viral properties of NER. Efforts are on to complete this compendium within this month's end. Development of point-of-care screening and patient monitoring devices, PPEs, low-cost mechanical ventilators/respirators, hand sanitizers and disinfectant platforms, biodegradable antiviral masks, high oxygen flow devices, ventilation systems are some of the preventive solutions being supported. Manufacturing of hand sanitizers by BIBCOLD, a PSU of DBT, whereby, a contribution of Rupee One will go to PM Cares Fund from each single bottle of this sanitizer sold commercially.

## Regulatory facilitation

- Fast-tracking COVID- Vaccines, prophylactics and therapeutics through development of a set of rapid regulatory guidelines with inter-ministerial co-ordination
- Rapid Response Regulatory Framework for expedited regulatory approvals for all diagnostics drugs and vaccines
- Interim Guidance Document on Laboratory Biosafety to Handle COVID-19 Specimens for R&D purposes
- “Guidelines for Sharing of Biospecimen and Data for research related to COVID-19” with NITI Aayog
- Regulatory guidelines to facilitate rapid COVID-19 vaccine development
- BIRAC Initiatives for Regulatory facilitation to start-ups
- FIRST HUB initiative, wherein, representatives from ICMR, CDSCO, GeMetc join for special weekly sessions, being conducted every Friday to address the queries of start-ups in wake of the COVID crisis.
- RIFC: Regulatory Information & Facilitations Centre, another initiative to help start-ups on regulatory and testing fronts.
- Regulatory facilitation of 250+ Start-ups through FIRST HUB and RIFC was done.

## Encouraging Start-up community

- 100+ start-ups being nurtured through BIRAC's Bio-NEST incubators to scale up their COVID 19 healthcare prevention and treatment solutions.
- Partnered with IKP and CCAMP-CCIDA for co-funding 20 innovative interventions to expedite their deployment.
- BIRAC has partnered with Invest India to seek CSR Funds for COVID-19 Research Consortium
- 20 BIRAC supported start-up products are available in the market such as Suraksha Kit by Aarna Biomed, Face Shields by Alpha Corpules, Hybrid Multiply Face Mask by Parisodhana, Hand Hygiene solution by

MicroGo, Medical Oxygen Generators by Cistern Systems and Hand Sanitizer for Public places by Go Assure, to name a few.

### Webinars and outreach activities

- DBT and Wellcome Trust India Alliance initiated a fortnightly webinar series highlighting DBT's response to COVID-19. The first webinar of the series was held on July 3, 2020 and discussed DBT's multi-pronged research strategy and action plan to address COVID-19. The second webinar of the series titled "Response of the Start-up Community to COVID-19" was held on July 17, 2020.
- DBT-IBSD has been organizing weekly webinar series every Saturday since May 9, 2020 on "Reimagine Ethnopharmacology" with a focus on COVID-19. So far, nearly 10 webinars have been held.
- BIRAC is conducting specialized Legal compliances guidance workshop series through Webinars; 204 Webinars have been conducted so far, for business mentoring, Fund raising, Industry Connect, Legal advice and sustenance in the Covid and post-Covid times. 20,925 Start-ups, Entrepreneurs, Researchers, Stakeholders have participated in the same.

### DATA MONITORING AND EVALUATION

Department decided to conduct "Socio-Economic Impact Assessment and Analysis of the various schemes and Programs" by an external agency. This is a pertinent response to the growing demand for validating and justifying the financial investments, human and scientific resources for societal development. Due to the COVID-19 pandemic, restrictions were imposed on travelling, meetings, and social Interactions across the country. Hence, various field and travel related activities could not be carried out completely by the agency. This has constrained the coverage of the study. However, efforts were made to approach the stakeholders through virtual platforms. Preliminary outcomes of the study are given in the Data Monitoring chapter. The preliminary results of the current study have revealed that there is immense scope to achieve DBT's vision of "Attaining new heights in biotechnology research and innovation for creation of wealth and ensuring social justice – specially for the welfare of the poor."

To strengthen monitoring of various activities, Department of Biotechnology has set annual targets against each output and outcome indicators based on the framework provided by NITI Aayog. These outputs and outcomes are in measurable terms, bringing-in greater accountability in the execution of schemes and programmes of the Department. Output refers to the direct and measurable product of program activities, often expressed in physical terms or units. Outcomes are the collective results or qualitative improvements brought about in the delivery of these services. The progress against the targets is updated by the Department quarterly on the dashboard developed and maintained by NITI Aayog.

### THIRD PARTY EVALUATION OF DBT'S SCHEMES AND PROGRAMMES

Department supports R&D activities in various areas including infrastructure development, generation of quality human resources, popularization of biotechnology, creation of centers of excellence, implementation of biosafety guidelines and policy reforms and biotechnology-based programs for societal benefits along with programmes under the Industrial and Entrepreneurship Development scheme. Since the various programmes of the Department are implemented under two broad umbrella schemes, therefore it was deemed appropriate to set up one sub-committee each for their evaluation. An Independent Apex Evaluation Committee was constituted to examine and monitor the evaluation process of the two Sub-Committees and to give recommendations on various efforts made by DBT during the evaluation period. The entire evaluation process was bifurcated into (i) Internal Assessment and (ii) External Assessment, in order to facilitate effective and smooth Third-party evaluation by the two subcommittees. The internal assessment of the Department to decide on continuation, merging, dropping, modification or scaling up of the various sub-programmes for implementation of the 2 schemes, was necessary as the first step to enable external assessment and to follow a holistic approach in aligning and synergizing schemes with national aspirations and developmental needs of the country; and to suggest indicative budgetary needs to meet the set objectives. Internal assessments of the schemes were carried out regularly twice a year wherein the Divisional Heads and Program officers presented progress of their respective schemes and way forward for next six months' duration.

During assessment, Program Divisions were given a format to present their programmes under the 2 schemes. This format was drawn from the guidelines provided by NITI Aayog. The Committees were apprised about the framework of the umbrella scheme and various activities under different programmes. Special emphasis was given to apprising the Committees about contributions of each programme and activity towards Sustainable Development Goals (SDGs) as defined by the United Nations and the National Development Programmes (NDPs) undertaken by the Government of India. The committee noted that the Department has managed to create a transparent system with the engagement of a large number of stakeholders in all its scientific activities and has taken an inspiring lead in region specific programs and for

social upliftment of disadvantaged populations as per the needs of the country.

The committees critically analysed the programs and made recommendations to improve, align and synergize the schemes with the national aspirations and developmental needs of the country. The committee appreciated the projects/missions/establishment of high-end facilities, initiative of planning and executing specialized Centres of Excellence which would be a major step towards creating science-based technology platforms in India. Overall, DBT has initiated necessary actions to follow up the recommendations of the third-party evaluation committee.



**02**

# **BUILDING CAPACITIES**

## “Human Resource Development, Training and Workshops”

The Human Resource Development Programme of the Department of Biotechnology is aimed at holistic development and support for students, young researchers and scientists working in the area of Biotechnology. Since inception, the Department has been supporting Biotechnology teaching at postgraduate level in niche areas of Biotechnology. The Department has been involved in capacity building to enhance the Biotechnology ecosystem through DBT-STAR College scheme, Skill Vigyan Programme under State Partnership through Science and Technology Councils, Biotechnology Finishing Schools, DBT-JRF, DBT-RA, Awards for Young mid-career and distinguished scientists and short term trainings for mid-career scientists, etc. The Department has also been conducting workshops for students and researchers. There are a number of international partnerships being supported to build capacity in cutting edge technologies and priority areas. The HRD Programmes of the Department of Biotechnology have already made tremendous impact on the overall development of biotechnology in the country which needs to expand keeping in view the latest trends in biotechnology worldwide.

Human Resource Development Program at a glance	
Colleges supported under star college scheme	66
PG student trained	782
Students trained under BITP	203
DBT-JRF fellowships awarded	268
DBT-RA fellowships awarded	94
Ramalingaswami Re-entry fellowships supported	88
Tata Innovation fellowships awarded	5
Innovative Young Biotechnologist Award	14
National Bio-Science Award for Career Development	10
National Women Bio-Scientist Awards	3
Biotech Product, Process Development and Commercialization Awards	5
Distinguished Biotechnology Research Professorship Award	2

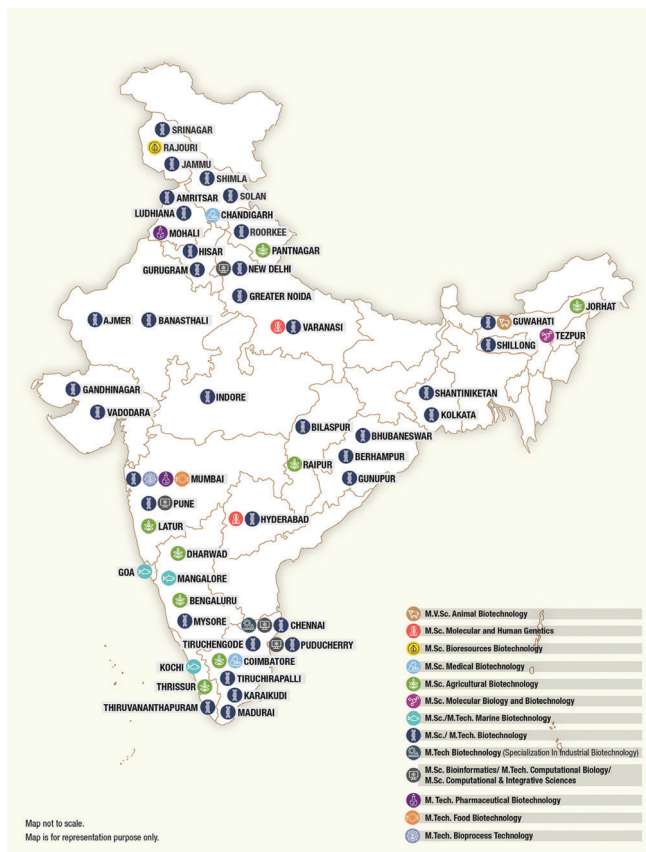
Research publications emanated out from various projects supported under HRD programs	205
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### (A) TEACHING PROGRAMMES:

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

Postgraduate Teaching Programme in Biotechnology and allied areas has been entitled to ensure high standard of teaching and to generate critical mass of trained manpower in the country. This programme has been implemented on the basis of core faculty strength, expertise, infrastructural facilities, R&D grants received by university on competitive funding basis, nearby institutions engaged in biotechnology R&D. This year the Department has done a fresh selection of courses for support under the PG teaching Programme. A total of 70 PG courses were selected for support in areas of general Biotechnology, allied areas of Biotechnology including Medical, Marine, Computational Biology, Bioprocess Technology, Bioresource's Biotechnology Pharmaceutical Biotechnology and Molecular and Human Genetics. The location of these institutions is depicted in Map (Figure). To ensure admission of quality students, selection was made through national level entrance test i.e., Graduate Aptitude Test in Biotechnology (GAT-B) conducted by DBT-HRD PMU, Regional Center for Biotechnology, Faridabad at 59 centers located across the country (Figure). Department has a provision to provide financial support for establishment of laboratory equipment facility essentially required for class room teaching, recurring grants for consumables, studentship, books and journals, travel, visiting faculty, contingency, thesis grant for in-house dissertation, equipment maintenance etc. In-house dissertation has been made mandatory for all the participating institutions and Department is also providing thesis grant of Rs. 50,000/- per student to ensure intensive hands on training. All selected candidates are paid studentships under DBT support. Financial support has been provided for ongoing students admitted in 2019-20 for courses supported during 14<sup>th</sup> Finance Commission.





Location of universities/ institutes selected for support under DBT Postgraduate Teaching Program

## (ii) DBT Star College Scheme

The DBT Star College Scheme was initiated in 2008 with the objective to support colleges offering basic science education at undergraduate level across the country. The scheme envisages improving critical thinking and 'hands on' experimental work at the undergraduate (college) level, thereby encouraging more students to opt for higher education in science. DBT is committed to the values of pursuit of excellence, academic and intellectual freedom, creativity and innovation, diversity, cooperation and communication & accountability. The Department, therefore, identifies colleges with ambition and potential for excellence and provide academic and physical infrastructure for achieving excellence in teaching and unique exposure of students to experimental science. Department has supported 325 undergraduate colleges across the country in the past 11 years. Apart from financial support, colleges have benefited tremendously from

guidance received in Advisory Committee meetings, mentoring, Task Force meetings and learning from peers in other colleges resulting in decreased dropout rates and increase in number of students pursuing a career in higher education in basic science courses.

**240 UG colleges being supported**

**52 new colleges supported this year**  
**33 Urban colleges**  
**19 Rural colleges**

**7 Star status Colleges this year**  
**6 Urban colleges**  
**1 Rural College**

**139 new proposals received for support**  
**77 Urban Colleges**  
**62 Rural Colleges**

**Star College module launched on the DBT e-ProMIS portal**

## Major Initiatives during the year

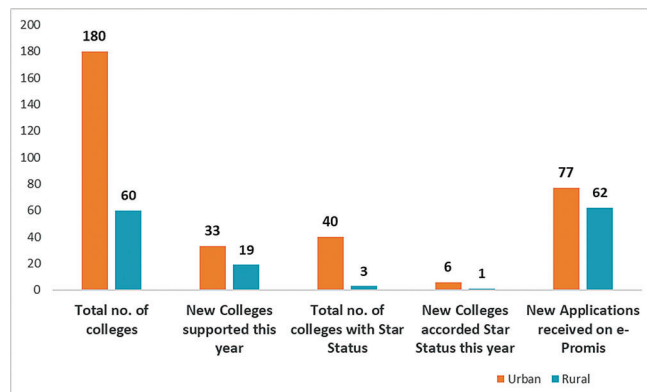
- **Launching of the Star College module on DBT-eProMIS portal**

The e-ProMIS is the online monitoring and project management portal of the Department. However, until 2019-20 aspiring colleges used to submit only hard copies of proposals. One of the major problems encountered was that in spite of a standard performance, there would be significant deviations from the Performance subject to individual interpretations by applicants. Besides, the existing process involved a tremendous amount of paper. The Star College module on DBT-eProMIS (online monitoring and project management portal) was launched during May 2020. For the first time since inception, proposals were received completely online. A total 139 proposals were received in response to the Call for proposals 2020-21. Applicant colleges, which also involved ones from the remotest part of the country were mentored and assisted on real time basis to enable them to successfully apply for the grant.

The Department is currently engaged in executing the Stage 2 of the module wherein the proposals shall be sent to the expert members and the experts can enter their comments on the e-ProMIS module, thereby eliminating the dependence on emails for correspondence. The reforms introduced have resulted in increasing the outreach of the program, ensuring user-friendliness of the application process, further smoothening of the screening process and also in enhancing the environment-friendliness since the dependence on paper has been largely eliminated.

### Achievements during the year

- The 8<sup>th</sup> meeting of the Task Force under the DBT Star College Scheme was convened online during 25<sup>th</sup>-26<sup>th</sup> August, 2020 via video-conferencing. In this meeting, 7 colleges were awarded Star Status out of 21 colleges which were reviewed; the remaining 13 colleges were recommended for extension for another 1 or 2 years based on their performance. Additionally, the annual progress of 45 colleges was reviewed during the meeting.
- The Department has also conducted 5 online Advisory Committee meetings which are intended to mentor colleges being supported under the scheme and is integral to the successful implementation of the scheme as per the approved objectives in respective colleges.
- A total of 240 undergraduate colleges across the country are currently being supported under the DBT Star College Scheme. During this year 52 new colleges were supported, of which 33 were urban colleges and remaining 19 were located in rural areas. A total of 7 colleges were accorded with the Star Status based on their performance: 6 urban and 1 rural college.
- The categorization of the scheme into urban and rural categories during 2018-19 has ensured a level playing field for applicants hailing from rural and urban areas of the country. With each passing year, the rural-urban divide is significantly diminishing. This is further evident from the fact that out of the 139 proposals received online in response to the call for proposals 2020-21, 77 are urban colleges while 62 are from rural areas.



Overview of the performance of the DBT Star College Scheme during this year

### (iii) Skill Vigyan Programme (Skill Development Programme) in Biotechnology:

This programme has been implemented with an objective to provide hands-on-training in tools and techniques in Biotechnology and allied areas to generate skilled manpower. This programme has been designed for providing skill training under five categories (i) Students (ii) Technician training (iii) Faculty training (iv) Entrepreneurship training (v) Biotechnology Finishing School Program. The programme has been implemented in six states viz., Arunachal Pradesh, Himachal Pradesh, Meghalaya, Odisha, Punjab and Uttarakhand through State Science and Technology Councils of respective states. The proposals of other 3 States viz., Karnataka, Telangana, and Andhra Pradesh has been approved and would be implemented this year. Efforts are being made to partner with all states and UTs to implement the Skill Vigyan programme across the country. Proposals have been received under call for proposals from 20 States/UTs and these would be evaluated in Expert Committee on Skill Vigyan for suitability. During the year 2020-21, support to 15 Certificate/Diploma courses for skill development in areas of Biotechnology has been continued.

### (B) NATIONAL FELLOWSHIP PROGRAMMES:

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

Department is providing fellowships to biotechnology students for pursuing doctoral research at universities



and / or research institutions across the country. The fellows are selected via all India level examination conducted across the country and based on the merit, top 500 candidates are listed under Category-I who are eligible to avail fellowship under DBT-JRF at any university/institute in India once they are registered for PhD while candidates beyond this number fall under category-II and are eligible for fellowship equivalent to NET qualification from extramural R&D project funds being supported at universities/institutes as the case may be. During 2020-21, a total of 13,910 applications were received, 9,956 students appeared for the online examination organized at 59 centers located across the country. Under Category-I, 477 students were selected for award of DBT-JRF and in Category-II, 264 students were selected. This year, a total of 767 ongoing students have been supported under DBT-JRF Programme.

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

DBT Research Associateship programme was started in 2001 for post-doctoral research in Biotechnology and allied areas at premier institutions across the country. This programme is being coordinated by Indian Institute of Science, Bangalore. The fellowship is initially awarded for a period of two years and support can be extended for 1-2 years based on review of progress. During the year 2020-21, a total 591 applications were received, out of which 80 candidates appeared for the interview and 36 candidates were selected for award of Research-Associateship. During the year, Department has developed an online DBT-RA management and information system for submission of applications by candidates and management of program online. The advertisement for the second batch for 2020-21 session has been published for submission of applications. This year, a total of 183 ongoing fellows and 36 newly joined fellows have been supported under DBT-JRF Programme.

**(C) PROGRAMMES FOR NORTH EASTERN STATES (NER):** Department has made a special provision in HRD scheme during 2010 for providing support to students/ research fellows with domicile of North-Eastern States or

those who have studied for past 3 years at university/ institute in NER states under DBT-RA Programme. During the year, a total of 61 applications were received and 07 candidates were selected for award of DBT-RA Fellowship from NER.

**(D) BUILDING CRITICAL MASS OF SCIENCE LEADERS**

**(i) Ramalingaswami Re-entry Fellowship:** The idea behind starting Ramalingaswami Re-entry Fellowship in 2006-07 was to attract high quality Indian brains working abroad to pursue their research interests in life sciences, biotechnology and other related areas in India. It was thought that this step will create a pool of highly skilled and trained researchers working on cutting edge technologies in Indian laboratories. By seeing the success of the scheme in past years, number of the fellowships have now been increased from 50 to 75 per year from 2017-18 onwards. So far, 450 fellows have taken up positions in various Indian Laboratories, out of which, 270 fellows have already been able to seek permanent faculty positions. As evident from the increasing number of applications for the fellowship, more and more number of people are showing interest to come back to India and serve the nation. In last few decades, Indian laboratories have also gained capacities, quantitatively as well as qualitatively, to provide excellent facilities for the fellows to pursue their scientific endeavors. In doing so, fellows have published their research work in peer reviewed National and International scientific journals; developed new technologies; filed patents and created a few spin off companies. Selection of fellows for the year 2020-21 is under process.

**(ii) MK Bhan-Young Researchers Fellowship Program:** The Department has launched a new grant opportunity, the M K Bhan-Young Researcher Fellowship Programme (MKB-YRFP), 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 75000.00/ 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 will be awarded for Research

work to be carried out at DBT-Autonomous Institutes only. The proposed no of fellowship under the program is 50. The fellowship has been launched on 9<sup>th</sup> November 2020 and advertisement to accept the application is underway.

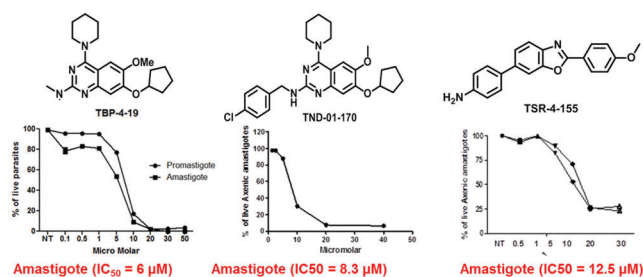
#### (E) INTERNATIONAL FELLOWSHIP:

- (i) **Khorana Program for Scholars:** The program is mainly designed to provide opportunities to Indian UG and PG students to gain exposure and access to world class research facilities at different laboratories of the USA for internship. The program promotes research and capacity building in frontier areas of biotechnology being implemented through India- US S&T forum (IUSSTF). 49 Students were selected for support during 2020-2021 under this program.
- (ii) **DBT TWAS Fellowship Program:** The DBT-TWAS Biotechnology fellowships was jointly promoted in 2004 by the Department of Biotechnology (DBT) and The World Academy of Science (TWAS), Trieste, Italy to bring foreign scholars from developing countries who wish to pursue their research in new emerging areas of biotechnology in the Laboratories/Institutes in India having facilities of Biotechnology Research. DBT provides fellowship and contingency grant to the selected candidates tenable at Institutes in India under three categories viz. (a). Full Time Postgraduate Fellowship to pursue PhD research programme, (b). Sandwich Postgraduate Fellowship to the Students (registered for doctorate in their own countries) for training in India to help in their PhD. (c). DBT-TWAS Postdoctoral Fellowship to pursue a postdoctoral research program in India. The aim is to address societal challenges through application of S&T in emerging areas such as affordable health care, water security, climate change adaptation, agriculture science, renewable energy and natural disaster prediction and management in their countries. Till 2020 about 100 publications have emerged out of this program. 25 fellows were selected for support in 2020-2021.
- (iii) **Indo-Australian Biotechnology Fund (IABF):**

The fund supports Indian and Australian Scientists, from both the public and private sectors, to collaborate in

cutting edge research in the area of science & technology. The call for applications for R&D proposals is announced in areas of mutual interest. Proposals are supported based on joint recommendation. Under this program, scientists/researchers from Australia and India visit each other's country for project related activities. Fifty-Six projects have been supported so far in various areas of life sciences. A study supported at IICB, Kolkata has identified advanced hit molecules against anti-leishmanial activity based on the life cycle of the parasite. In vitro pharmacokinetics studies resulted two potential lead molecules which have been selected for in-vivo pharmacokinetics and in vivo VL disease model study. The Centre also trained students and have collaboration underway with Australian counterpart.

In a project at CRISAT, Patancheru studies conducted on markers associated with salinity tolerance (India), drought resistance (India) and AB resistance (Australia) and deployed stress resilient improved chickpea varieties. Five genes from the "QTL-hotspot" region were found to contain substantial allelic variation between individuals for each trait separately. The Project has also contributed to release of first MABC drought tolerant line for commercial cultivation in India.



Selected Lead molecules

#### PhD Fellowship Programme under Indo-Australia Collaboration (Indian Institute of Technology, Bombay-Monash University):

The broad scope of the programme is to enable joint PhD degree from IIT Bombay and Monash University. This will also have one-year research at Monash University. Students do get a good exposure to Industry Academia Partnership and new areas of research under the program. 30 students are

undergoing PhD at various departments of IITB Monash Research Academy. This program is for a period of 10 years and a total of 65 students will be supported. Students who have completed PhD under this program have got placement at prestigious institutes, Universities and Industries in India and abroad.

#### (F) TRAINING PROGRAMMES:

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

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

##### (ii) Biotech Industrial Training Programme (BITP):

The Department of Biotechnology is supporting the Biotech Industrial Training Programme (BITP) for providing hands-on training for six months to fresh B.E./B.Tech./M.Sc./M.Tech. Biotechnology students. The objective of this program is to impart skill-based training to students so that their employability increases in relevant industries. To give more impetus to this programme, the Department has adopted apprenticeship model for implementation of DBT-BITP Program. Linkages have been developed with Life Science Sector Skill Development Council (LSSSDC), New Delhi for selection of partnering industries for providing apprenticeship in Biotechnology sectors. There is provision to select 800 students/year (including 100 for NER candidates) under DBT-BITP Apprenticeship Program. Stipend of Rs. 10,000/- p.m. is paid to all selected candidates for six months' period and companies are also providing apprenticeship to all trainees. The advertisement for submission of applications for 2020-21 session have been published in national dailies and websites for wide publicity of program.

#### (G) WORKSHOPS

- (i) **India Bioscience-Young Investigator meetings and students workshops:** Department has supported IndiaBioscience project with the objective to catalyze transformation in key areas of life sciences and biotechnology for mentoring to excel research activities, recruitment of trained manpower, quality education, outreach and science popularization through Young Investigator Meetings (YIM) for young investigators (Teachers and Scientists), workshops for Postgraduate, PhD and Post-Doctoral Fellows and Webinars. India Bioscience has also created life science and biotechnology researchers' database for reference and connecting with science community. During the year, 1 YIM, 3 Online Crafting Your Career (CYC) Workshops, Careers in Science workshops/talks, 3 webinars and 7 podcasts were organized on various themes/topics for scientific communities.

#### (H) DBT AWARDS - RECOGNIZING EXCELLENCE:

- (i) **Tata Innovation Fellowship:** The Department initiated the TATA Innovation Fellowship scheme in 2006 to recognize and reward scientists upto 55 years 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 upto of 5 fellowships are awarded. Each awardee receives, in addition to regular salary, a fellowship @ Rs. 25,000/- per month and a contingency grant of Rs. 6.00 lakh per annum. The duration of the fellowship is initially for three years which can be extended further by two years on a fresh appraisal. From its inception to March, 2019, 61 scientists have been awarded the fellowship.
- (ii) **Har Gobind Khorana-Innovative Young Biotechnologist Award (IYBA):** The Innovative Young Biotechnologist Award (IYBA), initiated in 2005, is a career-oriented award to nurture outstanding young scientists with innovative ideas and desirous of pursuing research in cutting edge areas of biotechnology. The awards are conferred to scientists

below the 35 years of age, subject to certain relaxations in cases of women, OBC, SC/ST and physically challenged. Scientists on a soft position are also eligible to apply for the award. The award carries a award of Rs.1.00 lakh/annum for candidates who are on permanent faculty position and Rs.75000/- per month for those candidates who do not have a regular faculty position along with a project grant to pursue their research. During the last five years, DBT has awarded 52 young scientists under this scheme. Selection of awardees for the year 2020-21 is under process.

(iii) **S. Ramachandran-National Bioscience Award for Career Development:**

National Bioscience Award for Career Development is conferred in recognition of outstanding contributions of scientists below 45 years of age who are engaged in basic and applied research in Biological Sciences including Biotechnology, Agricultural, Medical, and Environmental Sciences and all other allied areas. The award recognizes the significant contributions made by scientists in their respective domain research areas with potential for product and technology development. A maximum of 10 awards are conferred every year. Each Award carries a cash prize of Rs 2.00 lakh, a citation trophy along with project research grant of Rs 15.00 lakhs (Rs.5.00 lakhs/year) for a period of 3 years. Selection of awardees for the year 2020-21 is under process.

(iv) **Janaki Ammal-National Women Bioscientist Award:**

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

1.00 lakh with citation and a gold medal and Research Grant of Rs 5.00 lakhs per annum for a period of 5 years. Selection of awardees for the year 2020-21 is under process.

(v) **Biotech Product, Process Development and Commercialization Award:**

The aim of the Biotech Product & Process Commercialization Award is to recognize scientists/innovators/entrepreneurs/institutions/companies both in public as well as private sector who are working towards development and commercialization of process/technology/product in the areas of modern biology and biotechnology. Up to five awards are given every year. Each award carries a cash prize of Rs. 2.00 lakh along with a citation and trophy, however, if the product is commercialized and has much higher utility, cash award of Rs.5.00 lakh is given to the awardee. The award is given in an individual/team category as well as under institutional category. Selection of awardees for the year 2020 is under process.

(vi) **Distinguished Biotechnology Research Professorship Award:**

The Department has instituted Distinguished Biotechnology Research Professorship Award Scheme to utilize the expertise of superannuated distinguished scientists, who are still scientifically active and capable of making significant research contribution in biological sciences, biotechnology and related fields. The Scheme enables distinguished scientists to pursue their research interests in their institution within India. A maximum of 5 awards can conferred at any point of time.

(vii) **BioCARE Program:**

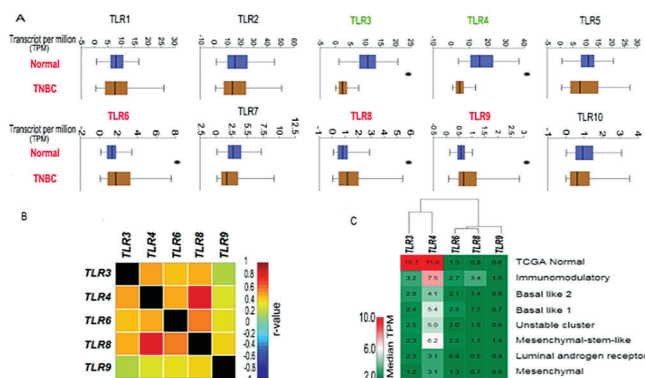
With the vision of Department to promote Women in Science and in an attempt to enhance the participation of Women Scientists in Biotechnology Research, the Department launched this mission program in the year of 2011. The program is mainly for career development of employed/unemployed women scientists for whom it is the first extramural research grant. The scheme gives opportunity to unemployed women scientists having a break in career to be back to the mainstream by getting their first grant 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.

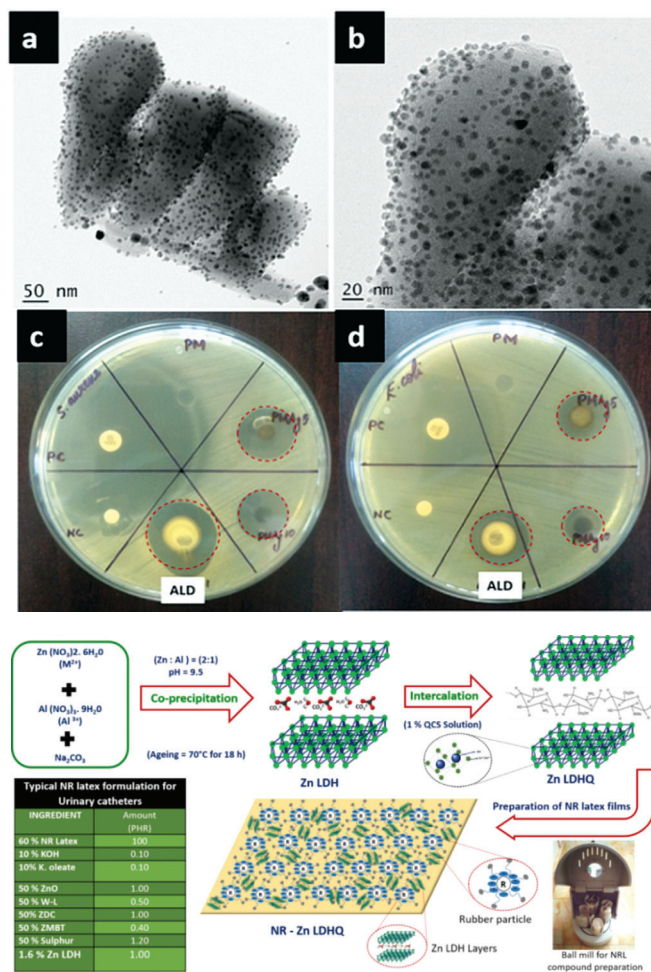
Five calls have been announced so far under the programme and 361 women scientists have been supported in various areas of Life Sciences. Thirty-two unemployed women scientist under the programme got permanent engagement in different universities/institute/colleges and industries and one scientist got an engagement aboard as a research scientist. Around 300 papers have been published so far. More than eleven patents have been filed. The Scientists have made poster presentations and got awarded on various platforms. In the year 2020-2021, seven women scientists have been supported for their new projects. Some studies under the programme have been highlighted here:

A study is being conducted at National Institute for Research In Reproductive Health (NIRRH), Mumbai on Triple Negative Breast Cancer (TNBC) patients with the aim to evaluate the status of Toll like receptor expression, and its prognostic significance in predicting chemotherapy response. The TLR expression status was studied in the publically available TCGA database and significant correlation is seen between TLR4 and TLR8 expression in TNBC tumors (Figure).



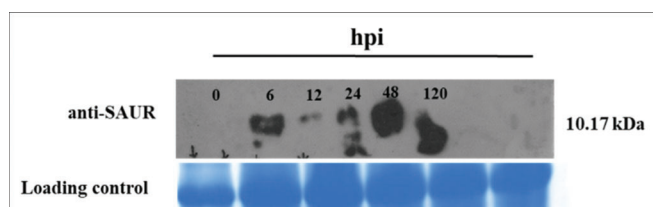
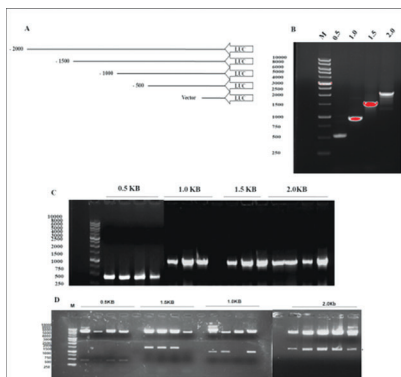
Differential expression of TLRs in TCGA-TNBC tumor dataset.

In another study at Department of Polymer Science and Rubber Technology, Cochin University of Science and Technology (CUSAT), Kerala, chitosan was successfully quarternized to obtain QCS, which exhibited superior antibacterial activity (Figures). The results have been published in the journal of Applied Polymer Science in March 2020 (<https://doi.org/10.1002/app.49608>).



TEM images of ALD and Zones of inhibition of ALD and ALD incorporated polymer films against gram positive *S. aureus* and gram negative *E. coli* strains. Figure : Schematic illustration of Zn LDH incorporated NR latex films

Studies were conducted on detection of possible association of specific nuclear membrane proteins namely Sad1/UNC-84 (SUN) and SINE 1 in immune response of chickpea against *Fusarium* and involvement of RanGTP, CROWD NUCLEI 1, GTP binding nuclear protein Ran1A, annexin and patellin in immune response during wilt disease. The nuclear localized protein in stress response, SAUR was cloned (Figure) and found maximum expression of SAUR protein at 120 hpi. The results revealed the involvement of nucleus localized protein as well as nuclear envelope proteins in the immune response of chickpea against *Fusarium* (Figure)



Promoter analysis of SAUR, PCR amplification of respective regions, Colony PCR of clones & Restriction digestion of clones. Figure: Western blot study showing expression of SAUR protein in time kinetic manner.

At Regional Centre for Biotechnology, Faridabad study supported on Metagenome Sequence Analysis of the Distal Gut Virome in Healthy Indian Adults. Significant proportion of sequences in the samples were found of a new family of bacteriophages. The studies needed to address other key questions such as presence of a core virome and population-discriminatory features

Studies at AIIMS, Patna on novel role of autophagy in Cancer stem cells and therapy induced cancer stem cell population demonstrated higher levels of autophagy significantly reduced the percentage of Glioma Stem Cell (GSC). Temozolomide (TMZ) at clinically relevant concentration resulted in an induction of autophagy in GSC and significantly increased the expression of GSC markers, suggesting an increased pool of GSCs developing effective therapeutic strategies (Figure).

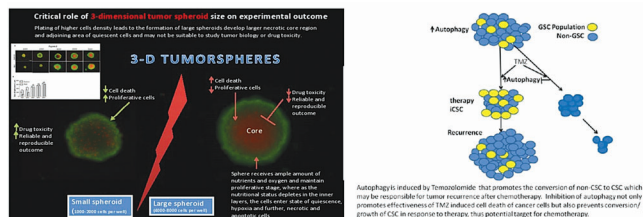
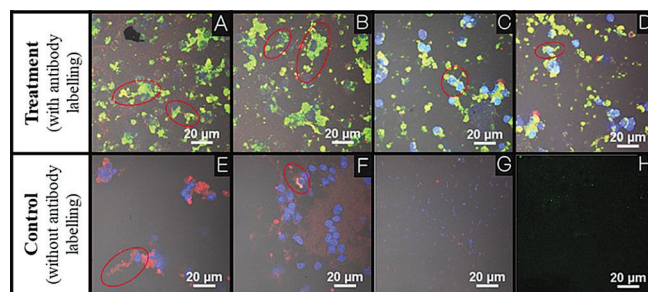


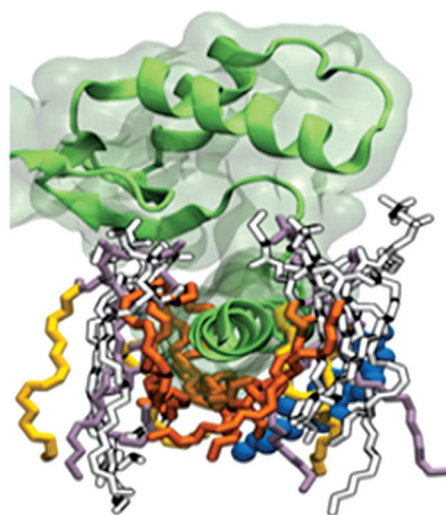
Figure: Study of cancer stem cell population demonstrated higher level of autophagy significantly reduced the percentage of Glioma Stem Cell (GSC).

A project on degenerative diseases of Retina has achieved retinal bipolar cell stimulation by targeting voltage gated sodium channels on cell surface and vital forms of neuronal signaling. The project optimized retinal bipolar cell isolation protocol and has been successfully able to stain voltage gated sodium channels on cell surface. A manuscript is in communication (Figure).



Voltage-gated sodium channels identified on isolated retinal bipolar cells

Study was carried out to understand, the role of age and disease related evolution of brain, lipid composition on the early onset and propagation of Parkinson's disease associated with the misfolding and aggregation of a neuronal protein  $\alpha$ -Synuclein by using computer simulations and state-of-the-art advanced sampling techniques (Figure). The study found mechanism that how docosahexaenoic acid, an essential omega-3 polyunsaturated fatty acid abundantly found in brain, preferentially interacts and modulates membrane bound  $\alpha$ -Synuclein, is now under review in ACS Chemical Neuroscience.



Representative simulation snapshot showing preferential solvation of protein  $\alpha$ -Synuclein (green cartoon) by polyunsaturated docosahexaenoic acid chains (orange).

(I) **POPULARIZATION & PROMOTION OF BIOTECHNOLOGY**

- (i) **Conference, Travel, Exhibition and Popular Lectures (CTEP):** To popularize Biotechnology activities in India, the Department provides financial assistance towards organizing Conference, Seminar Symposium, Workshop and Travel support to the researchers for presenting their papers in the conferences which are being organised outside the country. It also extends support for organizing DBT stalls in international and national exhibitions. Financial support is also provided for organizing Popular Lectures. The collective term for these four activities is CTEP (Conference, Travel, Exhibition and Popular Lectures). The dedicated web portal i.e., Online Submission and Monitoring System (OSMoSys), acts as a single window for the submission, processing and settlement of grants. This portal is not only easing the assistance

process but also provides timely deliverables. To achieve wider visibility, outreach and popularization, a one- day activity has been organized in the DBT Autonomous Institutes comprising of lectures by eminent scientists/faculties followed by exhibition of the work being carried out at the AI. The target audience/participants are researchers, academicians and M.Sc. students. Additionally, one day activities at DBT supported Star Status Colleges viz. Public/popular lectures /quiz/scientific programmes are also organized. The target audience/participants are undergraduate students, school students and public at large. Until March 2020 about 100 proposals have been supported. Thereafter, due to the Covid-19 pandemic and the subsequent travel restrictions and public gatherings nationally and globally have severely disrupted the activities under CTEP. CTEP activities would resume once a pandemic situation becomes normal.



## RESEARCH RESOURCES, SERVICES, FACILITIES AND PLATFORMS (RRSFP)

The overall objective of the RRSFP program is to enable the creation of major facilities/resources/platforms across the country besides the upgradation of research infrastructure across universities and institutes for teaching and research at the post graduate level. Concerted efforts have been undertaken by the DBT to establish and create research infrastructure, National Facilities and infrastructure across Universities.

Research Resources, Facilities and Platforms at a glance	
Infrastructure and facilities supported	39
Scientists and Researchers utilized the facilities	86
R&D project using infrastructure facility	41

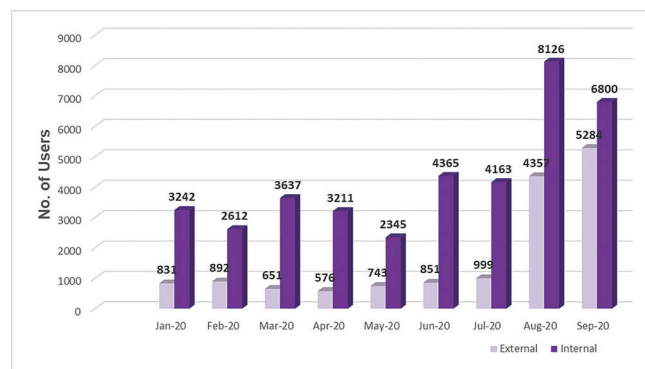
- The DBT- Boost to University Interdisciplinary Life Science Departments for Education and Research- **DBT-BUILDER** has been an important sub-program under the RRSFP program through which DBT has supported the Life Science Departments of various Central and State universities thereby promoting interdepartmental cross-talk with the vision to nurture a large number of post-graduate students to nurture them and make them competent enough for globally competitive emerging bio-economy.
- The Department introduced the DBT-Scientific Infrastructure Access for Harnessing Academia University Research Joint Collaboration- **DBT-SAHAJ** Infrastructure sub-program which primarily aims to create “National Service Facility/ Research Resource/ Platform” and facilitate access to resources that could not be provided by any single researcher's laboratory or scientific department but required for data acquisition, analysis and providing a proof of concept to cater the needs of a larger community.

### Significant achievements during the year:

The SAHAJ portal (<https://dbtepromis.nic.in/frminstrumentusability.aspx>) was introduced by DBT during

2018-19 and has since complemented the objectives under DBT-SAHAJ. First, the SAHAJ portal has promoted the concept of a consolidated database of sophisticated infrastructure facilities funded by DBT and the availability and geographical location of these resources to users, not only from DBT Autonomous Institutes but also from other academic institutions and industry partners. This measure has ensured that researchers are not required to travel long distances to access a sophisticated equipment / service, avoid long waiting time, and avail the services of trained personnel for their experiments / service.

An important outcome has been the increase in number of publications, quality of publications, filing of patents and reducing the rural-urban divide in terms of access to sophisticated facilities. The response to SAHAJ portal has been immense and can be witnessed from the fact that 1.80 lakhs users and Rs 6.28 crores revenue generated have accessed the equipment/services listed under the SAHAJ portal since its inception. Significantly, 53,685 users have utilized the SAHAJ portal (until September 2020) generating revenue around Rs. 2.00 crores despite the restrictions of 4 months due to Covid-19 pandemic. Further analysis revealed that while 38,501 users were from the institutes where this equipment are hosted, 5284 users were external users from other institutes and industry partners. The success of DBT SAHAJ has been exemplary in ensuring DBT's philosophy of “Science for All”.



Utilization of facilities under DBT SAHAJ during 2020

### ❖ Initiation of 3<sup>rd</sup> Phase of the “Access to Structural Biology Facilities at ESRF, France”

The European Synchrotron Radiation Facility (ESRF) located in Grenoble, France, is the world's most intense



X-ray source and a centre of excellence for fundamental and innovation-driven research in condensed and living matter science. Considering the vast areas of application of this facility, such as drug-discovery, identification and characterization of novel proteins etc. the Department of Biotechnology, Ministry of Science and Technology entered into a phase wise agreement with the European Molecular Biology Laboratory (EMBL) and the European Synchrotron Radiation Facility (ESRF), through its Autonomous Institute, RCB, Faridabad, for access to the BM14 beamline for macromolecular crystallographers in India in 2008.

The project was initially sanctioned for the period of 2009-2014 and is in its second phase. The renewal of agreement for the third phase has been sanctioned during this year with a total budget of Rs. 26.97 crores

for 3 years. The contribution of this facility on the national perspective can be appreciated from the fact that more than 300 Ph.D. students and 1.52 lakhs researchers have utilized the services till date and has led to publication of more than 500 high impact research articles.

❖ **Establishment of Class 100,000 (ISO 8) Facility for *in vivo* biomedical research at Indian Institute of Science, Bangalore**

The project was sanctioned during 2016-17 at a total cost of Rs.10.0 crores initially for a duration of 2 years which was later extended for another 18 months. The facility is expected to become fully functional by the end of this year and shall serve as state-of-art facility for breeding of Laboratory animals including transgenic/ knockout mice which caters to specific needs of select research discipline/s.




*Establishment of Class 100,000 (ISO 8) Facility for *in vivo* biomedical research at Indian Institute of Science, Bangalore*

In view of the restrictions due to the Covid-19 pandemic, the third meeting of Task Force on RRSFP was convened online on 27-28<sup>th</sup> May 2020 and again on 18-19<sup>th</sup> August 2020. The Task Force deliberated on 123 proposals that were received in response to the call for DBT- BUILDER. A total of 56 new proposals were approved by the Task Force for funding: 17 under Level I, 26 under Level II and 13 under Level III. The projects shall be implemented in various post graduate colleges and Universities across 15 states and 1 Union Territory. The efforts made under the DBT-BUILDER sub-program has resulted in the publication of 28 articles in international peer-reviewed scientific journals during this period.

### National Genomics Core:

Project on 'National Genomics Core' has been initiated to

facilitate pursuit of Biomedical Genomics at the national level by opening up its core facilities of genome sequencing and analysis to universities and other national laboratories. DBT has established the National Genomics Core (NGC) with its hub in NIBMG, Kalyani, and centres in CDFD, Hyderabad, and University of Allahabad. NGC provides consultancy and services to the academia, clinics and the industry using high-throughput sequencers and high-density microarrays in human-, bacterial- and meta-genomics. NGC is committed to provide affordable services in high-quality data generation and computational & statistical data analysis. NGC is constantly expanding its repertoire of service platforms. NIBMG and CDFD have started providing Genomic core services. Soon, the University of Allahabad will also start its activities.




## NATIONAL GENOMICS CORE

The National Genomics Core has been created to catalyze and facilitate genomics-driven discoveries and applications. The Core is accessible to all academic institutions and the industry for their own research and development. The Core houses and provides access to high-end genomics, computational and other relevant platforms to catalyze discoveries in all domains of biology. The ease of access to these platforms alleviates the challenges faced by researchers to generate and analyse genomics data on scale. This enabling environment attracts biologists to make insightful discoveries using the power of genomics.

**Location**

**Central Core**  
National Institute of Biomedical Genomics, Kalyani

**Regional sub-Cores**  
Centre for DNA Fingerprinting and Diagnostics, Hyderabad  
University of Allahabad, Allahabad



**Established & Supported by**  
Department of Biotechnology, Government of India



**03**

**RESEARCH AND  
DEVELOPMENT**

## AGRICULTURE AND ALLIED AREAS

Agriculture and Allied Areas Research and Development (Crops, Livestock and Fisheries) is a major thrust area of the Department. 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 programmes also focuses on infrastructure, capacity building and human resource development for innovative research through various fellowships / trainings and creation of new facilities. 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. Highlights of the major R&D activities in the area of Agriculture & Allied areas are given below.

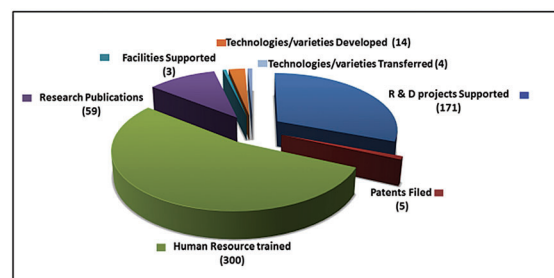
Agriculture and Allied Areas at a glance	
Ongoing projects supported in Agriculture Biotechnology & Allied Areas	266
New R & D projects, Network programs, platforms, facilities supported	48
Human Resources trained 1329	
Research publications emanated from R&D projects supported	246
Varieties/breeds/technologies/products, processes developed	30
Varieties/breeds/technologies/products/ processes transferred to stakeholders	4

### AGRICULTURE BIOTECHNOLOGY

Agriculture Biotechnology program of the Department is driven to reform agricultural research through adoption of technological advances, strengthening research infrastructure and human resource development in cutting edge research. The programme extends its support to R&D projects for knowledge generation, technology/product

development for enhanced productivity, nutritional fortification & improved quality parameters, abiotic/biotic stress tolerance, input use efficiency, climate resilience and biosafety. Priority areas of the Agriculture sector are addressed through major national networks, centers of excellence, international collaborations as well as public-private partnership. Research endeavors supported in Molecular breeding/Marker Assisted Selection (MAS), QTL/gene discovery and marker trait association studies have led to generation of pre-breeding material and improved crop varieties.

During the financial year 2020-2021, the department has supported more than 100 R&D projects including seven (7) Mission Mode Network projects, eight (8) Centre of Excellence projects, twenty-three (23) Network projects and three (3) Facility projects. Some of the new initiatives during the year 20-21 include:



Crop	Major Achievements
Rice	I. Three genotypes namely, Pusa 1847-12-62-90-39-7-15, Pusa 1847-12-62-184-36-9-155 and Pusa 1847-12-62-64-12-6-8 carrying bacterial blight (xa13, xa21) and blast (Pi2, Pi54) resistance genes nominated in the national Basmati trials; II. Three gene pyramided lines each with resistance to blast in the background of Mushk Budji and Kohsar III. More than 25 advanced lines developed in rice.
Maize	Three (3) maize hybrids Pusa HM4 Improved, Pusa HM8 Improved and Pusa HM9 Improved released and notified.
Mustard	Four determinate mustard hybrids (PHR-8024, PHR-8031, PHR-8076 and PHR-8095) ready for initial varietal trials and one (PHR-8022) for advanced varietal trials.
Banana	Rapid, low cost and user friendly multiplex dip stick assay for indexing banana viruses for onsite detection developed

A major programme “India-UK crop science fellowship (INcrops)” was launched under this partnership with an aim to create a skill set of trained manpower in the cutting edge technologies in crop sciences. It is aimed to send in ten (10) post-doctoral fellows per year to the UK institutions. The programme focuses on plant-pathogen/pest interactions; wheat pre-breeding; computational biology and the fundamental plant science underpinning yield enhancement, agronomy and photosynthesis.

Department has supported a Genomic selection and Speed Breeding Facility under a Network project at IRRI, Varanasi. This is first of its kind facility in India to facilitate faster genetic gains through speed breeding for generation advancement.



Speed breeding facility is targeted to undertake haplotype-based backcross breeding to transfer the superior haplotypes from landraces into elite backgrounds, and training and capacity development of 40 young plant breeders from India on breeding innovations.

A major mission mode programme has been supported by the Department on “Minor Oilseeds of India Origin”. The mission mode programme is aimed at sequencing/re-sequencing and phenotypic characterization of germplasm resources of Minor Oilseeds (Sesame, Linseed, Safflower and Niger). In the mission programme, the four (4) major Network projects in execution will provide information on new genes to combat biotic, abiotic stresses and nutrition. The four (4) major Network projects supported are:

**Mainstreaming sesame germplasm for productivity enhancement and sustainability through genomics assisted core development and trait discovery:** The project aims at phenotyping of 9840 accessions of sesame. Genotyping will be done for identification of genes/QTLs conferring resistance against selected biotic (phyllody & dryroot rot) and abiotic stresses (water logging and drought).

**Leveraging genetic resources for accelerated genetic improvement of Linseed using comprehensive genomics and phenotyping approaches:** Phenotyping and genotyping of linseed germplasm (2748 accessions) is in progress. The project will also undertake identification of trait specific germplasm accessions/genetic stocks for key agronomic (earliness, no. of capsules/plant, oil content, yield) and nutritional traits (omega-3 FA, lignan, protein), as well as for biotic and abiotic stress resistance.



Sesame Germplasm Evaluation at RRS, Vriddhachalam



Wild Linseed Germplasm

**Exploiting Genetic Diversity for Improvement of Safflower through Genomics-Assisted Discovery of QTLs/Genes Associated with Agronomic Traits.** Molecular core set of safflower germplasm (7000 accessions) is being developed under this project to discover genomic regions associated with seed yield, oil content, oil quality, resistance to Fusarium wilt, charcoal rot and aphid through genome wide association studies (GWAS). The project will also focus on developing pre-breeding material using the wild species, *C. oxyacantha* and *C. palaestinus* for exploring novel QTLs for yield.

Department continued its support to the major mission mode project on “Characterization of Genetic Resources” in various (27) crops. Under the mission programme, 2 major all India network projects were approved, and one is under approval. These projects will provide information on new genes to combat biotic, abiotic stresses and nutrition. The detail of network projects is as following:

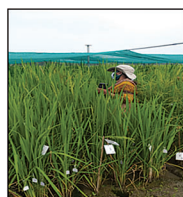
**Mainstreaming rice landraces diversity in varietal development through genome-wide association studies:** As a model for large-scale utilization of gene bank collections of rice, a total of 15251 accessions of rice are being genetically characterized for the development of core set followed by multi-location evaluation of core set for yield components, tolerance to abiotic, biotic stresses, resource use efficiency, grain & nutritional traits. The project will also facilitate development of elite donors for yield components, tolerance to abiotic, biotic stresses and nutritionally important traits.



Rice accessions grown at IARI, New Delhi



Uniform blast nursery (UBN) screening at MCRC, Khudwani, SKUAST(K)



Screening for false smut at IIRR, Hyderabad

#### Evaluation of rice germplasm at IARI, New Delhi, SKUAST-K and IIRR Hyderabad

**Germplasm Characterization and Trait Discovery in Wheat using Genomics Approaches and its Integration for Improving Climate Resilience, Productivity and Nutritional quality:** 7000 accessions of wheat including landraces available with Indian researchers and National Genebank are being used for agro-morphological characterization and genotyping/re-sequencing to facilitate gene discovery for biotic stresses (including rusts, powdery mildews, Fusarium head blight and spot blotch) and abiotic stresses (including drought, heat and salt tolerance). The project will accelerate genetic gain and speedy development of high yielding wheat varieties.



Off-season wheat nursery at Wellington, Tamil Nadu

A major network programme on “Pathogenomics of Plant Viruses” is being supported by the Department to combat plant viral diseases, a major cause of crop yield losses around the world

**R & D Projects:** During the year, R&D projects were supported both in basic and applied areas of research in agriculture biotechnology. Five (5) patents were filed, and fifty-nine (59) research papers were published during this period. Some of the major achievements of the projects

supported are as follows:

#### A. Cereals:

##### 1. Rice

- i. In the project “Marker aided incorporation of major genes conferring resistance to blast disease into genetic background of high altitude temperate rice (*Oryza sativa* L.)” marker-assisted backcross breeding approach led to development of blast resistant three-gene (Pi54, Pita2 and Pi9) pyramided lines SKUA-14-5 and SKUA-21-8 in Mushk Budjii and line SKUA-10-28 in the background of variety Kohsar.
- ii. The project entitled “Incorporation of biotic stress resistance gene(s) into the genetic background of Pusa Basmati 1509 through marker assisted backcross breeding” has led to the development of three genotypes namely, Pusa 1847-12-62-90-39-7-15, Pusa 1847-12-62-184-36-9-155 and Pusa1847-12-62-64-12-6-8 carrying bacterial blight (xa13, Xa21) and blast (Pi2, Pi54) resistance genes in the genetic background of Pusa Basmati 1509 which have been nominated in the national Basmati trials for their evaluation and release as commercial variety.

**2. Maize:** Three improved maize hybrids have been developed in the project “Enrichment of Nutritional Quality in Maize through Molecular Breeding”

- i. Pusa HM4 Improved: an improved version of HM4, developed through marker-assisted introgression of opaque2 allele with improved protein quality and possesses high tryptophan (0.91%) and lysine (3.62%). It has been released and notified for North Western Plain Zone
- ii. Pusa HM9 Improved: an improved version of HM9, developed through marker-assisted introgression of opaque2 allele with improved protein quality and possesses high tryptophan (0.68%) and lysine (2.97%). It has been released and notified for North Eastern Plain Zone [Bihar, Jharkhand, Odisha, West Bengal, & Eastern Uttar Pradesh].





*Pusa HM9 Improved    Pusa HM8 Improved    Pusa HM4 Improved*

*Maize Hybrids released and notified for various agro-climatic zones of the country*

## B. Oilseeds:

### 1. Brassica

The project “Germplasm enhancement for crop architecture and defensive traits in *Brassica juncea* L. czern. and coss” has led to the development of four determinate mustard hybrids (PHR-8024, PHR-8031, PHR-8076 and PHR-8095) and one determinate mustard hybrid (PHR-8022) which are set for evaluation under initial varietal trials and advanced varietal trials (Zone-III), respectively, during rabi season 2020-21 under All India Coordinated Research Project on Rapeseed-Mustard (AICRPR&M).

### 2. Groundnut

Training population of 340 elite lines has been developed for efficient Genomic Selection (GS) prediction in the project “A strategy to exploit genomic selection for achieving higher genetic gains in groundnut”.

## C. Vegetable and horticultural crops:

### 1. Tomato

Four tomato hybrids have been developed and one of the hybrid developed VRT 16-01 × P18-3 is a first hybrid to carry Ty-3 in homozygous state for resistance against Tomato Leaf curl Viral Disease (ToLCVD) in the project “Introgression of Begomovirus Resistance Genes in Tomato (*Solanum lycopersicum* L.) through MAS and Genomic Approaches”.



*Tomato Hybrids resistance against ToLCVD*

## 2. Banana

- i. In the project entitled “Development of a multiplex indexing technique using Gold nano-particles reporters for onsite detection of multiple viruses infecting banana” a rapid, low cost and user friendly multiplex dip stick assay for indexing banana viruses for onsite detection has been developed”.

## ANIMAL BIOTECHNOLOGY

Animal Biotechnology programme of the department is focused towards enhancing livestock production & productivity, and improving animal health through developing newer vaccines, therapeutics, diagnostics, newer reproductive technologies. The broad areas of research are genomics and genetic characterization, animal reproduction and nutrition, animal by-products, development of animal vaccines, diagnostics and therapeutics, technology for bovine sperm sexing, production of biopharmaceuticals through transgenesis and animal products. Department also initiated a One Health programme to establishing inter-sectoral collaborations among veterinary, medical, agricultural, environmental, forestry, meteorological and other areas to detect, prevent and control zoonoses and transboundary animal diseases.

The program aims at the sustainable growth of livestock, poultry and other animals for nutritional security and economic prosperity as well as enhanced production and productivity through biotechnological interventions.

### Process/Product/ Technology Developed:

- *Urine based early pregnancy diagnostic kit has been developed for cattles and buffalo.*
- *Developed extruded tomato pomace and apple pomace at both 2.5 & 5% level for inclusion in dog feed.*
- *Developed a device for compressive force of 636N to break canine teeth crown at 90 degree.*
- *Developed the cold sterilization protocol to achieve surgical grade asepsis in indigenous sutures.*
- *Designed 6 surgical grade stainless steel TPLO plates for cranial cruciate ligament rupture surgery.*

- Identified the rec. proteins (PPARA & SFRP2) as diagnostic markers for identification of Canine Mammary Tumor.
- Identified the diagnostic tear biomarkers for early KCS (RPE65 & FUT8) & for late KCS (APOA1, CLUL-1, RPE65 & FUT-8).
- Identified diagnostic serum biomarkers CRP, PGFM & IL-8 for Cystic endometrial Hyperplasia (CEH)-pyometra.
- Technology developed for cryopreservation of semen of dogs breeds viz., Pug & German Shepherd.
- Protocol developed for in vitro culture of chicken magnum cells for gene expression study.
- PGC based method was developed for construction of chimeric chicken.
- New method of diagnosis of Johne's disease in the domestic live stocks has been developed for field testing of native strain Indian Bison Type of *Mycobacterium avium* subspecies Paratuberculosis.
- Nano-Immuno Rapid Test has been developed to detect *Mycobacterium avium* subspecies paratuberculosis in milk samples.

**Process/Product/Technology Transferred to User Agency/ Industry/ Stakeholders:**

- ❖ Transfer of technology of Brucella "S19 mutant per vaccine to industry.

**Process/Product/Technology Commercialized:**

- ❖ Low Passage High Titre Canine Parvo virus (CPV-2b) Vaccine (TRPVB)
- ❖ Viroclean (Germicidal hand rub) (TRPVB)

quality semen has been supported.

- ❖ Chemical biology approach for early detection of pregnancy in buffalo (*Bubalus bubalis*) was supported.
- ❖ Program for identification of key molecular factors involved in resistance/susceptibility to paratuberculosis infection in indigenous breeds of cows.
- ❖ Development of novel semen extender to optimize post thaw quality for enhancement of productivity and multiplication of superior goat Germplasm has been supported.
- ❖ A Network Programme on Anthrax Diagnosis and Control in India was initiated.
- ❖ A major initiative for the establishment of a Consortium for One Health to address Zoonotic and Transboundary Diseases in India.

**Major outcomes and achievements of the programme are as follows:**

Translational Research Platform for Veterinary Biologicals (TRPVB): TRPVB is a unique partnership programme between DBT and TANUVAS. The mandate of this platform is to foster the productization in the field of veterinary biologicals by converging the presently distant academic research, industry and pathways of regulatory compliance. TRPVB has commercialized 12 products through technology transfer to industries and has several products / technologies ready for commercialization. TRPVB has mass produced 11 products including Teat Protect, Prosynch NC, BruAlert kit, TANUVAS SCC kit, TANUVAS Scrub kit etc and distributed to the Department of Animal Husbandry, Govt. of Tamil Nadu. TRPVB has successfully transferred the technology of canine parvo virus (CPV) virus-like particle vaccine and low passage high titer CPV-2b vaccine for canine. TRPVB is also offering diagnostic services on flow cytometry-based Evans syndrome detection, PCR-based haemoparasite detection in dogs, A1/A2 beta casein genotyping of cattle, Infectious bovine rhinotracheitis and Johne's disease sero diagnosis etc. TRPVB laboratory is accredited by NABL under ISO/IEC 17025:2017 for diagnosis of Bovine Trichomonosis and Bovine Brucellosis. TRPVB has a cGMP licensed manufacturing facility, a clean room and BSL-2 level laboratory facility. TRPVB was also instrumental in creating industry ready manpower through

**Major initiatives taken during the year 2020-21:**

- ❖ Phase-III of Translational Research Platform for Veterinary Biologicals (TRPVB) at TANUVAS, Chennai
- ❖ A programme for exploring molecular basis of seasonal variation of seminal attributes and identification of potential biomarkers for selection of buffalo bulls with



various programmes including Animal Biotechnology Career Enhancement Programme.

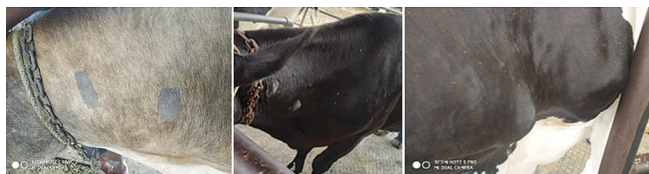
During the last year, a low passage high titre Canine Parvo virus (CPV-2b) vaccine was developed and commercialized to M/s TranScience Innovative Technologies (TSIT), Chennai. CPV- VLP vaccine developed as insect cell expressed recombinant protein was also transferred to M/s. Palamur Biosciences, Hyderabad. Under the DBT-TANUVAS partnership Program, during the COVID-19 lockdown period an alcohol-based hand sanitizer named, Viroclean was developed at Translational Research Platform for Veterinary Biologicals (TRPVB) based on WHO guidelines and commercialised. Manufacturing licence was obtained from State Drug authority and the product is in the market.

Bovine tuberculosis control- Mycobacterial diseases in animals' network (MyDAN) programme: The MyDAN project was initiated by the department with seven network centres to know the incidence of TB in different spectra, evaluate synthetic peptides as a suitable simple and confirmatory diagnostic tool (DST), evaluations of BCG for its efficacy in preventing disease and onward transmission and to develop national TB control programme for livestock in India which can be simulated across other countries. Systematic study of safety of DST, its evaluation for its dose response in cattle and buffaloes and its usefulness for DIVA is complete.

On comparison with different skin tests and IGRA, it was observed that there was huge difference noted between SIT and SICCT indicates an overlook at the usage of SIT as it there are possibilities of detecting non-specific mycobacterium.



Skin testing using syringe and



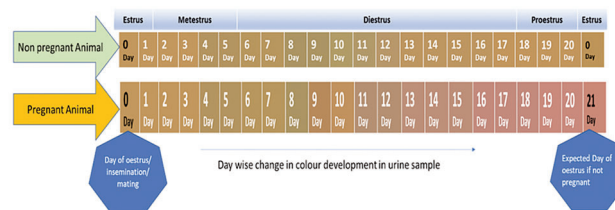
Prominent swelling at PPD-B injected sites in positive animals

Testing and evaluation of the health of laboratory animals: A multi-institutional program for the testing and evaluation of whole and recombinant antigen-based ELISA for monitoring the health of laboratory animals was initiated. The reagents were developed and various parameters for MVM, KRV, MHV and RCV were standardized. A technology is ready for transfer viz. ELISA based on whole antigens for RCV, KRV, MVM and MHV. A repository of reference sera for any further technology development is also developed. Further, the technologies developed are likely to drastically reduce the cost of monitoring of health of laboratory animals and improve their quality.

Early pregnancy diagnostic assay in cattle and buffalo: A multi-institutional program on the development of early pregnancy diagnostic for cattle and buffalo was supported. The urine and saliva were found to be best potential sources for diagnosis of early pregnancy. Further, a total of 31 proteins were reported exclusively in the urine of pregnant animals and two potential biomarkers viz. Nect (5-16-fold) and Fib (4-10-fold) were found in ELISA. A proof of concept for early pregnancy diagnosis was developed based on urinary metabolites (protein based) in pregnant urine. At least six of such metabolites form a red-violet lactone derivative coloured conjugate [(2,5-Dihydro-4-methyl-5-(2, 6, 6-trimethyl-4-oxocyclohex-2-enylmethylene) furan-2-one)]. Based on this colour reaction a colorimetric test was developed in form of a pregnancy diagnosis kit, Preg-D Bovine pregnancy diagnosis kit. Colour intensity is highest at around day 150 till end of pregnancy.



Preg- D bovine pregnancy diagnosis kit



Representative colour patterns in Prog-D test method

Canine Health Research: Department supported two major Network programme at PAN India level on Canine Health research that is being implemented at Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) Chennai, Tamil Nadu and Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab. The major research focus of these programs are on canine haemoprotozoan parasites, oncology, canine blood typing, canine enteric virus, canine contraception, canine ocular disorders and canine leptospirosis.

At GADVASU Canine Research Centre, veterinary Canine Blood Bank Unit, Leptospira Diagnostic Laboratory, Endoscopy and Dialysis Unit, nutritionally balanced dog biscuits with 30% Liver Powder & extruded dog feed with 15% rice gluten were formulated. Toggle pin, TPLO plates and TTA Cages were designed for treatment of canine arthropathies. Cost effective indigenous Nylon Fishline Sutures were developed. Root Canal & Crown Therapy in dogs was standardized. King dental impression arcade & stainless-steel crowns were designed for Root Canal Treatment. An acoustic sensor-based prototype capable of detecting pregnancy, fetal heartbeat, fetal health & litter size was designed. Rec RVL-G based quantitative ELISA for seromonitoring of vaccinal antibodies in dogs was developed. Cost effective indigenous corneal graft from Decellularized Porcine Small Intestinal Submucosa for treatment of Kerato-Conjunctivitis Sicca (KCS) cases was developed. Matrix protein of Canine Distemper virus (CDV) was developed for identification of circulating antibodies against CDV infection in canine which will be used for the development of LFA/ELISA kits. ELISA, Mixed bead-ELISA for detecting circulating auto antibodies against CMT were developed.



Toggle Pin

Suture Sleeve

Screws

Implants for Canine Arthropathies

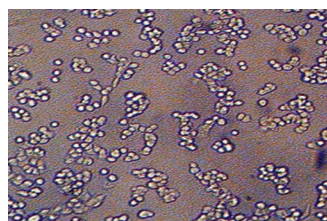


Dog Biscuits with Liver Powder

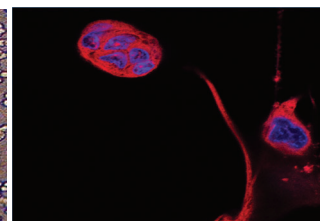


Indigenous Corneal Graft for treatment of Kerato-Conjunctivitis Sicca (KCS)

Further, at TANUVAS Canine Research Centre, a kit was designed for performance of Immunoglobulin staining at clinics and for flow-cytometric analysis in lab and a strip test was designed for detection of surface Immunoglobulin on RBC/Platelet surface with POC studies. Thrombocytopenia has been found to be a significant haematology feature and elevation in serum ALP levels is one of the important serological findings in dogs treated with CHOP therapy protocol. *B. gibsoni* infected dogs are three times more likely to develop Evans syndrome when compared to dogs without infection. Pirfenidone topical drops improved corneal clarity in dogs with corneal defects, Scaffolds of *Anthereamyliitta* supports corneal re-epithelialization. Dogs immunized with recombinant dZP3-GnRH<sub>2</sub> showed significant decrease in fertility as well as the number of pups born. Preliminary trials for the functionalized SMA polymer for intra-vascular application in rats and dogs revealed the membrane damage to the spermatozoa.



CPV samples showing cytopathic effect in MDCK cell line.

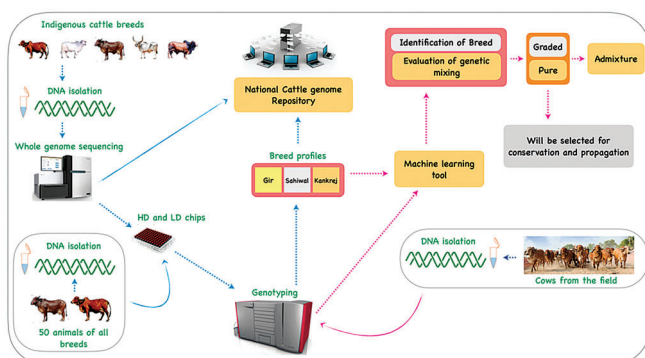


Immunofluorescence analysis of A72 cells infected with CPV-2b virus

Genomics for conservation of indigenous cattle breeds and for enhancing milk yield: A Program was supported to develop high density single-nucleotide polymorphism (SNP) chip for identification of pure indigenous cattle breeds as well as elite animals at National Institute of Animal Biotechnology (NIAB), Hyderabad. The whole genome sequencing data (coverage ~ 30X) of 176 animals was generated including



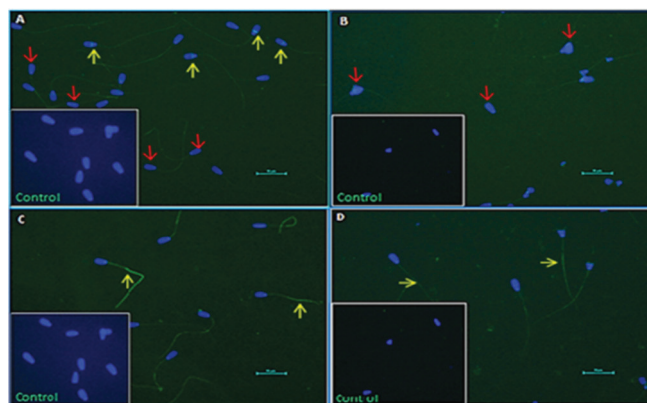
20 animals from each of five major breeds - Gir, Tharparkar, Kankrej, Red Sindhi and Sahiwal. The data was analyzed to identify SNPs and the SNP chip was generated for further use to delineate the admixture in cattle available in field and organized farms. One male each from major five dairy cattle breed (Gir, Tharparkar, Kankrej, Red Sindhi and Sahiwal) were selected for sequencing (10X genomics) based on its history/ pedigree records with an aim to assemble the whole genome. Further, the draft genome sequence for 4 major milch breeds (Gir, Sahiwal, Tharparkar & Kankrej) has been assembled.



Workplan of SNP chip development and Breed identification

Newcastle disease vaccine: A program for the development and evaluation of genetically engineered Newcastle disease vaccine was supported at IVRI, Izatnagar. A full-length infectious clone of Newcastle disease virus (NDV), pNDV-R2B- FPCS-CAV was generated with the regulatory signals of mesogenic NDV-R2B and transfected into the Vero cells resulted in generation of recombinant NDV containing the immunogenic genes of CAV. Further, it was characterized by molecular and biological methods to validate the pathogenicity and growth characteristics. Growth kinetics of the generated recombinant virus revealed it to be similar to the original parent virus with slight attenuation and Western blot analysis confirmed the identity of the virus on reaction with specific antibodies against NDV and CAV.

Selective Isolation of Sex Specific Spermatozoa in Bovines using Novel Biomarkers: Sex associated membrane (SAM) protein profiles were generated across X- and Y-spermatozoa which revealed 9 and 7 differential spots across X-enriched and unsorted semen from Jersey and Holstein Friesian bulls, respectively. The Flow Cytometric analysis revealed 4.43% to 9.69% of the spermatozoa to be bound with the X-enriched oligonucleotides and 4.18% to 22.11% of the spermatozoa to be bound with Y-enriched oligonucleotides.



Representative image of the 2D-gel of conventional and X-enriched spermatozoa

## AQUACULTURE AND MARINE BIOTECHNOLOGY

Fisheries and aquaculture is an important sector for the production of food to provide nutritional security. There have been continuous and sustained increments in the production of fishes in the past few decades. Fishes and their products have presently emerged as the largest group in agricultural exports from India. The department has made concerted efforts towards developing newer diagnostics and therapeutics, improvement in aqua feed, developing novel cell lines etc. through the adoption of molecular tools and techniques. The broad areas of research of programme are fish genomics, transcriptomics, therapeutics, diagnostics, marine ornamental marine bio-prospecting etc. Several training programs and workshops have been conducted to disseminate improved aquaculture techniques and to produce trained manpower on various aspects of Aquaculture and Marine biotechnology.

**Process Developed:** Established a process to isolate the protein protease inhibitor from marine bacteria *Oceanimonas* Sp. BPMS22.

**Process Commercialized:** A bioprocess to enhance the level of essential omega 3 fatty acid, EPA in marine microalga *Nannochloropsis oceanica* CASA CC201 by modulating the plant growth regulators has been developed and validated at large scale of 1500 L at commercial firm, ABAN Biotechnology, Chennai.

The main aim of this programme is to enhance aquaculture production, productivity and development of useful products and processes from marine resources for the benefit of the society.

### Major initiatives taken during the year

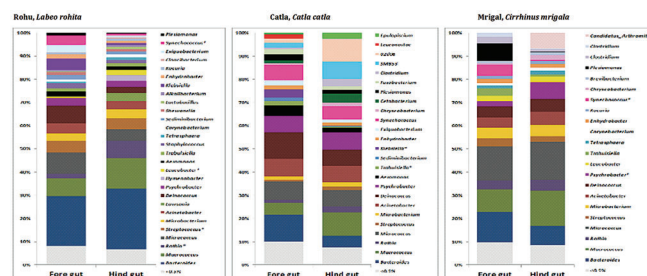
- Centre of Excellence and Innovations (EGS - CoEI) in Marine Fish Microbiome and Nutrigenomics
- Development of a new candidate species for Mariculture.
- Initiative on program for large-scale production of Lateral Flow Immunoassay kit to detect white spot syndrome virus (WSSV) of shrimp and its field evaluation.
- Initiative on De-novo whole genome and transcriptome sequencing of Asian green mussel, *Perna viridis*.
- Initiative for unravelling signatures of growth and salinity adaptation in *Etroplus suratensis* through omics approaches.
- Development of vaccines against emerging viral pathogens of fish in Indian aquaculture system has been initiated.

### Salient Achievements of the program are as follows:

Viral vaccine against nodavirus of fish: A whole virus vaccine was produced using seabass kidney and grouper eye cell lines. The gene encoding major capsid protein of nodavirus was used for a recombinant vaccine. Further, screening of VNNV in cobia broodstock oocytes, fry, fingerlings (up to 50dph) by RT-nPCR and a pilot study on the initiation of Live VNN virus in seabass fingerlings were carried out.

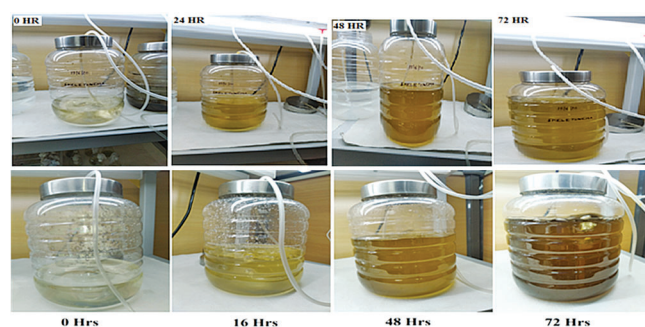
Prebiotic feed supplement for growth improvement of Indian major carps: The composite culture conditions for the Indian Major Carps (IMCs), i.e., Rohu, Catla and Mirgal were standardized in laboratory set up and four commercial and three natural prebiotics were applied to study their beneficiary effects on IMCs. The dietary supplementation of FOS (1%) and garlic powder (5%) is helpful in promoting growth of the IMCs under composite culture. Further, comprehensive high-throughput analyses of gut bacteria composition in three polycultured Indian major carps were performed and altogether, 19,71,569 sequences were retained from 54 samples (18 per species) corresponding to 3,202 OTUs. Intra-species variations in microbial composition were apparent at phyla-genus taxonomic levels together with a core

microbiota. Gut microbiome might have resulted from species-specific niche partitioning.

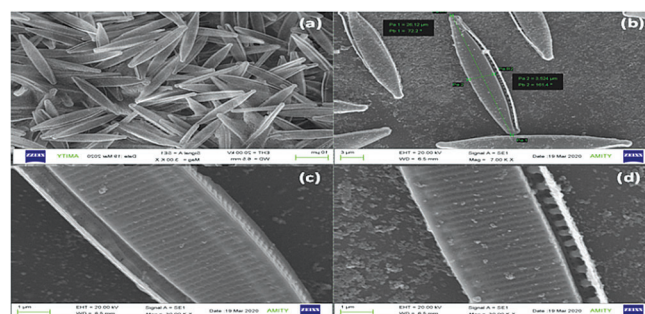


Bacterial community structure in the intestinal segments of IMCs

Diatom culture collection & segregation for nutraceuticals: The fucoxanthin and  $\omega$ -3 fatty acids producing diatoms species namely EPA and DHA have been identified and validated as a potential source of high-value biomolecules that contribute to the antioxidative and antibacterial efficacy. The results exhibited that ICP nanosilica is a key factor for the growth of diatoms and its metabolites. *Chaetoceros* sp. has also been explored in the management of wastewater and the utilization of their metabolites to enhance the nutritional value in diets. The biomass could be utilized in the form of a food source, biofuel, aquaculture feed, etc.



Mass Cultivation of *Skeletonema* sp. and *Thalassiosira* sp. in 5 L PET jar



SEM micrographs of *Nitzschia paleacea* isolated from Ca-alginate beads (Subarnarekha River)



Establishing Germplasm Resource Center for marine ornamental invertebrates: A “ICAR-NBFGR & DBT Germplasm resource centre for marine ornamental invertebrates” has been established which is equipped with Seawater filtration and recirculation setup, Quarantine, Water analysis, Mini livefeed stock culture units with Broodstock, Larval and Juvenile rearing sections. At this centre, more than 50 animal collections were conducted in eight islands of Lakshadweep and 286 individuals of ornamental shrimps and stocked in the facility. In addition, 35 sea anemones were also collected and stocked. A mass awareness on marine biodiversity conservation and opportunities for livelihood alternatives at Lakshadweep was also conducted at Agatti island in collaboration with the U. T. administration. More than 100 islanders, mainly women’s Self-Help Group members attended the event.

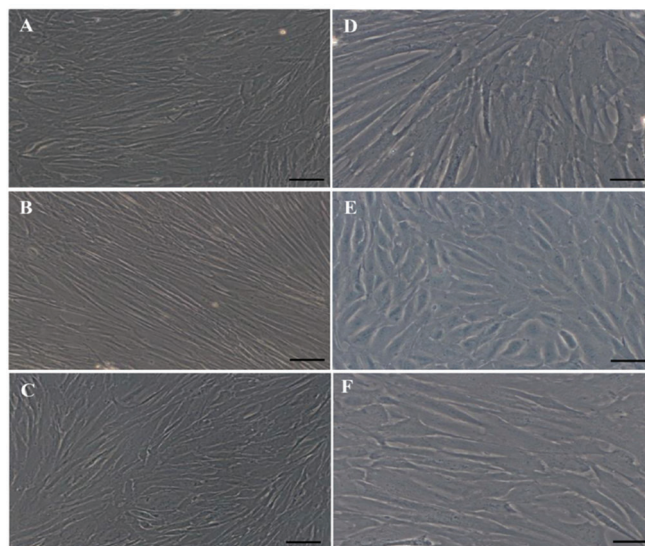


Genetic enhancement of economically important freshwater fish *Catla catla*: A total of 42 families of improved catla have been produced and stocked separately in nursery ponds. In total of 299 improved catla, from 13 nos. of full sib families produced and two additional stocks (Maharashtra and Bihar) were tagged with PIT tags and released in three communal ponds for further rearing and growth evaluation. In total ~1.49 million of uniquely mapped SNP’s were identified from catla population to be used for SNP array construction. The genomic organization of catla myostatin gene was validated. Additionally, four CRISPR/cas9 constructs were prepared from the catla myostatin genes and microinjected into zebrafish fertilized eggs to validate the gene disruption capabilities. Fin tissues from twenty-one breeding males and twenty breeding females have been collected and preserved towards the DNA repository.

Establishment of National Repository for finfish and shellfish viruses: The National Repository of Aquatic Animal Viruses, which is in the making, consists five shrimp viruses (WSSV, IHNV, MNV, HPV, MBV/PmNV) one brackish water fish virus

(VNNV) six fresh water fish viruses (TiLV, CyHV2, CEV, RSIV, MCV and IPNV) two viruses of fresh water prawn (MrNV and XSV) and two molluscan viruses (OsHV and Irido Virus). Currently eleven viruses in the form of isolates or lysates out of sixteen viruses committed have been maintained as follows: NCAAAH, Cochin has WSSV, IHNV, HPV, MBV and CyHV2; CHC Vellore WSSV, IHNV, MNV, HPV, MBV, VNN, TiLV, CyHV2, MrNV, XSV; ICAR-CIFA CyHV-2 and CEV; ICAR-CIFE WSSV, PmNV, NNV, TiLV. Primers of all known viruses and positive controls of majority of them are available with the Institutions to address outbreak of viral diseases in Indian aquaculture systems.

National Repository of fish cell lines and application in virology, toxicology and gene expression studies: A total of sixty-two cell lines (46 cell lines developed at CAHC and 16 obtained from NBFGR) have been maintained and supplied. Twenty cell lines developed in CAHC from a variety of fish were deposited in NBFGR in good condition and cryo-preserved. Seventeen new cell lines have been developed from rainbow trout, tilapia, silver pompano, cobia and goldfish. In NBFGR, Lucknow, a total of 11 cell lines developed namely (SRE, *Schizothorax richardsonii* eye muscle); (BBF *Bareilius bendelisis*, fi); (CMgT-1 *Clarias magur*, Testis); (CMgB-1 *Clarias magur*, barbells); (CMgM-1 *Clarias magur* muscle), CMgF-1 (*Clarias magur*, fin) DDaF-1 (*Dario dario*, fin), LRoF-1 (*Labeo rohita*, fin) and ZFiM-1 (*Danio rerio*, muscle); OCrf-1 (*Oreochthys crenusoids*, fin) and CNoF-1 (*Ctenops nobilis* fin).



Cell lines of eye (RTE), spleen (RTS) and kidney (RTK) established from *Oncorhynchus mykiss*.

Attempt to develop diagnostics and preventive measure for suspected fish viral diseases encountered in Assam: The regular monitoring of fish farms is being carried out across various districts of Assam for health status of fish as well as disease occurrence. A leaflet with colored photographs of diseased symptoms was prepared and circulated amongst the stakeholders of Assam for awareness and to gather information on occurrence of any diseases related viral symptoms. Collection of suspected virus infected fish

samples based on clinical signs, behaviour and mortality and transportation to the laboratory is being carried. Collected samples have been preserved in  $-80^{\circ}\text{C}$  and processed for further investigation. Freshwater fish samples were collected from different districts of Tamil Nadu for screening of CyHV-2 and TiLV, and the results revealed the occurrence of CyHV-2 in goldfish collected from aquarium shops located at Vellore and Chennai, and occurrence of TiLV in tilapia collected from ponds located at Katpadi in Vellore District.

## BIOENERGY, BIORESOURCES, ENVIRONMENT AND FOREST

Department promote R&D for Biofuel Technology development recognizing the need for clean and renewable energy. The program aims to make available cost-effective biofuel technologies through R&D in Biofuel areas and various schemes like Centres of Excellence, extramural projects, fellowships, and international cooperation. Environmental Biotechnology programme is one of the areas where impetus is on waste management and environmental improvement. Efforts have been made to generate/formulate consortia from the existing isolates as well as new isolates for site-specific remediation of xenobiotics from the environment etc. The aim of the programme is to support R&D programme in the area of Bioresources and Secondary Agriculture for biomass biotransformation, bioresource systems analysis, and technologies associated with conversion production of value-added products and processes from natural resources. The Department has also taken this initiative to facilitate scientific research and development, and demonstration projects on forest biotechnology. Overall aim of the programme is to support forest biotechnology with a focus on mapping and technological intervention for forest conservation, resource utilization, scientific management of invasion, studying ecosystem services and climate change mitigation.

Bioenergy, Bio-resources and Environment Areas at a glance	
on-going projects supported	120
New R & D projects, Network programs, platforms, facilities supported	51
Manpower trained	1155
Research publications	202
Research leads/ technologies/products developed	20
Research leads transferred to stakeholders or commercialized	5

### ENERGY BIOSCIENCES

The Energy Bioscience program aims to make available cost-effective biofuel technologies through R&D in Biofuel areas

and various schemes like Centres of Excellence, extramural projects, fellowships and international cooperation. The broad areas of research include Fermentation (2G-Ethanol), Enzyme Technology, Pre-treatment of Biomass, Biomethanation technologies, Systems and Synthetic Biology, Life Cycle Analysis, Algal Biotechnology and Other Biofuel Candidates. In 2020, 7 new projects were sanctioned, and 38 ongoing projects were supported, resulting in 21 research publications in peer reviewed journals, and support for more than 84 manpower positions. Apart from this, 5 Centres of Excellence in Bioenergy were supported, resulting in 98 research publications, 27 patent filings and support for more than 150 manpower positions.

### Salient Achievements of the program are as follows:

**2G Ethanol:** Technology has been demonstrated at 1 TPD scale, with Steam explosion pilot plant at 300 Kg/Day scale. This technology is being taken up for further scale up and demonstration at 12 Tons/day scale by Industry. Indigenous Enzyme development for biomass hydrolysis is being supported in mission mode.

Enzymes for lignocellulosic pretreatment, such as beta-glucosidase, cellobiohydrolase, endoglucanase and LPMO have been isolated, characterized and engineered. Several novel enzymes and auxiliary proteins for biomass hydrolysis were identified mostly from fungi by two DBT –Bioenergy Centers. The DBT-ICGEB Centre has genetically engineered a fungus for production of an active enzyme preparation with a specific activity that is comparable to the commercial enzyme, CTec3 from Novozymes. However, the team is working to increase the titer to lower overall enzyme production cost.

The DBT-IOC Centre has developed a fungal mutant that produced about 12 FPU/ml of culture broth at 5 Litre scale. This enzyme technology has been scaled up to 5,000 L bioreactor with more than 10 FPU/ml enzyme titer value. Specific strategies for improving the specific activity of the enzyme and rate of production have been recommended to increase productivity of a highly active enzyme. Efforts are on for scale-up, cross validation, demonstration and IP protection. DBT- ICT has been evaluating the enzymes developed by ICGEB/ IOC Centres by making cocktails with  $\alpha$ -glucosidase (BGL) addition and comparing the mixtures

with commercial samples. This has helped other Centres as a good third-party evaluation.

The DBT-Pan-IIT Centre produced a structure-based engineered  $\alpha$ -glucosidase, a chimera of endoglucanase- $\alpha$ -glucosidase, as supplements to fungal enzyme cocktails. Hyperthermophile enzyme hydrolase research centre (HERC) has been set up at IISER Mohali as a repository for thermophilic and hyperthermophilic organisms and their enzymes. This centre has cloned and produced several carbohydrate active enzymes which will be evaluated for use in 2G Ethanol and biorefinery applications.

A yeast strain that can ferment both hexoses and pentoses rapidly is a critical need for higher yields of alcohol. Hence efforts taken by DBT-IOC Centre in which a two-stage fermentation protocol developed in which hemicellulose derived sugars are fermented first before enzymatic release of glucose from cellulose and further fermentation of glucose to ethanol. This integrated process avoids catabolite repression and supports almost complete fermentation of initial xylose.

Lignin Valorization is important to make the 2G ethanol cost effective. Hence under this study Post-fermentation 2G lignin residue was fractionated by solvent extraction to lignin, silica and carbohydrates. Proof of concept demonstrated for production of levulinic acid & lactic acid from the carbohydrate fraction. Utilization of 2G lignin residue as such in bitumen is also being explored.

**Algal Biofuel:** With a goal to minimize waste generation and follow the concept of circular bioeconomy, DBT-TERI Center aims at the development of technologies for an algal-based biorefinery by using algae biomass as platform feed. 100,000 L indigenous sunlight-distributed algal system has been installed at Mumbai (Local algal strain; *Dunaliella tertiolecta*) has been successfully grown with the productivity of 15-18 g/m<sup>2</sup>/day. Wet algal lipid extraction method has been developed with 100% lipid extraction efficiency at a laboratory scale. The Scale-up of this process is in progress.

**Cyanobacterial Biofuels and platform chemicals:** Highest succinate titre from engineered robust, local cyanobacterial strain reported (~1g/lit). Modern synthetic biology toolbox like CRISPR-cpf1 developed for co-production of Succinate and ethylene. Portable and tunable promoter

library developed with 48 promoters with dynamic activity range for cyanobacteria. Comprehensive platform for <sup>13</sup>C metabolic flux analysis has been set up for cyanobacterial strains to understand the detailed metabolic profiles and bottlenecks for rational pathway engineering.

**Biofuel production from yeast:** A novel oleaginous yeast isolate *Rhodotorula pacifica* was isolated and this yeast accumulated lipids at >50% of dry cell weight. Genetically engineered yeast producing fatty acid ethyl ester (FAEE) has also been constructed.

**Biohydrogen:** Laboratory scale process developed for hydrogen production from enzyme hydrolyzed sugars of acid pretreated Azolla and water hyacinth and algae, Spirulina biomass with yield efficiency in the range of 60-70%. Future studies are targeted towards the use of mixed algae (*Dunaliella tertiolecta* and/or *Chlorella*) biomass raised at the Mumbai site. Hydrogen production process will be scaled up in 100 and 1000 L scale using algae and water hyacinth biomass along with its techno-economic analysis.

**CO<sub>2</sub> to algal oil and high-value chemicals:** DBT- IOC Center in collaboration with Lanzatech has developed an excellent continuous process for converting CO<sub>2</sub> and H<sub>2</sub> to algal oil rich in omega-3 fatty acids. This is a demonstration of carbon capture to acetate by the Lanzatech process coupled with heterotrophic algal growth for exploiting industrial waste streams or syngas containing CO and H<sub>2</sub>. Further studies on energy balance and cheaper H<sub>2</sub> source are being worked upon

**Life Cycle Analysis (LCA) and Techno Economic Analysis:** Model framework for cost-optimization of ethanol production was set up under DBT-PAN IIT project and successfully applied in Maharashtra. Multi-objective optimization model has been developed to study trade-offs between cost, GHG emission and water footprint. Macro-economic model has been set up to study biofuel policy implication. Calculation of regional water availability impacts, development of process flowsheets for cyanobacterial based production systems are among few targets set for the next phase.

**Waste to Energy:** Two demonstration plants successfully commissioned and operated for converting municipal solid waste (bioorganic fraction) into energy by an improved



biomethanation process at the scale of 3 Tons-7 Tons/day. The trial is ongoing for operation at full capacity of plants located at Hyderabad and Goa.

Overall, the Energy Bioscience program has resulted in development and demonstration of advanced biofuel production technologies at lab and pilot scale with knowledge generation and capacity building in cutting edge research. In order to make the biofuels cost effective, efforts are continued to develop and demonstrate integrated bio refinery platforms by production of value-added products and chemicals from by-products. Novel clean technologies developed and demonstrated to convert municipal solid waste and sewage into energy and clean water. These technologies once implemented will significantly contribute for energy security and de-carbonization of transport sector and hence protecting the environment.

**UNATI Mission:** Under the UNATI Mission, 10 promising clean technologies have been identified for demonstration with DBT support at different sites across India, in collaboration with local stakeholders such as municipalities and other urban local bodies. The identified technologies include biomethanation, constructed wetland, bio-toilets, chemical & membrane free water purification etc. The first five projects under this initiative were formally launched on 01<sup>st</sup> Oct 2020, on the eve of Gandhi Jayanti, with an aim to achieve “Swachh Bharat”.

The projects under the UNATI Mission are collaborations between the implementing agencies and local municipalities or urban local bodies. The local stakeholders will contribute resources such as land and waste materials as input to the project, and after successful demonstration of the technologies, the installations will be handed over to the local stakeholders for operation, maintenance, and upkeep. This is intended to improve the chances of success of the project due to the close involvement and commitment of the local stakeholders through MoA with the implementing agency.



*Representative figures of technologies being demonstrated under UNATI Mission. Clockwise from top left: CSIR-IICT Anaerobic Gas lift Reactor technology, Openwater.in Chemical and membrane free water purification technology, GPS Renewables biomethanation technology, SPRERI biomethanation*

**Launch of Clean Tech Demo Park:** DBT-BIRAC Clean Tech Demo Park at Barapullah drain site, near Sundial Park, Sarai Kale Khan, was inaugurated by Hon'ble Minister for Science & Technology, Health & Family Welfare, and Earth Sciences on 08 Oct 2020. The DBT-BIRAC Clean Tech Demo Park will be used to demonstrate innovative Waste-to-Value technologies with support from DBT and BIRAC. This park will be managed by the Clean Energy International Incubation Centre (CEIIC), a public-private-partnership incubator set up jointly by DBT, BIRAC and Tata Power.

### Mission Innovation: Accelerating the Clean Energy Innovation

Mission Innovation (MI) is a global initiative of 24 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. The Mission Innovation initiative is making a concerted effort to enhance the pace of innovation and scale of transformation in support of a clean energy revolution to meet the requirements and goals for India's economic and energy security promptly. This is being achieved by:

**Increasing International RD&D Collaborations:** To encourage and facilitate the leveraging of knowledge, capabilities, and resources among Mission Innovation

members and other stakeholders, DBT (via Mission Innovation) via a “Collaborative” approach, launched the Funding Opportunity Announcement for Carbon Capture (IC3), Sustainable Biofuels (IC4) and Converting Sunlight (IC5) and 49 collaborative R&D projects supported. For details please visit: <http://mission-innovation-india.net/foa/>

**Raising awareness of the transformational potential of Energy Innovation:** A wide range of workshops and events were organized to bring together key stakeholders to agree on priorities, promote innovation, opportunities for innovators & investors and explore opportunities for further collaboration. This initiative has helped to highlight the importance of clean energy innovation, address the key gap areas and at strengthening the international platform for collaboration and stepping up the pace of innovation via ambitious research, development and demonstration activities that can help members to unlock clean energy transition pathways measurably and successful transition to MI2.0 via Mission-oriented approach (Stakeholder engagement>2000 stakeholders). The details can be accessed at <http://mission-innovation-india.net/mi-india/>

**Increased Private Sector Engagement and Investment in CEIIC:** DBT and its Public Sector Undertaking, BIRAC has joined hands with Tata Trusts in successfully setting up the Clean Energy International Incubation Centre (CEIIC) to provide end-to-end support to startups, ranging from infrastructure, technology, angel funding, access to venture capitalists, mentorship, exposure to national and international organizations, experts. Under Mission Innovation mandate, the Incubation Centre launched two National Product Energy Challenge events which resulted in 25 winning solutions covering different areas of Clean energy.

**Clean Energy Investment and Technology Innovations:** IEA and the Ministry of Science and Technology, Govt. of India is currently focusing on assessment of R&D investments in clean energy in the country. The Joint partnership is helping to address the Clean Energy Transition in Indian landscape and highlighting the need for exchange of good practices, suggesting a way forward for policy and decision-makers.

**Avoided Emissions Framework: India-Sweden Collaboration:** India through CEIIC (a joint initiative of DBT

and Tata Trusts) and Sweden through RISE has collaborated under Avoided Emissions Framework (AEF) to accelerate the clean energy initiatives for a Sustainable Future. Under this partnership, eight companies have been selected to demonstrate an initial 100 million tons of potential CO<sub>2</sub> emission reduction by 2030. Details can be accessed at <https://misolutionframework.net/>

**Delivering the Mission Innovation Breakthroughs:** MI Solutions- The Mission Innovation Breakthrough Solutions has resulted in four Clean Energy Success Stories in India exemplifying the determination of scientists and engineers in universities and industry across India, to continue to drive the phenomenal progress made to date, and to succeed in delivering a clean growth revolution. The details can be accessed at <http://mission-innovation.net/resources/publications/>

**Mission Innovation Champions:** Scaling the Potential of Clean Energy Innovation: Turning Awareness into Action: Mission Innovation Champions is a recognition programme to celebrate and support innovative researchers who are accelerating the clean energy revolution. The MI Champions Program 2019 & 2020 has resulted in recognizing exceptional clean energy innovators in India on key innovative clean energy research and technology developments. MI Initiative has resulted in 2 Global MI Champions from India (Prof. SP Gon Chaudhuri and Dr Purnima Jalihal) scaling up innovations in Clean energy. The details can be accessed at <http://mission-innovation-india.net/mi-champions>.

**Information Sharing:** The preparation of reports and related documents highlighting the key gap areas, challenges, success stories and winning solutions in Clean energy has helped in enabling a better and faster understanding of the knowledge and good practices, generating new ideas, team cementing, getting top talent access (nationally and globally) about the clean energy sector. The reports/publications can be accessed at <http://mission-innovation-india.net/reports/>

**Engagement with MI Community:** India has been actively participating in MI Ministerial(s) and at the 5th Mission Innovation Ministerial (MI-5) held virtually on 23rd September 2020 hosted by Kingdom of Saudi Arabia was attended by a high-level delegation led by the Hon’ble Minister of Science & Technology, Earth Sciences and Health and Family Welfare

Dr. Harsh Vardhan, Secretary DBT Dr. Renu Swarup and senior officials from DBT and DST. The Hon'ble Minister of Science & Technology, Earth Sciences and Health and Family Welfare led the Indian delegation and presented India's commitment for MI 2.0 activities. MI Impact was presented by Secretary DBT highlighting the key impact of the clean energy innovation activities at the national and international level. The meeting reaffirmed India's commitment via Joint Member Statement to accelerate the pace of innovation and facilitate clean energy transitions by advancing the solutions and technologies needed to support national goals. Details can be accessed at <http://mission-innovation-india.net/mi-5/>



Hon'ble Minister at 5<sup>th</sup> MI Ministerial held on 23<sup>rd</sup> September 2020 (Virtual)-MI Global Champion India 2020

## ENVIRONMENTAL BIOTECHNOLOGY

Environmental biotechnology provides the means to balance national development with environmental protection leading to sustainable development. The overall objectives of the environmental biotechnology programme are to support R&D activities including translational research, knowledge generation, demonstration of technology on pilot scale, large-scale application of proven technologies, and capacity building. The broad areas of research include bioremediation, solid & liquid waste treatment, environmental monitoring, and ecosystem conservation & restoration. In 2020, apart from 41 ongoing projects, some new projects were supported. A total of 44 research articles were published in peer reviewed journals, and more than 112 manpower positions were supported. Two waste treatment demonstration projects under International Collaboration have been implemented at Barapullah drain site in New Delhi.

Under the LOTUS-HR project under the Indo-Netherlands collaboration, the drain water has been thoroughly

characterized and a toolbox of technologies has been developed for wastewater treatment. Under the DBT DESMI project sanctioned under the Indo-Danish collaboration, a system for removal of floating debris from the drain has been installed, which has been shown to remove up to 4 tons of waste per day.

**Highlights of the major achievements of the program are as follows:**

**Bioremediation:** Under a network project among 9 institutes, a platform is being created for engineering custom bioremediation strategies for petroleum contaminated sites. Contamination profiles of different sites at Lakwa, Assam, and Ankleshwar, Gujarat have been generated, augmented by data from geographical information systems (GIS) and remote sensing. Ongoing work includes isolation and characterization of potent microbes and plants for bioremediation, design and testing of formulations, and ecotoxicological analysis of test interventions.

Bioaugmentation and biostimulation approaches for bioremediation of the pesticide Hexachlorocyclohexane (HCH) was demonstrated on a 85 m x 45 m site at Barabanki, Uttar Pradesh, with initial HCH concentration ranging from 20 – 200 mg/g of soil. Over a period of 1 year, the a-HCH concentration was successfully reduced by 62 – 87%.

Bacterial dye-decolorizing peroxidases from *Bacillus subtilis* and *Pseudomonas putida* have been isolated and characterized in detail. This data can be used to engineer enzymes for potential use in textile wastewater treatment, and lignin degradation for biomass pretreatment.

**Solid & liquid waste treatment:** Customized constructed wetland (CW) technologies have been developed for treatment of household sewage and industrial effluents including distillery waste, paper and pulp mill waste and textile industry waste. A system for removal of floating debris from the Barapullah drain has been installed in collaboration with DESMI, Denmark, resulting in removal of 175 tons of waste and preventing it from flowing into the Yamuna river. Under the LOTUSHR project in collaboration with Netherlands, a toolbox of wastewater treatment technologies has been established on site at Barapullah drain to facilitate selection of treatment combinations for optimum treatment of wastewater.



**Environmental monitoring:** A protein-based biosensor for detection of phenolic compounds with a 10 ppb limit of detection has been developed. This biosensor is being developed into a rapid and cost-effective strip-based test for monitoring xenobiotic compounds in the environment. A study was conducted on the effect on the effect of mass bathing in Ganga on the microbiome and effect on human health. It showed that inspite of massive perturbation in the microbiome, the self- healing properties of river system rapidly brought about restoration of the previous equilibrium.

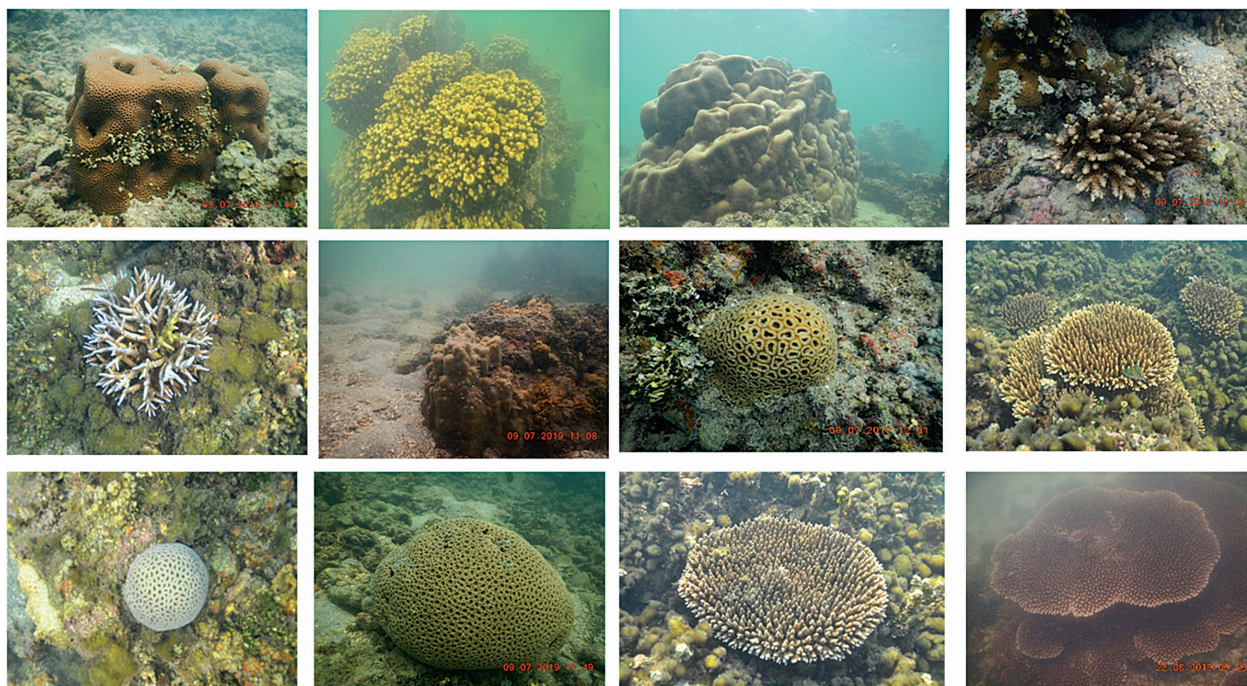
**Ecosystem conservation & restoration:** Mangrove restoration technology developed with DBT support was successfully demonstrated at approximately 5-acre scale at Sunderbans, West Bengal. The restored mangrove successfully survived cyclone Amphan. Based on this success, a new project has been sanctioned for implementation of this technology at field scale of approximately 100 acres.

A novel thermophile, *Thermus parvatiensis*, has been isolated from hot spring in Manikaran, Himachal Pradesh. A thermostable DNA polymerase has been isolated from this organism, with potential to be an indigenous replacement

for Taq polymerase used in PCR. A recombinant *E. coli* strain has been overexpressed with catechol 1,2-dioxygenase gene from *Paracoccus* sp. MKU1 to produce cis, cis-muconic acid from catechol. Cis, cis-muconic acid is used for the synthesis of a wide variety of polymers including biodegradable plastics.

Detailed molecular structural analysis of a dye degrading peroxidase from *Bacillus subtilis*. has revealed the mechanisms behind binding of different dyes to the enzyme active site, and the degradation of the dyes. This information can be used to enhance the dye degrading abilities of the enzyme and widen the range of dyes it can degrade.

A detailed record of the corals of Palk Bay was created and samples collected to strengthen the repository museum of corals of Palk Bay established at the Department of Marine and Coastal Studies at Pudumadam. This will also be used to develop a digitized data bank for corals and their associated zooxanthellae for future identification and research activities. This data is invaluable for assessing the effects of global climate change on reef environments and predicting their effect on the fishing industry and broader economy.



Corals Diversity in Palk Bay

*Parthenium*, *Cannabis* and *Solanum* species growing in areas polluted with distillery effluent showing phytoaccumulation of heavy metals in the roots and visualized here by Transmission Electron Micrography (TEM). This phenomenon is being investigated for development of phytoremediation technology for contaminated sites.

Vertical Flow Constructed Wetland (VFCW) with Biofilter (BF) for treatment of sewage and fish market waste before discharge of treated water into Sal river at Madgaon, Goa. This system is currently treating 30 m<sup>3</sup> of wastewater a day, and shown to be effective in lowering BOD, COD, TSS, enteric bacteria, and significantly reducing concentrations of pesticides like phorate and chlorpyrifos.

## BIORESOURCES AND SECONDARY AGRICULTURE

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

- Inventorisation and characterization on bioresources.
- Prospecting of bioresources for novel genes and genes products, biomolecules, and compounds.
- Improvement of economically important bioresources.
- Technology development of value-added products from Natural Resources.
- Capacity building including strengthening of infrastructure and other biomolecules components of R&D.

NCMR-NCCS, Pune	<ul style="list-style-type: none"> <li>• Total Culture Deposited 72586</li> <li>• 4778 (2020) Identified &amp; 420 AMR culture deposited</li> <li>• 21 Research article published</li> <li>• Three new species of bacteria described</li> </ul>
Multi-institutional Project in NER	<ul style="list-style-type: none"> <li>• 6 Component 29 Teams</li> <li>• Identified 6 New Diatoms</li> <li>• 3 new Mollusca</li> <li>• 15 Research article published</li> </ul>
NCS-TCP	<ul style="list-style-type: none"> <li>• 471672 Samples tested by ATLs</li> <li>• Certified 513.3 Million plants</li> </ul>
Biodiversity characterization	<ul style="list-style-type: none"> <li>• 84% Country's forest covered</li> </ul>

During this year, efforts are being continued to support the research for bioprospecting, inventorization and characterization, value addition and sustainable utilization of bioresources along with relevant training, capacity building and awareness generation. Various Brainstorming-cum-Consultation meetings were organized for prioritization of R&D areas based on available research leads. The Department has taken an initiative towards creating a consortium programme/virtual centre of Marine Bioresource and Biotechnology Network. The network comprises of around 20 institutes (DBT, CSIR, ES, MoEF & CC and ICAR) and Indian universities which are looking towards the basic, applied and translational research in the field of Marine Biology. The consortium programme of Marine Sciences comprising four thematic areas includes - Fundamental Research: Marine Biology; Cell and Developmental Biology; Marine bioresources, Biochemistry & Microbiology; Marine Ecology, Ecosystem services & Bioremediation for exploring ocean resources. So far, seven network project proposals under this consortium has been finalized and under process for financial concurrence.

The DBT has taken an initiative to participate in the Earth BioGenome Project (EBP), a global effort to sequence the genomes of nearly 1.5 million known animals, plant, protozoan and fungal species on Earth. The Indian component will be called as 'Indian Initiative on Earth Biogenome Sequencing (IIEBS)'. The IIEBS will allow our country to participate in this major global effort and collaborate with the leading nations of the world in undertaking and completing a task that will revolutionize biology. The objective is to sequence about 1,000 plants and animals (100 Reference Genome and 900 Draft Genome) during the next five years. The benefits that are expected to come from the sequencing projects will be in terms of generating new knowledge, development of new products for the bioeconomy, facilitation of conservation efforts and enhancement of national capacities in the cutting edge areas of genomics and bioinformatics.

**Salient Achievements of the program are as follows:**

**National Centre for Microbial Resource (NCMR):** DBT created a central facility, the National Centre for Microbial Resource (NCMR) as a Centre of Excellence in 2017, originally established as the Microbial Culture Collection in 2009 to

cater the need of authenticated, reliable biological materials and associated information for the research fraternity and biotech industry. NCMR has a mandate of exploring and conserving the microbial diversity of India and of developing an infrastructure to facilitate services of the highest standard in microbial identification, characterization, and preservation. NCMR is the single largest culture collection in the world, putting India in the top five countries with the largest collections. NCMR is playing a pivotal role in the NCMR remains committed to enrich and exploit this hidden treasure for its biotechnological benefits. NCMR has signed MOUs for collaboration with AMR surveillance networks like, KARSNET (Kerala AMR Surveillance Network), MAHASAR (Maharashtra State Antimicrobial Resistance), SAP-CARD (State Action Plan to Combat Antimicrobial Resistance in Delhi), and WINSAR-D (WHO-IAMM Network for Surveillance of Antimicrobial Resistance in Delhi). It has also developed links with Armed Forces Medical Services and FSSAI for the deposition of AMR microbes. NCMR has expanded its biological resources and has continued to accept diverse biological materials for preservation, such as DNA, protein, as well as environmental samples, in addition to microbial cultures. NCMR has standardized procedures to ensure the long-term preservation of these resource materials in its repository. NCMR provides a range of services involving the identification of microbes, including bacteria, archaea and fungi. These services are available for pan-India users. NCMR has added customized services such as processing of environmental samples for isolation of microbial cultures, phytoplasma detection, and identification and typing of microbial strains. This year, the process of purification of cultures deposited as mixed status has been initiated. NCMR is now accepting the bulk deposits (more than 100 strain per batch) of bacteria and fungi. Screening of fungal cultures has been started for the biodegradable myco packaging. NCMR has finished the supply of cultures to industrial and academic partners under a DBT sponsored program for various screening activities.

This year a total of 4,778 cultures have been identified either by 16S rRNA gene sequencing or by MALDI-TOF MS. *Acinetobacter*, *Aeromonas*, *Arthrobacter*, *Bacillus*, *Burkholderia*, *Enterobacter*, *Klebsiella*, *Ochrobactrum*, *Pseudomonas* and *Stenotrophomonas* represent the top ten most abundant genera. The total number of cultures deposited under the 'General deposit' category has reached

5,942, of which 3,500 are listed in the online catalogue after authentication and are accessible to academia and industry. In addition to these deposits, ten cultures were accepted as patent deposits under the Budapest treaty, and a total of 18 community DNA were deposited to meet the National Biodiversity Authority requirements. During this period, 420 cultures have been received for general deposit under anti-microbial resistant category from different hospitals and medical colleges. A large number of requests for culture supply, microbial identification/characterization, and genomic/metagenomics services have been received and completed. More than eight thousand bacterial strains received from IBSD, Imphal were processed for identification by MALDI-TOF MS.

Microbial repository established at IBSD, Imphal has got a total collection strength of 72586 microbial cultures including bacteria, fungi, yeast and actinobacteria. These microbial isolates were isolated from different unique ecological niches of NE India such as caves, hot spring, cold spring, high altitudes, sacred forest, fermented foods and beverages, lakes, forest, endophytes, epiphytes, mushrooms, and untouched ecosystems collected from Manipur, Meghalaya, Mizoram, Arunachal Pradesh, Sikkim, Tripura, Nagaland and Assam. Identification of the nearly 20,000 microbial cultures was carried out using MALDI-TOF mass spectrometry.

**Bioresource and Sustainable livelihoods:** A multi-institutional project, Bioresource and Sustainable livelihoods in North East India comprising six components and 29 teams has been supported to develop a baseline quantitative inventory of bioresources of NER, improve bioresource-based income through promotion of bioresource driven ecotourism, bioresource products and development of new biological products and germplasm and enhance the scientific capacity of Northeast India in biodiversity science.

During the current year, several new insect bioresources documented from NER with a few species fetching very high income for the local communities (Rs. 30-45000 per kg). Six new species of diatoms and three new species of molluscs have been described and published. Descriptions of several new species of lower plants, insects and molluscs are currently underway. Anti-biofilm activity of biochemicals isolated from *Gaultheria fragrantissima* oil published in Nature Scientific Reports. A total of 15 scientific and technical



workshops were organized wherein 536 students, practitioners and government officials from NER received training. A total of fifteen papers have been published or are accepted for publication so far. Three patent applications for bioresource based products developed under this project have been filed.



A collage of markets across Assam (left), Sikkim (Bottom right) and Kalimpong (Upper right) of the Eastern Himalayan region showing how selling bioresources in local markets are an important source of income for the women of the North-Eastern region

**Prospecting of Genes and Molecules for Product Development:** Projects have been supported for prospecting of novel genes, molecules, enzymes etc. from plants, microbes, fungi, lichens for production of potential products of industrial importance. A network project has been supported on developing standardized herbal formulation through prospecting of bioactive molecules/extracts from Seabuckthorn (*Hippophae rhamnoides* and *H. salicifolia*) to develop standardized herbal products for cardiovascular problems, immunomodulation, inflammation, wound healing and ulcer. *H. rhamnoides* and *H. salicifolia* material were extracted in different polarity of solvents and alcoholic, hydroalcoholic (80:20), water extracts were prepared. UPLC analysis showed that leaves have more polyphenols than fruits, but vitamins and carotenoids are more in fruits. UPLC-DAD based quantification of amino acids (Glu, Thr, Ala, Pro, Lys, Met, Leu) in *H. rhamnoides* samples hence, both have their own values for the development of herbal products. A total of 23 insects have been screened for Anti-Microbial Peptides from Hymenopteran (ants, bees and wasps) insects and bioassays from solvent extracts of six species have shown biological activity. One species of

ant, *Monomorium indicum* has yielded eight active fractions out of which one fraction showed good antimicrobial activity against both Gram+ve and Gram-ve bacteria. This fraction yielded seven potential AMPs of which five peptides were characterized and sequenced. All the seven antimicrobial peptides identified so far from these two species are novel peptides. Under the IBSD Flagship programme, Conservation, Propagation and Mass Multiplication of Selected Orchid species from North-East has been initiated and a pilot project has been sanctioned for developing bio-based entrepreneurship in North-East India. This Flagship programme aimed at exploring the potential of few selected species of the North East region for improvement of natural products contributing to environment protection, health security and sustainable growth of the economy. Under this programme, a total of 60 Orchids have been collected so far. Identification of 10 Potential entrepreneurs is under process.

#### Biodiversity Characterization and Digitized Inventorization

**Quantitative assessment of plant resources in hot-spots of the country:** The programmes on mapping and quantitative assessments of geographic distribution and the population status of plant resources were completed for the hot spots- Western Ghats, Eastern Ghats, North Eastern and Eastern Himalayan Regions and Andaman and Nicobar islands with significant achievements. A first ever systematic attempt has been made for quantitative assessment of plant resources in Madhya Pradesh, Central India. This assessment has been done in a grid-based manner and compiled the data in the form of database. A total of 22 districts of Madhya Pradesh out of 52 were covered from Nov. 2017 to March 2020, in which 705 transects were sampled in 650 forested grids out of the total of 2496 forested grids. Herbarium preparation has been completed for more than 300 plant specimens.

**Indian Bioresource Information Network (IBIN)** conceived by the Department as a single digital window to bring together all the available database and information on the bio-resources and biodiversity of the country in one platform. The main objective of IBIN project is to serve relevant information on bio-resources of the country to the professional involved in bio-prospecting, marketing, protecting bio-piracy and the conservation of bio-resources. The digital data sets being updated and hosted by

IBIN shall go a long way in sustainable utilization and conservation of bio-resources of our country. The species data consists of taxonomy, distribution, chemical and biochemical, pharmacological and other use information on plants, animal, marine and microbial assets of the country. The satellite telemetry tracking of Jacobin Cuckoo is a part of IBIN project in collaboration with Wildlife Institute of India. This initiative is taken by tagging the solar powered Platform Transmitter Terminal (PTT) of 2 gram to the Jacobin cuckoo. Jacobin cuckoo (*Clamator jacobinus*) is also known as “Chatak”, heralds the onset of monsoon in India and arrives during summer to breed from southern Africa by flying over the Arabian Sea and the Indian Ocean. This bird tagging helps to track their movements which is picked up by the Argos satellites when they pass overhead. The ground-based the satellite system calculates the position of PTT and the bird carrying it, and then transmits data to software for visualization of its movement patterns and stoppage sites. Through this tracking technology, the near real-time observations will help to monitor the changes in Indian monsoon patterns and could help in planning the conservation and climate monitoring programmes. During current year, the design and development of new IBIN species portal with updated taxonomy and synonyms of plants, animals, fungi, chromista, bacteria, protozoa and archaea, approx. 45,000 unique species, are completed. The chemical composition of ~250 plant species with its distribution, images, 2-D and 3-D view is contributed by the CSIR-CIMAP, Lucknow and its integration into new IBIN portal is in progress. The prototype is developed for Convolutional Neural Network (CNN) based butterfly identification mobile app by IIRS and a web application for the same is developed by UASB. The high-resolution field photographs of ~700 plant species are contributed by IIRS and IHBT for new IBIN portal.

**DBT- Department of Space Mission on Biodiversity characterization:** Under the Mission of DBT in collaboration with Department of Space towards a national level assessment of biodiversity richness, so far 84% of the Country's forest cover has been characterized. A new initiative has been undertaken recently towards mapping of Coral Reefs. The Mission activities include the creation of new geospatial inventory of Indian coral reefs covering 172 grids of Indian coral reef regions at 1:25000 scale. The project is going to deliver a new status report on Indian coral reefs

and carry out change detection vis-à-vis 2004-08 coral reef inventory based on Indian Remote Sensing satellite. During the current year, the uncharted, coast-fringing Mithapur reef of Saurashtra coast, Gujarat has been mapped for the first time using Resourcesat-2 LISS-IV data dated 14<sup>th</sup> February 2016. Preliminary coral reef habitat map has been prepared using digital classification. Ground-truth (GT) data for Mithapur reef was collected this year. Two shore-perpendicular transects (covering distances of 894.70 m and 526.45 m), 14 quadrates and 19 random sample points are collected as field data. A total of sixty-two GT points (habitat and substrate information) were collected from Mithapur reef and surroundings for calibration of the classified, pre-field map of Mithapur reef. Six different genera of corals (*Favia*, *Porites*, *Montipora*, *Goniastrea*, *Acanthastrea* and *Goniopora*) have been identified on the field.

The project on Biodiversity Characterization at community level is targeted at developing an Earth Observation based strategy for monitoring biodiversity at the vegetation community level in India. The project is being carried out by 7 participating institutions (NRSC, RRSC-C, IIRS, Kerala Forest Research Institute, French Institute of Pondicherry, Andhra University, M.S. University of Baroda) in 9 regional landscapes across Western Ghats (6), Eastern Ghats (2) and Western Himalayas (1). This project initiated linking of Earth Observations based variables with reference to assessment of decadal changes to the regional forest landscape using satellite remote sensing data, spatial characterization of vegetation communities using multi sensor, Earth Observation data and field studies, evaluating the utility of stand level canopy heterogeneity and height as a predictor of biodiversity, identifying Earth observation variables that are relevant to monitoring biodiversity and generation of web based data repository and information systems. Novel spatial pattern mining tool technique spatial pattern mining tool technique (emerging hotspot analysis technique) has been explored.

#### **National Certification System for Tissue Culture Raised Plants (NCS- TCP)**

**Production of quality planting material:** National Certification System for Tissue Culture Raised Plants (NCS-TCP) has been established by the Department of Biotechnology (DBT), Govt. of India as per the Gazette of India Notification under the Seeds Act 1966 with the objective

of certifying the production and distribution of disease free and quality tissue culture plants. Since its implementation in the year 2006, NCS-TCP has been instrumental in building capacities of the tissue culture companies for producing quality planting material and also enhancing their market reach through a certification process. NCS-TCP facilitates production and distribution of quality tissue culture plants among growers through a well defined quality management system (QMS) which is first of its kind in the world. Currently 84 Tissue Culture Production Facilities (TCPFs) have been recognized under the system which include almost all the leading companies. 4 Accredited Test Laboratories (ATLs) are also functional along with two Referral Centers (RCs) under this system. More than 550 million plants have been certified under NCS-TCP. Since implementation of NCS-TCP across the nation, incidence of virus infection has been significantly reduced with no major virus outbreak being reported in the tissue culture plantations during last thirteen years of implementation of the certification system.

This year, NCS-TCP has made significant progress in terms of recognition tissue culture companies, testing, certification, capacity building, updating of guidelines, creating awareness among stakeholders etc. Total of 4,71,672 samples were tested by ATLs. Out of these 2,02,024 samples are of mother plants and the remaining 2,69,648 samples are of tissue culture raised plants, certifying 513.3 million plants. Protocol for virus indexing has been developed/ refined for Banana, Potato, Sugarcane, Apple, Date palm, Bamboo and Orchid. Protocol for genetic fidelity has been developed/refined for 5 tissue culture raised plants namely Sugarcane, Potato, Banana, Bamboo, Date palm. Tissue Culture Standards for four new crops i.e. Date Palm, Pineapple, Pomegranate and Teak have recently been developed.

## SILK BIOTECHNOLOGY

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

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

### Salient achievements

Under a network project on integrated biotechnological approach towards improvement of quality and productivity of tropical tasar silk implemented jointly at CTR&TI Ranchi & NIAB, Hyderabad, whole genome sequencing of *Antheraea mylitta* conducted using DNA of isogenic line rearing of *A. mylitta* DABA ecorace. SMRTbell and 10 X chromium library preparations conducted successfully. Data revealed quality library preparation. Two SMRTbell libraries were used for the sequencing using PacBio sequel. As a result, total of 10.22 GB data was generated (4.98GB from SMRT 1 and 5.24 GB from SMRT 2) with an average polymerase read length of 7.83 kb and 8.11 kb from SMRT 1 and SMRT 2, respectively. Bioinformatics work revealed *A. mylitta* genome sequence and obtained *A. mylitta* whole genome sequence has been uploaded on NCBI Database. In a network project on Validation of the DNA markers in silkworm being implemented jointly at SBRL, Bangalore, and CSRTI, Berhampore, Marker assisted selection lines for NPV tolerance (MASN) are bivoltine lines synthesized that showed stability in rearing and adaptability in south, north and north-west regions. The hybrids developed from MASN line, Nistari x MASN4 is suitable for West Bengal as a potential alternative to existing ruling hybrids whereas the bivoltine MASN x CSR4 hybrid is a potential alternative for bivoltine sericulture in West Bengal and north- west India against the existing ruling hybrids. Molecular marker- based bivoltine hybrids and Nistari x MASN cross breeds are developed which are suitable for rearing in north India that can improve the sericulture. The hybrids have to be authorized and are recommended for distribution to farmers. A project has been carried out on development of diagnostic tool for early detection of baculovirus causing tiger band disease in *Antheraea proylei*: jointly at SBRL, Bangalore and RTRS, Imphal. PCR based technique has been developed to detect the tiger band virus (AnprNPV) in silkworms, moths at early stages as well as a major source of infection is identified from the contaminated egg surface. A protocol



has been developed to remove the virus present on the egg surface and the preliminary findings indicate that leads to the significant improvement in oak tasar cocoon production besides prevention of the disease. An egg surface disinfection technique was developed which was further tested and validated on field samples at various seed production centres providing a greater degree of assurance by showing increased cocoon yields (15-20% higher) against the previously developed conventional disinfection methods. The outcomes from this study would have given ways to ponder over future research to further understand and improve the oak tasar culture.

A network project on identification of the most active cocoonase of sericigenous insects through molecular characterization *being implemented jointly at* CTR&TI Ranchi, IISER, Pune and BIT, Mesra, Cocoonase enzyme linked post translational modification and rigorous characterization study conducted. Cocoonase crystal structure prepared successfully. Comparison of various ecoraces cocoonase activity and its characterization was conducted. Cocoonase variants trypsin and proteolytic enzyme papain was compared with cocoonase which showed activity in cocoon softening with 55% silk recovery. Based on activity, cocoonase/variants screened based on structural similarity. Impact of temperature, pH, substrate, inhibitors and inducers on cocoonase activity has been conducted and the appropriate condition standardized. MALDI analysis of 8 ecoraces cocoonase samples was conducted. Various characterization tools were used i.e. colorimetric analysis, FTIR, TGA/TDA and DSC of cocoonase treated and soda treated silk fibre. X-ray diffraction with the new crystals of cocoonase showed improved resolution 1.8 Å.



Fig. 6: Initial use of cocoonase variant trypsin in softening of tasar cocoons to get silk with natural color and luster

A project on analysis of DNA and RNA components of the nuclear matrix in *Bombyx mori* embryos has been supported at GITAM, Visakhapatnam. The study revealed for the first-time genome-wide MAR regions during silk gland development to understand the dynamics associated with chromatin architecture. The databases published in NCBI from this study can be used as a platform by other researchers working on silkworm biology. The developmental dynamics of silk gland MARs can be taken as a foundation to understand the differences in gene expression during silk gland development. A project has been carried out on Gene Expression Profiling for the Identification of Resistant/Tolerant Genes to Microsporidian Infection in Lamerin Breed of Silkworm, *Bombyx mori* implemented jointly at Seri-Biotech Research Laboratory (SBRL), Bangalore; and Indian Institute of Science, Bangalore. The study showed the upregulation of specific antimicrobial genes, serpins in response to microsporidian infection. The upregulation of these genes in Lamerin breed in comparison to CSR 2 is an indicative of the tolerance/resistance exhibited by the Lamerin breed against the *N. bombycis* infection.

**Work on Genetic enhancement of Mulberry by Genomics Approaches:** A multi-component Network Project being coordinated by CSRTI, Mysore. Sequencing, *de novo* assembly and structural annotation of the *Morus indica* (K2) nuclear genome has been completed. Resequencing of 22 accessions of mulberry at high-depth followed by pre-processing and mapping of the reads to *Morus* (*M. notabilis* and *M. indica*) genomes has been completed. The genetic diversity in mulberry germplasm were evaluated using informative SSR markers. Extensive phenotypic characterization of the panel of germplasm for drought, yield and nutrient use efficiency data has been recorded for one cropping season. Significant variation among the panel of germplasm in stomatal frequency and chlorophyll content was noticed. Variations in the stomatal number and size at different positions on the leaf. Bi-parental mapping population for SNP linkage map construction and identification of root rot resistant QTLs has been developed. Transcriptome data on growth and drought stress have been generated and submitted to the database (SRA numbers: SRX9004356, SRX9004357, SRX9004358 and SRX9004359). More than 30% of the transcriptome belong to category of proteins of unknown function (PUFs) which

can be used for novel gene discovery and also for identifying molecular markers. An Indian patent on 'a method for inducing early and rapid bud break in mulberry plants' filed (Application no. TEMP/E-1/27174/2020-CHE). A comprehensive biology document on mulberry has been developed for confined field trails of transgenic mulberry. Putative mulberry transgenic plants co-expressing SHN1 and DREB2A developed using G4-variety and are being characterized. Preliminary results showed that primary metabolites varied among ten genotypes (V1, G2, G4, S13, K2, Mysore Local, S36, MR2, MI 0027, ME 0168). V1 recorded high primary metabolites, whereas least metabolites were observed in Mysore Local, K2 and ME 0168. Protein content ranged from 13 - 24 mg/g fw and moisture content ranged from 74-80 % among the genotypes. Secondary metabolites were extracted V1, G4 and G2 under different conditions and subjected to GC-MS analysis. TBME extracts under sonication showed better metabolite levels. Growth of *Spodoptera litura* is affected by sugar mimicking alkaloid 1-Deoxynojirimycin (DNJ). *S. litura* does not possess beta-fructofuranosidase gene unlike that in *Bomby mori*.

A project has been carried out on Design and development of silk fibroin coatings for biomedical applications at CSIR-National Chemical Laboratory, Pune. Novel testing methods have been developed to quantify adhesion of nano-coatings to elastic polymeric substrates such as PDMS. Demonstrated novel protocols for stable crack resistant Silk Fibroin coatings on PDMS. Novel blends of silk fibroin with recombinantly produced elastin protein for coating applications. The formulations and protocols developed as part of this work have the potential to be used in biomedical implant applications.

## TRANSLATIONAL RESEARCH ON MEDICINAL AND AROMATIC PLANTS

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

Phytopharmaceutical Mission for NER	<ul style="list-style-type: none"> <li>QC&amp;QA facility established</li> <li>cGMP facility is being set up</li> </ul>
COVID-19 Pandemic response	<ul style="list-style-type: none"> <li>Call for proposal-230 proposals received</li> <li>Phase II trial of AQCH</li> <li>3 Sub-Network with Ministry of AYUSH established</li> </ul>
Joint DBT-AYUSH call	<ul style="list-style-type: none"> <li>Received 300 Proposals on RET medicinal plants</li> </ul>
R&D	<ul style="list-style-type: none"> <li>Turmeric mission launched</li> <li>Topical gel for Bovine Mastitis developed</li> </ul>

During this year, the Department has launched a 'Phytopharmaceutical Mission for North East Region of India' with a view to promote development of phytopharmaceuticals in North East Region. A QC and QA facility for medicinal plants has been already established and cGMP facility for pilot-scale extraction for phytopharmaceutical products from the Medicinal Plants of NE India are being set up. Under the Inter-Ministerial Cooperation program of CSIR, DBT and ICMR on 'Phytopharmaceutical drug development', a pipeline of phytopharmaceutical drugs has been developed. This include: developing phytopharmaceutical drug from *Ficus semicordata* for diabetes; developing phytopharmaceutical drug from *Trachyspermum ammi* for Post Kala-azar Dermal Leishmaniasis (PKDL); CBD-THC Enriched phytopharmaceutical drug for cancer pain management; cannabis based phytopharmaceutical drug for management of resistant pediatric epilepsy; development of *Boswellia serrata* based phytopharmaceutical drug for osteoarthritis.

The Department has signed a Memorandum of Understanding (MoU) with National Medicinal Plant Board, Ministry of AYUSH for Inter-Ministerial Cooperation on biotechnological intervention in AYUSH sector and to have a platform for exchange of information between the NMPB, the Ministry of AYUSH and DBT. Proposals are being developed for joint funding and implementation by Ministry of AYUSH and DBT. Department has invited a 'Joint Call for R&D Proposals on Biotech interventions in medicinal plant' with an aim of making sustainable availability and use of medicinal plants to support R&D proposals in the following thrust areas: Finding substitutes and sustainable alternative plant parts for Rare, Endangered and Threatened (RET) medicinal plant species; Development of bio-actives and

marker compounds for authentication of raw medicinal plant materials; Elite identification, development of propagation techniques and conservation; Varietal development and establishment of quality standards in respect of norms related to toxicity and heavy metal content to increase acceptability of botanicals in the international market and Non-destructive methods and sustainable harvesting for priority species such as *Commiphora wightii* and Ecological Niche modeling on RET medicinal plants species. In response to the above Joint Call for Proposal, the Department received a total of 300 proposals in the suggested thrust areas. The Department has constituted a “Joint DBT-AYUSH Expert Committee” for final evaluation of shortlisted proposals for financial support jointly by DBT and NMPB, Ministry of AYUSH.

A Turmeric Mission programme has been launched with an aim to generate high-quality raw material for developing nutraceutical products / dietary supplements from turmeric for global market as well as developing curcuminoids / curcumin-based therapeutics for various disease segments. Two projects focussing on quality enhancement of turmeric for nutritional and quality profiles and efficient post-harvest management practices and integrated development of turmeric sector in north eastern and Bundelkhand regions for improvement of productivity, quality and post-harvest processing technology have been undertaken. Three projects on nanocurcumin-based combinatorial therapy for tuberculosis, pre-clinical assessment of novel curcumin formulations as drugs for breast cancer therapy and evaluation of safety and efficacy of curcumin (Biocurcumax capsule) as an adjunct drug to standard therapy for treatment of uncomplicated *Plasmodium falciparum* malaria have been undertaken.

### Salient achievements

A project has been supported to study the manipulation of Rumen Microbes Using Medicinal Plants Extract to Enhance the Nutraceutical Value of Milk as a Functional Food at ICAR-National Dairy Research Institute NDRI, Karnal. The study revealed that dietary supplementation of *Bacopa monnieri* and *Aloe vera* extracts in animal have the potential to manipulate the rumen microbes and enhance the nutraceutical value of milk via increasing the amount of unsaturated fatty acids (UFA) and reducing the saturated fatty acids (SFA) content. Supplementation of *Bacopa monnieri*

and *Aloe vera* was found to modulate the rumen fermentation by changing the biohydrogenating microflora and enhancing the health beneficial fatty acids and decreasing the SFA content of milk in lactating goats. Milk obtained from supplemented groups of *Aloe vera* was found to have greater antioxidant capacity than other groups. Overall, medicinal plants extract increased the nutraceutical value of goat milk not only by modulating the fatty acid profile but also the antioxidant potential.

A project has been supported for the Development of Phytopharmaceutical product for Bovine Mastitis jointly at CSIR-IIIM, Jammu; ICAR-CIRG, Mathura; and ICAR-NDRI, Karnal. Topical gel formulation for Bovine Mastitis was developed using extracts of *Boswellia serrata*, *Bergenia ciliata*, *Terminalia bellerica* and *Piper betle*. Product was evaluated in *in vitro* and *in vivo* assays for their anti-infective and anti-inflammatory activity and found effective. Six best extract were selected from four medicinal plants (*Terminalia bellerica*, *Piper betle*, *Boswellia serrata* and *Bergenia ciliata*) for the development of three topical gel product as anti-infective and anti-inflammatory for bovine Mastitis. Topical gel showing promising activity and comparable with marketed product Diclofenac gel (Voveran gel; Novartis) as control. Oral and Topical formulation was evaluated found effective subclinical form of mastitis in target animals at ICAR-National Dairy Research Institute (NDRI) and ICAR-Central Institute of Research on Goat. Supplementation of herbal product with application of mastitis formulated gel showed a positive and significant effect in reducing the somatic cell counts in milk.

A project has been supported at Amrita Institute of Medical Sciences and Research Centre, Kochi for the Development of Plumbagin ointment as topical anti-microbial agent for the treatment of *S. aureus* skin and wound infections. 0.02% plumbagin incorporated carbomer hydrogel (P-CHG) was prepared by incorporating plumbagin to carbomer C934P hydrogel. The gel system showed good antibacterial activity against *Staphylococcus aureus* laboratory (ATCC35556) and MRSA clinical strains. The activity of the gel was remained almost intact till 6 months after which it gradually reduced. 0.02% P-CHG showed promising antimicrobial activity against tape stripped infection mice model of *S. aureus* skin infections. In the project on product development based on thymol-rich Jammu monarda being jointly implemented at CSIR- IIIM, Jammu and FFDC, Kannauj various field



experimental trials have been conducted on *Monarda citriodora* on experimental field of FFDC, Kannauj (U.P.) and MSME TC project Imphal (Manipur). The overall performance of the crop was good having excellent oil recovery (0.6%). The oil of *Monarda citriodora* is the good source of Thymol content which is used in various flavour and fragrance industry. Five formulations of anti-phytopathogenic activity were developed using the essential oil of Jammu monarda and its constituents. They were evaluated against tested pathogens using dual culture assay. Two thymol-based fragrance formulations for soap, agarbatti, flavor and prototype for Toothpaste have been standardized. A project has been supported at *Manipal University, Manipal* to develop a species-specific marker that can help to distinguish individual medicinal plant ingredients from its closely related species using next generation sequencing technology in three classical ayurvedic formulations (*Punarnava churna*, *Guduchi Churna* and *Rasnadi Churna*) for authentication of the formulation as well as individual plant species used thereof. Medicinal plants in ayurvedic pharmacopoeia of India namely *Boerhaavia diffusa* (Punarnava), *Tinospora cordifolia* (Guduchi), *Alpinia galanga* (Rasna) which are also the main ingredients of Punarnava churna, Guduchi Churna and Rasnadi Churna along with their adulterants/substitutes *Trianthema portulacastrum* (Punarnava), *Tinospora malabarica* (Guduchi), *Aplinia calcarata* (Rasna) were selected for the present study. Total of 30 accessions were collected from different regions of Karnataka state, identified and germplasm is maintained in the institute green house.

Work has been initiated on Phytopharmaceutical Development of *Trachyspermum ammi* for Post Kala-azar Dermal Leishmaniasis jointly at *Balaji Utthan Sansthan, Patna*, *Jadavpur University, Kolkata* and *ICMR-Rajendra Memorial Research Institute of Medical Sciences, Patna*. Extracts of *Trachyspermum ammi* were prepared as Hydro-alcoholic extract, Ethyl-acetate, Chloroform, Hexane and Methanol fraction. Ethyl acetate fraction has been found to have maximum percentage of standard marker compound (Thymol) present therein. In the present achievement, Ethyl acetate fraction found to be very effective with non-significant morphological changes of the host cells that have been observed during study on intracellular amastigote susceptibility test. The second line of effectiveness is with Chloroform fraction but shows some morphological changes

of host cells. In a network project jointly implemented at *CSIR-IIIM, Jammu*; *IASST, Guwahati* and *IBSD, Imphal* on Phytopharmaceutical Development of *Ficus semicordata* Buch.-Ham. ex Sm. as per regulatory guidelines of DCGI, the plant material (figs/fruits) of *Ficus semicordata* was collected from different sites of Ukhrul district of Manipur. The investigations revealed a significant or promising blood glucose lowering activity of enriched fraction at 150-250 mg/Kg doses when administered as once daily dose for 14-21 days to streptozotocin induced diabetic rats. Under the phytopharmaceutical mission for NER, a project has been implemented at *IASST, Guwahati* for the Setting up a Quality Control (QC) and Quality Assurance (QA) Laboratory Facility for quality assurance of herbal drugs. The Microbiology and Analytical laboratory of QAQC are being prepared as GLP Clean Room Class 100000 area as per ISO standards. IASST has recently obtained certificate of the Quality Management System standard: ISO 9001:2015 (Cert. no. 281999-2019-AQ-IND-RvA) which will further facilitate in obtaining NABL accreditation for the facility.

A multi-component Network Project on demonstration of Cultivation, Processing and Value Addition of Selected Aromatic Crops in Bundelkhand Region jointly implemented at *CSIR-Central Institute of Medicinal and Aromatic Plants CIMAP, Lucknow*, *Fragrance and Flavour Development Centre, Kannauj*; *CSIR-Indian Institute of Integrative Medicine (IIIM), Jammu* and, *Bundelkhand University, Jhansi*. During current year, a total of 64 awareness and training programme have been conducted and 3919 farmers/women and youth have been trained. A total area of 1121.40 acres has been covered with selected aromatic crops in both the years that produced 21694.50 kg of essential oils. Till date, 21 field distillation units have been installed in selected farmer clusters. Apart from oil and planting material, 89,720 man-days were generated in the lien agriculture period in drought affected areas. A total of 57 awareness-cum-training programs have been conducted on preparation of agarbatti from spent material of aromatic grasses in which total 3676 participants participated and benefitted. Total 2000 kg essential oil produced by the farmers from the aromatic plants viz., Lemongrass, CKP 25 (825 kg), Rosagrass (1,175 kg) in the year 2020-21 and generated income Rs. 27.37 lakh. Total 33.495 lakh slips (planting material) procured by the CSIR-IIIM, Jammu by the beneficiaries/ farmers of

Bundelkhand region in the rate of Rs. 0.50/ slips and generated income to farmers of Rs. 16.75 lakh. Gross total 45- 50.00 lakh incomes generated by the farmers up to October 2020 by cultivation and processing and sale of aromatic crops in the Bundelkhand region. In the wake of pandemic COVID 19 the training programme and other procurement process were continuing through the online mode. During the period 10 training cum awareness programmes offline and online has been conducted for farmers/growers in whom 315 peoples were participated/ benefited. Order of Six (06) 500 kg capacity directly fired type ms field distillation units has been placed to firms/ manufacturing company.



Performance of Aromatic plants CKP 25, CK-10 and CN 5 in Bundelkhand region

A multi-component Network Project on Field Demonstration of Cultivation and Development of Processed Technologies of Aromatic Plants – Patchouli, Citronella and Sugandh Mantri in Assam has been continued at Kelkars Education Trust's Scientific Research Centre, Mumbai in collaboration with Institute of Horticulture Technology, Mandira, Assam for demonstration on cultivation of selected Aromatic Crops in 100 acres area (Patchouli: 60 acres; Citronella: 35 acres and Sugandh Mantri: 5 acres) in farmers' fields in Assam. The project is aimed to evaluate performance of elite varieties of selected aromatic crops in 100 acre target areas in farmer's fields in Assam. It involves establishment of Demo Plantation and Plant Nurseries for Cultivation, Mass Multiplication and supplying of planting material with total handholding and training of the farmers. Distillation of the Biomass is done at the farmers fields and the essential oil produced from farmer's fields are given assured buy-back. Patchouli Variety propagated by Kelkar group is Johar variety

brought from Indonesia. The variety is registered. Plants are developed by tissue culture at SRC, Mumbai. Patchouli variety acclimatized in India has 25-36% Patchoulol. Citronella Ceylon variety is propagated in Assam Tea Estates. Variety has better herbage yield and oil percentage. Variety is registered at Jorhat Regional Research Centre, CSIR, NEIST, Jorhat. IHT procured Jor Lab C-5-Latest var. released by NEIST, Jorhat and CIM ZIWA from CIMAP, Lucknow. For Sugandhmantri, R&D Centre, NEDFi, Khetri, and Wild habitat of endemic areas like Kanchanpur (Tripura), Kakocharri area (Nomens line between Tripura & Chittagong), Barak Valley of Assam, Arunachal Pradesh, Nagaland areas have been collected.

A multi-component Network Project on Identification of Elite Planting Material of Selected Temperate Medicinal Herbs, Mass Multiplication, Field Demonstration and Post-Harvest Processing jointly implemented at Bennett University, Greater Noida, G.B. Pant National Institute of Himalayan Environment & Sustainable Himachal Unit, Mohal-Kullu and, Zandu Foundation for Health Care, Gujarat. The project aims at developing rural enterprises among high altitude farmers of Himachal Pradesh and Uttarakhand through mass multiplication and production of quality plant material of four medicinal plant species, *Swertia chirayita*, *Picrorhiza kurroa*, *Nardostachys jatamansi* and *Rubia cordifolia*. The elite planting material of four medicinal plant species, *Swertia chirayita*, *Picrorhiza kurroa*, *Nardostachys jatamansi grandiflora* and *Rubia cordifolia* have been identified as per API criteria from Himachal Pradesh and Uttarakhand. Total 4,55,000 plants of *P. kurroa* out of which 2,35, 000 in Uttarakhand 2,20,000 in H.P. have been planted in farmers' fields, covering acreages of 5.3 acres and 4.0 acres, respectively. Seed germination and nursery raising has been optimized for *Swertia chirayita*, which is extremely endangered species in India. Total 27,500 seedlings of *S. chirayita* have been transferred in farmers' fields, followed by their trainings on cultivation practices, which would provide enough seeds for achieving project targets. RAPD-based DNA fingerprints have been identified for populations of *N. jatamansi* and *R. cordifolia* for quality assurance, genetic purity and IPR protection of elite material. Propagation of *N. jatamansi* has been optimized wherein individual shoots along with roots emerging from the rhizomes were separated (process known as Splitting Rhizomes Shoots), planted in individual pots containing soilrite mixture to obtain mass

multiplication under growth chamber and the same practice can be successfully implemented in field conditions. Genetic stock centre for maintaining elite material of all 4 medicinal plants has been established at the experimental farm of GB Pant institute, Kullu, H.P.



Raising nursery of elite planting material of *Picrorhiza kurroa* in Padergaon and Ramni villages of district Chamoli in Uttarakhand

## FOREST BIOTECHNOLOGY

Considering the multidimensional importance of forest areas, the Department of Biotechnology initiated this program with the aim to support Research and Development (R&D) in the area of Forest Biotechnology. Efforts are being made by the Department through specific calls for research proposals to encourage R&D programs in emerging areas of Forest Biotechnology. During the year, a call for proposal given in the identified priority area towards development of biotechnological mitigation and adaptation strategies in forestry sector to meet the challenges of climate change, support cutting-edge research using newer technologies like tree genomics for understanding of forest tree biology, development of tree diagnostics and planting material improvement for improved productivity and biodiversity of forested ecosystems. Proposals were also invited for development of site-specific technological packages for restoration and rehabilitation of degraded & fragile forest eco-systems and technologies for measuring & maintaining ecosystem services from forests, modeling & control of invasive species in protected areas using biotechnological approaches. In response to the aforesaid call for proposal, a total of 182 proposals were received by the Department. The proposals were evaluated by Expert Committees and recommended projects are being processed for sanction of the projects.

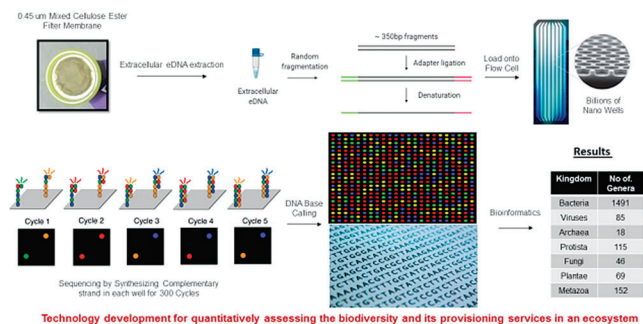
*Total 22 ongoing R&D projects are also being supported under the program. These projects are mainly focused on study of biotechnological approach to elucidate adaptation mechanism, migration pattern and reproductive biology of indicator temperate-alpine plants in Himalayas in response to changing climate, assessment of adaptive genetic diversity in teak and sandalwood to guide conservation and genetic improvement efforts, Co-management and sustainable use of non-timber forest products in three protected areas of Western Ghats, efficacious management of wood borers in protected areas of forest by pheromone loaded organogel, genome wide and geospatial approaches for enhancing the adaptive potential of threatened rattan resources in India etc. Six research papers have been published so far and more than 50 human resources in form of JRF/SRF/RA are being trained in the multidisciplinary areas of forest biotechnology.*

### Salient Achievements of the program are as follows:

In the network project on assessment of adaptive genetic diversity in teak and sandalwood genetic improvement efforts are being made to guide conservation at IFGTB, Coimbatore and KFRI, Kerala, and Osmania University, Hyderabad. About 30,000 annotated transcripts were obtained for teak, which would form the basis for SNP studies and their functional validation. Single nucleotide variations ranging from 48,926 – 1,00,199 and InDel variations of 16,119 – 26,455 were recorded across the seven transcriptomes analysed. This would form the basis for the development of molecular signatures for climate change adaptations. A diagnostic DNA marker was developed for screening sandal spike disease in populations.

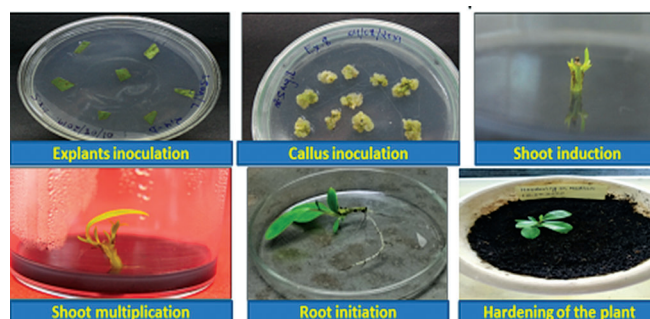
PCR-free eDNA meta-bar barcoding technology for quantitative biodiversity assessment in protected aquatic ecosystems being developed at CCMB, Hyderabad. The study has elucidated that biodiversity of an ecosystem can be studied using a PCR-free NGS method. Along with this, investigators also developed a cheap and quick LAMP and qPCR assays that can be carried out in the field using hand-held devices for rapid detection and quantification of abundance of any species of interest.





In a network project being implemented at Delhi University, Sikkim University and IIT-Kharagpur, biotechnological approaches are being attempted to elucidate adaptation mechanism, migration pattern and reproductive biology of indicator temperate-alpine plants in Himalayas in response to changing climate. Phenological study, floral biology and pollinator interactions study for *Rhododendron arboreum* have been done. With increasing elevation, late onset of phenological events was observed. Birds/Bees had greater roles in pollination of *R. arboreum* flowers. Different physico-chemical analysis on soils from study sites was established and will continue in the next seasons. The total genomic DNA has been extracted for both species and Illumina based sequencing has been done. The data generated has been used to extract microsatellites. 250 primer pairs had been designed for each genus. Model showing potential distributional areas for *R. arboreum* in Sikkim have been done. Prediction of future distribution of *Rhododendron arboreum* was done by establishing relationship between species occurrence locations and the environmental variables at those locations, in the current scenario, using Species Distribution Models (SDMs).

Germplasm collection, characterization and development of regeneration protocol of Chironji (*Buchanania lanzan*) from protected forest area of Madhya Pradesh is being carried out at JNKVV, Jabalpur. Detailed survey and collection of germplasm was undertaken and a mother stock in nursery has been established. Genotyping and genetic diversity analysis of collected germplasm has been carried out. Mass multiplication using leaf explants and nodal explant work is underway.



Protocol standardization for mass multiplication

Assessment of distribution, genetic diversity and population status for conservation of recently described tree species (*Eugenia agasthiyamalayana*, *Calophyllum pascalium* and *Garcinia gamblei*) from Agasthiyamalai Biosphere Reserve (ABR), Western Ghats, India is being attempted by CSIR-CIMAP Regional Centre, Bengaluru. Field trips were conducted to explore various parts of south India (Kerala, Tamil Nadu and Karnataka). All three species were collected. Attempts have been made for the mass multiplication of these selected plants by seeds. Seeds of *Eugenia agasthiyamalayana*, *Calophyllum pascalium* and *Garcinia gamblei* were collected. Besides, the investigators have standardized the DNA isolation and amplification protocols for the respective markers and the samples were amplified for Internal transcribed spacer (ITS) region and primers designed.

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

## HEALTHCARE AND MEDICAL BIOTECHNOLOGY

Providing affordable healthcare for all in a populous country like India is a challenging task. DBT's mandate for Healthcare & Medical Biotechnology has been coordination and promotion of Biomedical research, understanding the causes of human diseases such as non-communicable diseases, emerging infections, anti-microbial resistance, genetic disorders, maternal and child health, nutrition issues at the genetic and molecular level, early detection, preventive measures, development of vaccines, innovative tools and therapies, healthcare delivery systems and development of products for medical applications. Over the years, Department of Biotechnology has funded projects in different thematic areas that include, Bioengineering, Chronic Diseases, Drug Development, Human Genetics, Infectious Diseases, Maternal & Child Health, Public Health & Nutrition, Stem Cells & Regenerative Medicine & Vaccines.

Healthcare and Medical Biotechnology Areas at a glance	
Ongoing Projects	498
New projects supported	81
Manpower Trained	3399
New facilities / research infrastructure established	28
Research publications	781
Patents applications filed 49	
Technology developed/transferred/commercialized	32

## BIOMEDICAL ENGINEERING

The multidisciplinary domain of Biomedical Engineering fosters and supports innovative ideas in the field of Biomedical Devices and Bioinstrumentation.

No. of Research Publications during 2020-21	14	Process/Product/Technology Developed
No. of Patents Applied	3	<ul style="list-style-type: none"> <li>PLUTO: A modular, portable, and compact robot for training</li> </ul>

No. of Patents Granted	1	different hand functions (for hand neurorehabilitation)
No. of Human Resources trained	41	<ul style="list-style-type: none"> <li>The technology for Sonography Training Simulator has been commercialized with Merkel Haptic Systems. The Software converts CT/MRI data to 3D modals</li> </ul>

A Portable Raman Spectrometer with high efficiency SERS multifiber probes have been developed at Amrita Centre for Nanosciences and Molecular Medicine Kochi. A use and throw type transparent SERS sensor has been developed for enhanced Raman data from tumor tissue. Portable Raman device showed a classification accuracy of 93% in differentiating malignant, pre-malignant and healthy tissue samples. Silk/CMC/Gelatin (SCG) double network hydrogels for cartilage repair have been developed at IIT Kanpur. SCG hydrogels have enhanced mechanical properties and were resilient, an important property for load-bearing ability of cartilage. SCG hydrogels enhanced the chondrogenic commitment of stem cells both *in vitro* and *in vivo*. Scaffolds based on self-assembling peptide dendrimers and resorbable calcium phosphates for endodontic tissue regeneration has been developed jointly by Sree Chitra Tirunal Institute for Medical Sciences & Technology and IIT Delhi. Guanidine appended polydiacetylene and Lysine appended polydiacetylene has been synthesized through original in house methods and their molecular structure is being designed for the first time.

### Portable Raman spectrometer with SERS probes

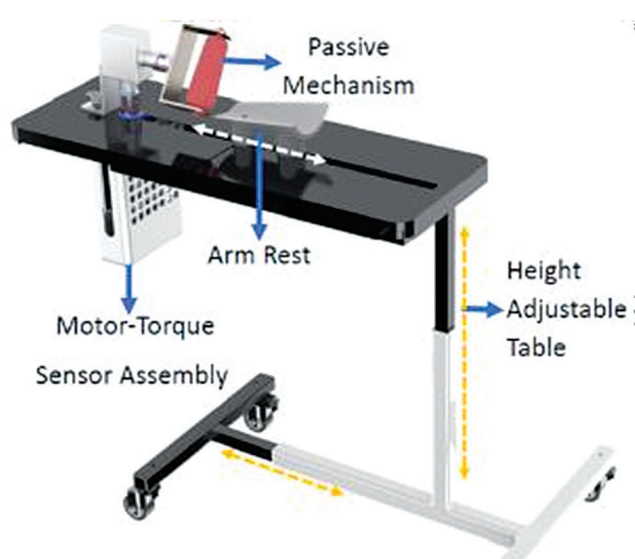
1. Commercial probe with SERS tissue substrate
2. Custom made high efficiency probe with SERS cap
3. Commercial probe
4. NIR laser source
5. Spectrometer



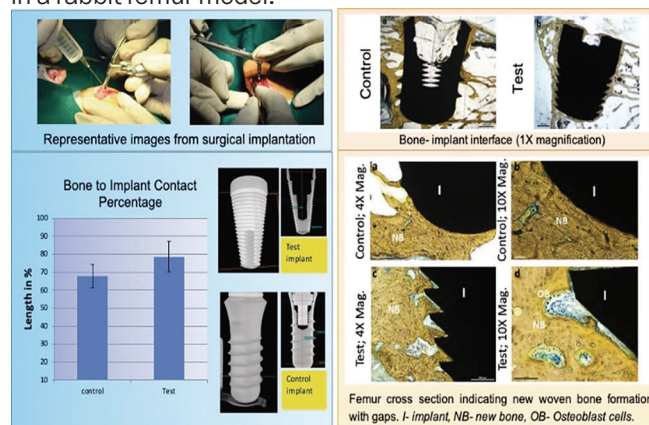
In a project at IIT Madras fine tuning of the algorithm that converts CT data into ultrasound images, in terms of efficiency, real-time performance has been done. This technology for Sonography Training Simulator has been commercialized with Merkel Haptic Systems, a start-up company in the IITM Research Park. This ultrasound simulator engine is integrated with the 6DoF position tracker. Software for converting CT/MRI data to 3D models have been acquired and abdominal model has been constructed.



A modular, portable, and compact robot for training different hand functions (hand neurorehabilitation) has been designed and preliminary clinical evaluation on patients has been completed at CMC Vellore. The novelty of the proposed robotic device is its highly modular architecture that allows training of different hand functions through the use of single actuator and a set of single degree of freedom (DOF) passive mechanisms that can be easily attached/detached to the actuator shaft. This robotic device is called the plug-and-train robot or PLUTO. In another project being implemented at National Institute for Research in Reproductive Health and IIT Mumbai a microfluidic device was developed to study spermchemotaxis. Its ability to identify putative chemoattractants and test different biological fluids for the presence of chemoattractants was demonstrated. The information generated and the knowledge gained can be applied for making sperm selection / sorting devices exploiting the properties of chemotaxis. This can greatly enhance the success rate of IVF and other ARTs. Under DBT's Translational Centre of Excellence on Biomaterials for orthopaedic and dental applications at IISC, Bangalore, a



new generation of polymer acetabular socket was fabricated using a compression molding approach. The HDPE-UHMWPE-modified GO nanocomposite showed enhanced mechanical properties with uncompromised cytocompatibility. Compression molding trials were performed to fabricate the acetabular socket and extensive micro computed tomography analysis was carried out for 3D microstructure characterization as well as to compare with a clinically used acetabular liner. Results of the gross and histopathological evaluation, and histomorphometry evaluation indicated that the dental implant prototype is biocompatible and has good osseointegration property after three months of implantation in a rabbit femur model.



## CHRONIC DISEASE BIOLOGY

Chronic, Non-Communicable Diseases (NCDs) are steadily increasing around the world and are major killers in the modern era. Globally, more than 70 % of deaths are due to



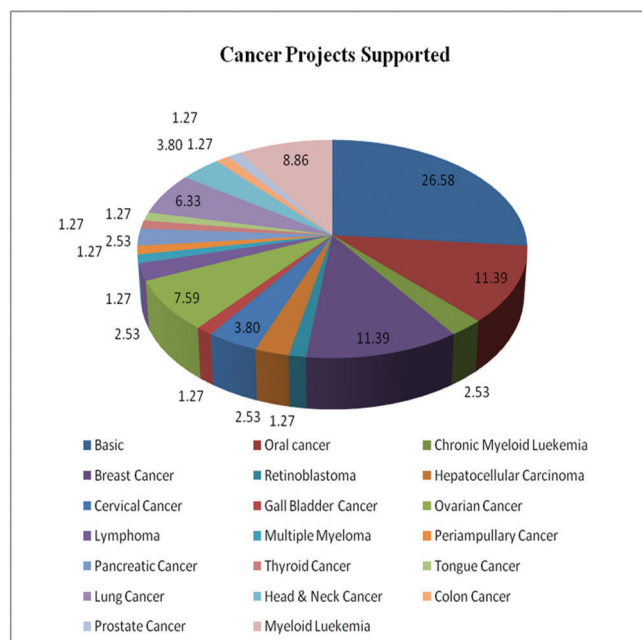
chronic diseases. Chronic diseases—including, cancer, diabetes, hypertension, stroke, heart disease, respiratory diseases, arthritis, obesity, and oral diseases are expected to cause three-quarters of the disease burden by 2030. The increasing burden of NCDs, has made prevention and management of NCDs a global priority.

The Department of Biotechnology (DBT) has made concerted efforts in strengthening Chronic Disease Biology R&D through various endeavours. Major efforts and programs are being implemented through review mechanisms of Technical Expert Committee (TEC), STAG Medical Biotechnology and Biotechnology APEX Board.

### Significant Outcomes and Achievements

No. of Research Publications during 2020-21	136	Process/Product/Technology Developed
No. of Patents Applied	12	<ul style="list-style-type: none"> <li>Retinoblastoma specific DNA aptamers</li> </ul>
No. of Human Resources trained	313	<ul style="list-style-type: none"> <li>LCN2 antibody as potential therapeutic molecule</li> <li>microRNA signature for colon cancer</li> <li>Novel Anti-Hypertensive Cardio-Protective Composition</li> <li>Patient derived TNBC xenografts</li> </ul>

**Cancer Biology:** DBT supports Cancer Biology Research in various ways, both financially and intellectually. It provides resources to individual investigators and to institutions, provides leadership to national infrastructures to carry out basic, applied and clinical research and to develop new methods to prevent and treat disease and conduct research especially in challenging areas pertaining to different types of cancer as summarized in the figure. Funding for cancer research in DBT has now become more applied i.e., movement from basic science to translational and clinical application.



DBT's support for Unit of Excellence at NII on 'Role of BLM Helicase as a Global Tumor Suppressor' has shown that BLM acts like a clamp or adaptor molecule, thereby enhancing the degradation of oncogenic transcription factor, c-Jun; elucidated that absence of BLM increases a colon cancer specific microRNA signature which may be used as a biomarker to detect early stage of the disease; demonstrated that three FDA approved small molecules can revert chemotherapeutic drug mediated resistance in cancer cell lines and mouse xenograft models; corrected the mutated BLM gene in patient fibroblasts, thereby generating an isogenic system which can be used for drug screening and mechanistic studies; discovered the mechanism by which patient derived mutant proteins cannot enter mitochondria, thereby offering a therapeutic possibility for multiple mitochondrial defects. The work has been published in *Nature Communications* and *Cell Reports*. This is an example of DBT's support for a five-year program, transitioning from basic to translational.

DBT's support for Centre of Excellence Program in Christian Medical College, Vellore on 'Mechanisms of Resistance in Leukaemia' has established low cost effective care using arsenic trioxide in acute promyelocytic leukemia and moving this therapy to front line therapy in its management. A low-cost effective care clinical trial in the management of relapsed APL by repurposing approved drugs to treat this cancer has

also been developed. The research findings have been published in *Blood & Leukemia*.

DBT VNCI- Hormone resistant Breast Cancer study with TMH Mumbai, ACTREC Mumbai, NIBMG Kalyani and NCCS Pune has recruited 131 patients in therapy sensitive and 142 patients in therapy resistant cohort. Preliminary analysis has identified known (genetic aberrations in Estrogen gene ESR1) as well as potentially novel genetic aberrations that play a role in resistance to hormone therapy. DBT's support for Centre of Excellence Program in 'Triple Negative Breast Cancer' at Rajiv Gandhi Center for Biotechnology (RGCB), Trivandrum has successfully established the Patient Derived Xenograft Models for drug screening for the first time in India.

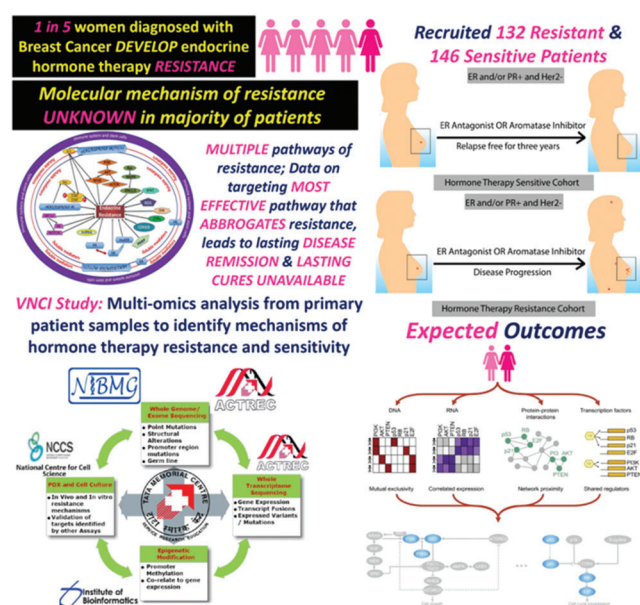


Fig. DBT Virtual National Cancer Initiative: Multi Omics Hormone Resistance in Breast Cancer

DBT has also supported programs for creation of state-of-the-art infrastructure for cancer diagnostics and research. Under this scheme, and as a special drive for the Kashmir state, DBT funded the Cancer Diagnostic Centre at Sher-I-Kashmir Institute of Medical Sciences (SKIMS), Kashmir. During the past six years this project has been providing high end molecular biology based diagnostic investigations to the patients of J&K in general and to the patients of Kashmir valley in particular.

**International Cancer Genome Consortium – India Project:** The International Cancer Genome Consortium

(ICGC) was formed to obtain comprehensive catalogues of genomic abnormalities (somatic alterations, abnormal expression of genes, epigenetic modifications) in 50 different tumor types and/or subtypes which are of clinical and societal importance across the globe. India is a founding member of this consortium along with countries such as Australia, Canada, China, France, Japan, UK and USA. India has participated in ICGC to generate evidence of genomic alterations in oral cancer, which is of high prevalence in our country. India's participation has been fully supported by the Department of Biotechnology and has been academically spearheaded by the National Institute of Biomedical Genomics (NIBMG), Kalyani, and the Advanced Centre for Treatment, Research and Education in Cancer, Mumbai. The project has used the latest genomic technologies and has generated data whole-genome and whole-exome DNA and RNA sequencing of about 300 oral cancer patients. Many novel genomic inferences have been derived that are specific to the type of oral cancer found in India, in which most parts (gingivo-buccal region) of the oral cavity – but not the tongue – are affected. These genomic inferences have been correlated with exposure to environmental carcinogens found in tobacco that is used predominantly chewed by Indian oral cancer patients. The ICGC-India team has obtained and validated the complete somatic mutational landscape of oral cancer. Many new genes (e.g., *FAT1*, *HRAS*, *ARID2*) not earlier known to be associated with gingivo-buccal oral cancer have been identified. Using the data on genomic alterations, four subtypes of gingivo-buccal oral cancer have been identified. These subtypes differ by the nature of treatment that they may respond to and also by the length of disease-free survival after treatment. Overall, the ICGC-India project has provided a rich set of academic dividends, as evidenced by a set of high-impact publications, and translational targets for clinical intervention in oral cancer.

DBT has implemented flagship programs on cancer at two of its autonomous institutions; 'Head and Neck Cancer Risk Factors of India: North East Focus (HEROINE STUDY)' at Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram, and 'Integrating Multi-omics Data using Big Data Analytics to Infer Optimal Life-course Trajectories for Management of Non-Communicable Diseases (NCDs): Cervical Cancer as an Exemplar' at National Institute of Biomedical Genomics (NIBMG), Kalyani, West Bengal.

**Other Chronic Diseases:** Existing studies have concentrated on disease combinations or chronic disease incidence, prevalence and risk factors leading to development of cohort studies and establishment of disease-specific bio-banks. Joint cohort development addressing basic and clinical questions and monitoring structures with long-term funding has been implemented for (a) Chronic Kidney, and (b) Systemic Lupus Erythematosus.

**Indian Chronic Kidney Disease (ICKD):** ICKD study has established one of its kind of prospective cohort studies in chronic kidney disease in developing countries like India, which is coupled to a serial, annual bio-bank. The study is internationally recognized and a part of international collaborative network of kidney diseases (iNET-CKD). The study has shown for the first time that socio-economic determinants are important with respect to quality of life in patients with chronic kidney disease.

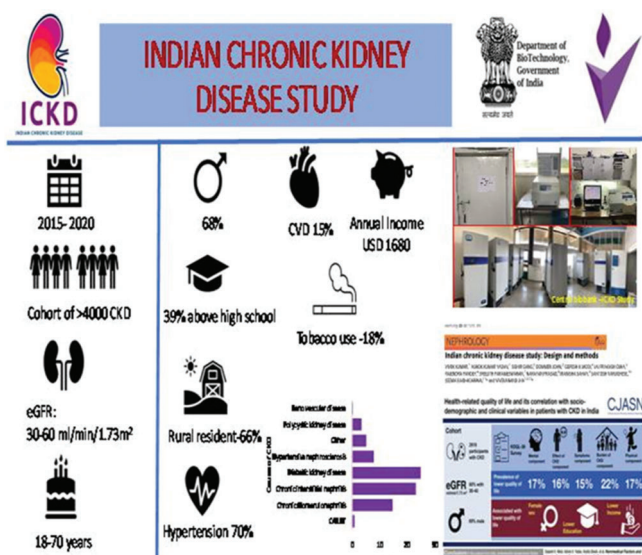


Fig. Indian Chronic Kidney Disease

**Systemic Lupus Erythematosus (SLE):** Researchers in the Systemic Lupus Erythematosus (SLE) study have developed a cohort of 1281 patients with SLE which will serve as a resource to study this disease. They also observed that Lupus has significant early mortality in India due to late presentation and have developed a simple score to differentiate infection from flare in SLE.

**Other Non-Communicable Diseases:** Among the Non-Communicable Diseases (NCDs), Diabetes is one of the most

common metabolic disorders. Existing studies supported by the Department focus on micro and macro vascular complications of diabetes, toxicity of energy fuels etc. From the findings so far, it has been found that Sodium butyrate induces colonic Tregs and is further able to ameliorate hyperglycaemia in Non-obese diabetic (NOD) mice. Besides, results of another study suggest an iron-mediated oxidative damage occurs in kidney due to chronic high glucose exposure. Another study has revealed that young adults who are overweight, but not yet obese, are at risk for Type-2 Diabetes Mellitus, and the risk is more in men compared to women. In another project, investigators have developed a VEGF165a isoform specific antibody targeting only pro-angiogenic form of VEGFA, which may find use in treatment of ocular diseases like diabetic retinopathy and age-related macular degeneration.

Project on Translational Research Studies on Some Disorders of the Eye implemented at LVPEI, Hyderabad has demonstrated that the discovery of novel molecules in the pathogenesis of inherited and age-related eye diseases will lead to the development of potential biomarkers for predictive testing. Preclinical evaluations of RPE cell injections in RCS rats have enabled the researchers to consider drafting a clinical trial protocol for the applications of hiPSC-RPE cells. The research team has advanced the technology to measure and correct the optical distortions of the eye, and in collaboration with Prof Pablo Artal, a state-of-the-art binocular adaptive optics technology is being built that can effectively correct the optical aberrations of these highly distorted eyes. This device is nearly ready and is expected to be delivered at LVPEI in the first quarter of 2021.

Under the Glue Grant Scheme, a collaborative research program between clinicians from AIIMS and basic scientists from THSTI/NII has focused on improving understanding of the biological basis of kidney disease, asthma, and blood cancer in children. Completely functioning platforms in microscopy, flow cytometry, tissue culture/molecular biology labs have been established in St. John's Medical College under this scheme. The genomics platforms using the NCBS campus have generated substantial progress in HLA multiplexing and pathogen discovery. Also, fully functioning "crisper" platforms around the MIR-182-CML Notch project have been established.



Being contemporary, DBT is envisaging initiating partnership centres in chronic and lifestyle diseases such as diabetes, cardiovascular diseases, cancer, respiratory diseases, eye diseases, autoimmune disorders, musculoskeletal disorders etc.

## NEUROSCIENCES

The Department has a focus on understanding the basic biology of neurological disorders such as dementia, stroke, epilepsy etc. and neurological injuries such as brain and spinal cord injury as well as neuro-infections and neuromuscular and movement disorders, brain cancer etc. A population-based cohort study called 'Longitudinal Cognition and Aging Research on Population of the National capital region (LoCARPoN)' was supported under Indo-Netherland joint collaboration to study the known as well as novel determinants of Stroke and Cognitive function. At the urban site i.e., AIIMS, New Delhi, 7505 participants were assessed, while at rural site i.e. Comprehensive Rural Health Services Project, Ballabgarh, 1872 participants were assessed. A bio repository has been setup in AIIMS for storage of biological materials. At urban site, a total of 2604 MRIs have been conducted till now. In addition, a national workshop "*Building Knowledge for Prevention of Stroke and Dementia: A National workshop on Population Based Cohort Studies*" was held in December 2019 in All India Institute of Medical Sciences (AIIMS), New Delhi with Hon'ble Ashwini Kumar Choubey, Minister of State for Health & Family Welfare (MoS-HFW) as the Chief Guest.

DBT has supported a multi-institutional 'Dementia Science Programme' with National Brain Research Center (NBRC), Manesar as the model centre. The programme aims to arrive at reliable estimate of prevalence and incidence of dementia including Alzheimer's disease in the country. The pilot studies were conducted at Palwal (rural community site) and Bengaluru (urban community site). The Palwal site had 31 participants, and the Bengaluru site had 63 participants. In addition, the pilot study was conducted at AIIMS, New Delhi with 15 patients. Preliminary findings suggest that PICLAM gene variant may be associated with Dementia. A 'Collaborative Neuro-Engineering Platform for Excellence in Innovation and Translational Research' in All India Institute of Medical Sciences (AIIMS), New Delhi was supported with an

aim to provide unsupervised computerized evaluation of surgical skills and provide feedback to trainee neurosurgeons to improve their performance. The repository of virtual models of the existing microscopic and endoscopic neurosurgical instruments developed in the project is being used for various applications such as novel instrument development, e-learning, computerized evaluation of surgical skills and virtual reality simulations. A synthetic silicone scalp and dura surrogates developed was validated for visual and tactile haptic properties mimicking real tissues. A low cost localization tool for neuroendoscopy is being developed to train neurosurgeons for neuro-navigation. The project will lead to the development of electro-mechanical physical simulators and 3D graphics haptic-based virtual reality simulators for training of minimally invasive neurosurgery.

A project at BHU, Varanasi aims to explore the molecular mechanisms which lead to anti-viral responses and inflammation in the brain during Chandipura virus (CHPV) infection. Studies are ongoing to understand the miRNA mediated gene regulation mechanisms involved in promoting inflammation and anti-viral responses during CHPV infection. In a project supported for understanding the effect of hypoxia on preterm births, Fetal neural stem cells (FNSCs) have been successfully differentiated into astrocytes, oligodendrocytes and neurons. In a project at Centre for Cellular & Molecular Biology (CCMB), Hyderabad it was observed that chronic alcohol addiction diminishes cognitive behaviour flexibility in mice due to the perturbations of neuroglial activity and the alcohol addiction is associated with reduced hippocampal neuronal activity but increased glial activity. At Indian Institute of Sciences, Bengaluru, it was demonstrated that an upregulated expression of lysozyme during neuronal injury leads to heightened pain typical of neuropathic pain. The data obtained suggest that lysozyme and neuronal TLR4 have a direct role in neuropathy.

At All India Institute of Medical Sciences (AIIMS), New Delhi, it was observed that modulation of key enzymes leads to altered levels of kynurenine metabolites in the hippocampus of patients with mesial temporal lobe epilepsy (MTLE). This study shows tight association between concentration of hippocampal kynurenine pathway metabolites and excitatory synaptic transmission.

## DRUG DEVELOPMENT PROGRAM

India is a global leader in generic pharmaceuticals manufacturing. However, many generics manufactured in India are at the end of their respective product life cycle, with limited new R&D taking place. Furthermore, our country has a high burden of both communicable and non-communicable diseases and is vulnerable to epidemics. In order to keep pace with global innovation and to improve health outcomes, there is a need to foster R&D for new and cost-effective therapies. With the aim to put India on the global map in terms of R&D innovations in the area of drug development, the Department has initiated a new program on “Drug Development” with a vision to develop indigenous and cost-effective new drugs against diseases prevalent in our country.

### 1. Major New Efforts:

The Department of Biotechnology (DBT) in collaboration with its Public Sector Undertaking, Biotechnology Industry Research Assistance Council (BIRAC) announced a Joint Call to invite proposals in the area of “Development of Drugs from existing leads with established proof of concept” against the following diseases:

- Communicable Diseases
  - a. Tuberculosis
- Non-Communicable Diseases
  - a. Cardio-Vascular Diseases (CVD),
  - b. Chronic Obstructive Pulmonary Diseases (COPD) and
  - c. Cancer (oral, head and neck, cervical and breast cancer)

The Department has received a very good response under this Call. After two rounds of discussion, 6 proposals have been recommended for financial support.

### 2. Novel Monoclonal Antibody (mAb) based Immuno Therapeutics: Considering Immuno-therapies an important area for disease management,

and to tap the huge potential of novel antibody as immuno-therapeutics, Department has announced a Joint call with BIRAC on “Globally Accessible and Cost-Effective Novel Antibodies”. This programme aims to discover and develop affordable and globally accessible novel antibodies against Antimicrobial Resistance (AMR), Human Immunodeficiency Virus (HIV) and Snakebite Envenoming (SBE). Under this Call too, the Department received a good response and 4 proposals have been recommended for financial support.

3. A Mission program on Snakebite envenoming i.e. Mission- Next Generation Treatment for Snakebite (NGTS) was recommended by the Department with a vision to develop an indigenous, cost-effective and globally accessible technology with the aim to cater the needs of the affected people and facilitate employment generation through training and skill development. Considering snakebites as one of the well-known medical emergencies in many parts of the world, especially in rural setup, World Health Organisation (WHO) has included snakebite into Category A of neglected tropical diseases. Since, India accounts around 50% of mortality and morbidity due to snakebite in the world, there is an immense need to support research and innovation for the development of products for addressing snakebites.

## HUMAN GENETICS, GENOME ANALYSIS & PRECISION MEDICINE

Human Genetics and Genome Analysis and Precision Medicine program of DBT supports research to uncover the role that the genome plays in human health and disease. The program supports research across a spectrum: basic research to shed light on the structure and function of the genome; translational research to decipher the molecular bases of human diseases; and clinical research to establish how to use genomic information to advance medical care. The Program Division seeks to address the burden of genetic diseases via supporting research on developing cost-effective diagnostic methods for genetic diseases, implementing prenatal and newborn screening programs, facilitating R&D on developing personalized medicine regimens and development of affordable therapies for genetic diseases.

During the current year, the Human Microbiome Initiative of select endogamous Indian populations and Genome India a project for cataloguing the genetic variation in Indians has been launched. Projects on determinants of excess alpha globin chain as a central modifier of phenotypes in beta thalassemia and uncovering causative mechanisms of Schizophrenia and Parkinson's diseases using in vitro tools have also been taken up. The genetic diseases which have been studied include various lysosomal storage disorders, multiple myeloma, Wiskott - Aldrich syndrome, Systemic Lupus Erythematosus, Sickle Cell Disease, Thalassemia and other hemoglobinopathies, and acute lymphoblastic leukaemia. Some of the major ongoing research programs are- Unique Methods of Management of Inherited Disorders (UMMID) initiative, National Genomic Core, Celiac Diseases Consortium, mitigation of clinical phenotype by activated

platelets in severe Hemophilia, multi-centric effort towards understanding a high-resolution, genomic architecture of congenital nonsyndromic deafness in India etc. About 25 research publications emanated from the R&D activities supported under this program and more than 200 human resources (JRF/SRF/RA) were trained in the area of Human Genetics and Genomics.

Efforts have also been made to formulate a National Mission on Health Genomics. Draft DPR has been prepared and circulated for expert comments and inter-ministerial consultation. Draft note for proposed national policy and roadmap on research in genomics to actualize the benefit of genomics research in healthcare, agriculture and environment has also been prepared and circulated for expert comments and inter-ministerial consultation.

## Proposed National Mission on Health Genomics

**Aim:** Improving health and disease outcomes in India through predictive, preventive, personalized and participatory healthcare using genome, transcriptome, metabolome, microbiome and exposome profiling, counselling, and improved diagnosis and therapeutics

Genomics and other "omics"-based studies	Affordable Diagnostics and Therapeutics	Biorepositories and Biobanks	Data Sharing and Access	Innovation, Entrepreneurship and Start-up Ecosystem	International Cooperation
<ul style="list-style-type: none"> <li>❖ GenomeIndia: Cataloguing the genetic variation</li> <li>❖ Microbiomics</li> <li>❖ Exposomics</li> <li>❖ Nutrigenomics and Ayurgenomics</li> </ul>	<ul style="list-style-type: none"> <li>❖ Rare and Genetic Diseases</li> <li>❖ Cancer</li> <li>❖ Lifestyle Diseases</li> <li>❖ Maternal and Child Health</li> </ul>	<ul style="list-style-type: none"> <li>❖ Resource for future studies on contribution of various factors in determining health and disease outcomes</li> </ul>	<ul style="list-style-type: none"> <li>❖ Establishing framework and infrastructure for sharing and access of high-throughput data</li> </ul>	<ul style="list-style-type: none"> <li>❖ Affordable Molecular Diagnostics</li> <li>❖ Big Data Analytics in Precision Health</li> <li>❖ Affordable Precision Therapeutics</li> </ul>	<ul style="list-style-type: none"> <li>❖ Genomics Consortia</li> <li>❖ Longitudinal Biobanks</li> <li>❖ Data Science and Predictive Analytics</li> </ul>

**Impact :** The mission would open new vistas for advancing personalized medicine regimen in the country paving the way for predicting health and disease outcomes and modulating treatment protocols on the basis of the genome sequences



## Salient Scientific Achievements-

### Unique Methods of Management of Inherited Disorders (UMMID) Initiative:

The Department launched 'UMMID' initiative to tackle inherited genetic diseases in newborns. UMMID envisages working at three levels of medical care with a close link between training and establishment of diagnostic services. Under the pilot phase of the UMMID initiative, the Department has supported the establishment of five genetic laboratories, seven training centres for training clinicians in diagnosis and management of genetic diseases and screening of pregnant women and neonates in seven aspirational districts. The Genetics Labs- NIDAN Kendras (National Inherited Disorders Administration Kendras) would provide comprehensive clinical care including diagnosis, management, multidisciplinary care, counseling, prenatal testing at five Government hospitals spread across four states. The Training Centres are providing training in Biochemical Genetics, Cytogenetics, Molecular Genetics, Clinical Genetics and Comprehensive clinical care to the clinicians working in Government hospitals. Seven Aspirational Districts namely Mewat, Haryana; Yadgir, Karnataka; Haridwar, Uttarakhand; Washim & Nandurbar, Maharashtra; Ranchi, Jharkhand; Shrawasti, Uttar Pradesh have been identified for screening of pregnant women and newborn babies for diagnostics of inherited genetic diseases to provide comprehensive clinical care. So far about 34000 pregnant women and 16000 newborn babies have been screened.



Expansion of the UMMID program is planned in the coming year. In this direction, Mission program on Rare and Genetic Disorders is being worked upon with the objectives of developing novel affordable diagnostic methods and therapies for rare genetic diseases; to elucidate the disease biology of rare genetic diseases so that targets for diagnostic and therapeutic interventions could be identified; and to improve counselling, screening, and diagnosis of rare genetic diseases. The Department also issued an advertisement inviting proposals to establish more Nidan kendras. About 100 proposals were received and further actions have been initiated for due diligence and evaluation of proposals.

#### Mission Programme on Rare and Genetic Diseases

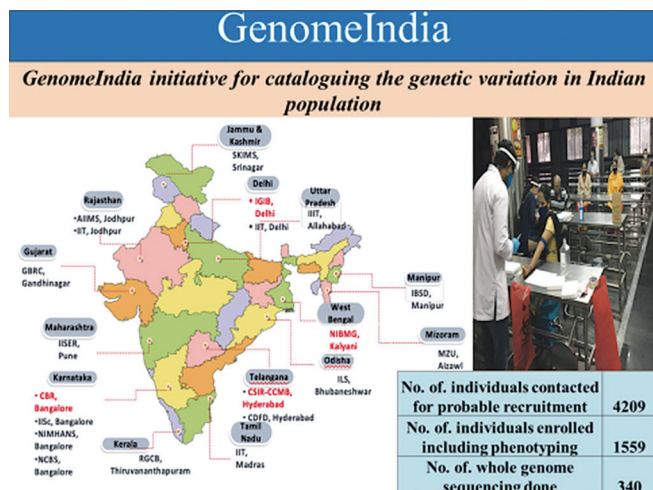
**Aim:** Reduce the burden of rare genetic diseases in India through better prevention, early diagnosis and improved therapies

Affordable diagnostics and therapeutics	R&D for Improved Understanding of Rare Genetic Diseases	Expansion of DBT-UMMID initiative
<ul style="list-style-type: none"> <li>Development of affordable PCR/array/sequencing-based diagnostic techniques</li> <li>Repurposing of approved drugs towards development of novel therapeutic solutions</li> <li>Food based therapeutics for inborn errors of metabolism</li> <li>Safe and cost-effective genome editing and delivery technologies for gene therapy</li> </ul>	<ul style="list-style-type: none"> <li>Delineating the mutation spectrum of poorly-characterized rare genetic diseases</li> <li>Understanding the role of various mutations in the pathobiology</li> <li>Development of computational methods for predicting the effects of mutations in different genomic backgrounds</li> <li>Creation of biorepositories / biobank for various rare genetic diseases</li> </ul>	<ul style="list-style-type: none"> <li>Screening of ~3 lakhs pregnant women and neonates for diagnosing rare genetic diseases</li> <li>Training on Clinical Genetics in Biochemical Genetics, Cytogenetics, Molecular Genetics, and Comprehensive clinical care</li> <li>Establishing Genetic Diagnostic Units (NIDAN Kendras) for providing comprehensive clinical care including counseling, diagnosis, management, and multidisciplinary care.</li> </ul>

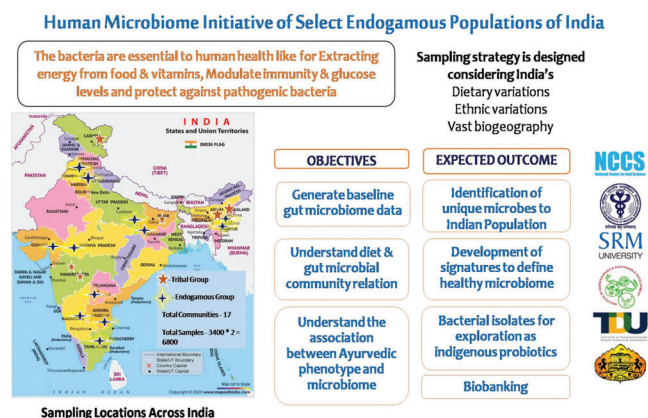
**Impact:** The mission would be instrumental in estimating the prevalence of various rare genetic diseases and would help in addressing the burden of rare diseases based on an integrated preventive strategy

### GenomeIndia Initiative:

The Department has recently initiated a pan India Genome India project for cataloguing the genetic variation in Indian population. The goals are to start with and execute whole genome sequencing and subsequent data analysis of 10,000 individuals representing the country's diverse population. 20 national institutions are collaborating for this project. This will help build an exhaustive catalogue of genetic variations in Indian population, and aid in the design of a genome wide association chip for Indian population which will facilitate further large-scale genetic studies in a cost-effective manner. So far, 2654 individuals have been approached for recruitment as study participants into the project. 839 participants have been enrolled and 290 samples have undergone WGS and genome wide high-throughput genotyping. Analysis of genetic variants calling in these genomes are in progress.

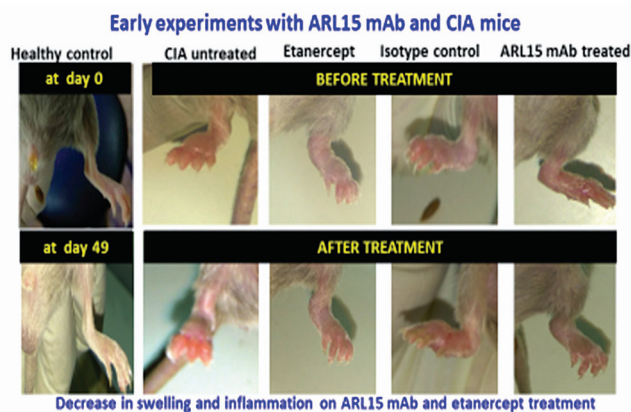


**The Human Microbiome Initiative of Select Endogamous Populations of India (HMI):** DBT Human Microbiome Initiative is an initiative to map the Indian population-specific microbiome to understand diet and biogeography-mediated changes in the microbiome. It will complement the Genome India initiative of the DBT, which is aimed at mapping the genome of the same populations, thus deciphering genome-microbiome interactions. This project is being implemented by NCCS in collaboration with multiple institutions, including KEM Hospital and Research Centre, AIIMS, Institute of Bioresources and Sustainable Development, Institute of Trans Disciplinary Health Science and Technology, and S. P. Pune University. The expected outcomes include characterisation of the microbiome of diverse Indian communities, generation of comprehensive baseline microbiome data from healthy Indian subpopulations that could help design approaches based on microbial modulation to mitigate lifestyle-associated disorders, and elucidation of the relationship between Ayurvedic 'prakriti' types and the microbiome. In Phase I of the HMI, 17 different endogamous groups across India, including tribal groups, will be focused on, to find the influence of diet, lifestyle, geography and age on the gut microbiome by using targeted metagenomic and whole metagenomic approaches. The samples collected in the project will be preserved as biobank in hospitals.

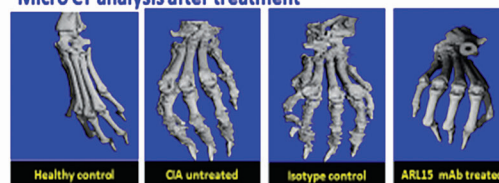


## Centre of Excellence Project on Genome Sciences and Predictive Medicine

In this Centre of Excellence project at University of Delhi, South Campus (UDSC) and AIIMS, New Delhi, notable progress has been made to fulfill the broad objective of identifying potential drug targets for Rheumatoid Arthritis (RA). Three targets identified, namely ARL15, BTK and MAP3K8, have been taken forward for lead molecule development. In addition, functional characterization of ARL15, the novel GWAS hit for RA has been carried out using multiple hypothesis-free approaches. Structural Characterization of ARL15 and Rational Drug Discovery to Combat Rheumatoid Arthritis work component have also shown significant progress.



### Micro CT analysis after treatment



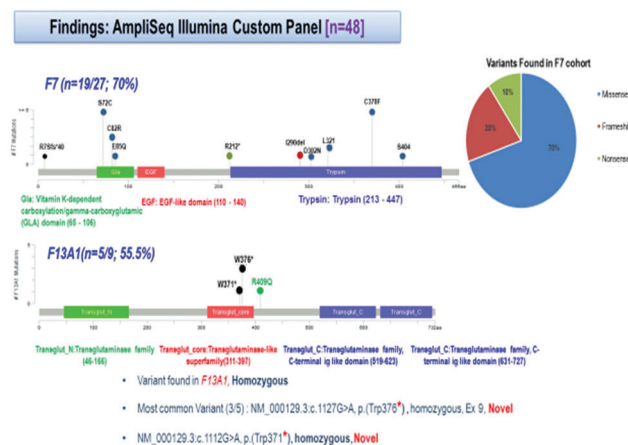
**Consortium on Celiac Disease:** In this network project, a national biorepository is being established at AIIMS, New Delhi for well-characterized patients with celiac disease (CeD). Till now, 253 patients with CeD have been recruited, 22 patients with CeD after 6 months of treatment, 50 FDRs of patients with CeD and 76 controls from all the collaborative centres. Multiple aliquots of their sera, plasma, DNA, intestinal biopsies (histopathological blocks, in RNA later and plain vials), stool samples, urine samples (approx. 6750 aliquots in total) have been stored. Investigators have earlier demonstrated two markers namely plasma citrulline and I-FABP as potential biomarkers for enterocyte health. Investigators are also in the process of analyzing data more rigorously to identify few biomarkers for validation purposes.

### Other R&D projects

In the project on tumor genome profiling and minimal residual disease estimation in acute hematological malignancies using single-platform next generation sequencing strategies at TMC, Kolkata, investigators have established processes and pipeline of biobanking, copy number variation analysis and mutational profiling. The process of downstream translational work on the biobanked samples has been established. The strategy of using 3 FISH probes integrated with flow ploidy successfully risk stratifies BCP ALL patients. The same strategy was published in Pediatric Blood and Cancer Journal.

In the project on establishment of a biorepository of epilepsy and investigating the relation of multidrug transporter polymorphism with fetal malformations at SCTIMST, in Thiruvananthapuram, there were 3096 registrations and 2328 completed pregnancies with known outcomes. After applying the selection criteria, there were 148 children with major malformations excluding genetic and chromosomal disorders. On a final tally, there were 101 children with major malformations who were eligible for including in this study (101 living children). Study also concluded that polytherapy carried higher risk of malformation, and exposure to sodium Valproate carried higher risk of major malformation.

A comprehensive diagnostic NGS panel for inherited bleeding disorders to aid carrier screening and prenatal diagnosis is



being developed at PGIMER, Chandigarh. Integrative genomics approach to identify the role of co-regulators in dendritic cell immune responses and its impact on T helper cell differentiation is being studied at ILS, Bhubaneswar. Investigators have identified co-regulator proteins NCoR1 and SMRT along with a NR TF RXR $\beta$  that upon depletion induces tolerogenic and strong inflammatory phenotype respectively. They have also found an association of SMRT protein expression with RA patients.

### INFECTIOUS DISEASE BIOLOGY

Under the aegis of Infectious Disease Biology program, the Department is supporting basic and applied research to better understand and ultimately provide solutions in terms of therapeutics, diagnostics and preventive measures for 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; neglected tropical diseases such as Malaria, Leishmania, Dengue. The Department provides funding opportunities and a comprehensive set of resources for researchers that support discovery and interdisciplinary research, pre-clinical development, and clinical evaluation in the area of infectious diseases including COVID-19 conditions. Some of the significant achievements made during this period are:



## Research Leads/Technologies developed:

S.No.	Leads/Technologies	Affiliation
<b>AMR</b>		
1.	Potent antimicrobial action of PPEF against MSSA, MRSA and VRSA	JNU, New Delhi, IIT, Bombay; ICT, Mumbai in collaboration with Anthem Biosciences, Bangalore (Industry)
2.	Novel pyrrole derivatives as inhibitors of Resistance-nodulation-cell division (RND) efflux system	NIPER, Mohali MTECH, Chandigarh
3.	Cocktail of bacteriophages against biofilm forming MDR UPEC.	PGIMER, Chandigarh
<b>Malaria</b>		
4.	Leads identified in the protein and nucleic acid synthesis pathways of Malaria parasites (1) Lysyl-tRNA synthetase, (2) Prolyl-tRNA synthetase, (3) Phenylalanyl-tRNA synthetase, (4) 6-hydroxymethyl-7,8, -dihydropterin pyrophosphokinase dihydropteroate synthase.	ICGEB, New Delhi
5.	Curcumin as an adjunct therapy against malaria	IISc, Bangalore JNCASR, Bangalore ILS, Bhubaneswar
<b>Tuberculosis</b>		
6.	HRM analysis of rpoB gene and Kat G gene for screening of MDR from CSF culture isolates	PGIMER, Chandigarh
7.	Mycobacterium tuberculosis proteins: WhiB3, WhiB4 and WhiB7 as potential drug targets.	IISc, Bangalore
8.	'TB-Detect' kit	AIIMS, New Delhi
9.	Aptamer-Based TB Antigen Tests for the Rapid Diagnosis of Pulmonary Tuberculosis.	AIIMS, New Delhi THSTI, Faridabad PGIMER, Chandigarh
10.	Test compound Against mycobacteria from NIPER Hyderabad.	NIPER, Hyderabad
11.	TB & COVID-19 Diagnostic Platform	UDSC, New Delhi
12.	Therapeutic drug monitoring using Tandem Mass Spectrometry for Clofazimine, Moxifloxacin, Levofloxacin and Bedaquiline and using Immunoassay technique for Linezolid & Amikacin	P.D Hinduja Hospital, Mumbai
<b>HIV</b>		
13.	Epap-1 mimics as anti-HIV-1 compounds.	University of Hyderabad, Hyderabad
14.	Engineered recombinant protein antigen of trimeric mimic of HIV-1 envelope glycoprotein spike	THSTI, Faridabad & AIIMS, New Delhi
<b>Other Areas</b>		
15.	Tyrosination sensor, a genetically encoded sensor that can specifically label tyrosinated microtubules.	InStem, Bangalore
16.	Telmisartan as a novel drug against CHIKV infection	ILS, Bhubaneswar

**Mission Antimicrobial Resistance (AMR):** Considering Antimicrobial Resistance as a global threat, the Department had launched an ambitious “Mission Program on Antimicrobial Resistance” in 2018-2019, with the vision to develop indigenous and cost-effective therapies against AMR; categorization of AMR-specific pathogen priority list of India; establishment of Bio-repository for AMR-specific pathogens; and development of rapid and cost-effective diagnostic kits to identify AMR-specific pathogens. Following achievements have been made so far under this Mission Program:

- a. The Department has notified National Centre for Microbial Resource (NCMR), National Centre of Cell Sciences, Pune (an Autonomous Institute of DBT), a National Facility to function as a Bio-repository for resistant microbes/infective agents (Bacteria and Fungi)” and to carry out collection, storage, maintenance, preservation and characterization of these microbes across the country.
- b. In collaboration with WHO, Country Office, New Delhi, the Department has prepared National AMR-specific Pathogen priority list for India to prioritize R&D work in this area in our country.
- c. A Joint Call with BIRAC was announced to support Projects in the area of development of new antibiotics and alternatives to antibiotics. The Department has supported 10 projects in this area.
- d. With a holistic and multi-sectoral (One Health) approach, “India’s One Health Initiative” to combat problems associated with AMR was launched.
- e. India has partnered with Global AMR R&D Hub as a member of Board of Members.

**R&D Support:** Scientists from IMTECH, Chandigarh observed that Bacterial efflux pumps act like bilge pumps by flushing antibiotics out of the bacterial cell and are responsible for antibiotic resistance in many Gram-positive and Gram-negative strains. Their EPIs represent a new drug class against MDR pathogens. Their synergistic EPI candidates may similarly revive the commercial prospects of generic antibiotics for host, enabling the re-introduction of these agents as EPI-based combination products, thereby extending their product life-cycles. Additionally, their synergistic EPI candidates can facilitate research and development efforts

by enabling significantly lower antibiotic doses to achieve a therapeutic effect, thereby addressing the problem of dose-related toxicity. The chromosome-level genome assembly and the genomic datasets including SNPs, Indels and CNVs in *C. tropicalis* strain MYA-3404 reported in the study of JNCASR, Bangalore will facilitate comparative genomic analysis of drug-resistant and sensitive Indian clinical isolates and help decipher the contribution of the genomic changes to the emergence of antifungal drug resistance in the Indian clinical isolates of *C. tropicalis*.

A group of scientists from JNCASR, Bangalore, YGCARE, Bangalore, NARI, Pune and IoB Bangalore performed a multicentric clinical study in which they proposed to examine the viral evolution of HIV-1 in India and its impact on viral pathogenesis. Their data are suggestive that the emerging viral strains of HIV-1 enjoy superior replicative fitness through their higher infectious or latency qualities. Their work indicates that the viral incidence and prevalence of HIV-1 in India is likely to alter due to the emerging novel viral strains and no data from developed countries could provide such information as completely different HIV-1 subtypes are present in those countries. The work of such kind has not been performed in the context of Indian population, previously, and this information could be important for the purpose of disease management in India.

Scientists from THSTI, Faridabad and AIIMS, New Delhi described that platelet factor 4 (PF4), secreted specifically from activated platelets during Dengue infection, promotes virus replication in immune cells by inhibiting Interferon pathways. The platelet factor is antagonist to CXCR3 (receptor for PF4) significantly inhibits Dengue virus (DV) replication, suggesting a treatment regimen for this viral infection. They are currently developing small molecule inhibitors to both PF4 and CXCR3 to inhibit DV replication in hosts. A clinical team at ICGB, New Delhi made exemplary efforts in developing MHC Class I tetramers in the lab. These tetramers are made up of four MHC molecules along with a 8-9-mer peptide that are brought together with a biotin molecule that is conjugated to fluorescently-labelled streptavidin. Scientists from CDFD, Hyderabad employing a standardized enzyme immunoassay with PPE17 (Rv1168c) as candidate antigen, were able to successfully discriminate TB patient’s sera from BCG-vaccinated healthy controls. Further, they observed that PPE17 displayed higher sensitivity

in detecting extra pulmonary and smear negative pulmonary TB cases which are difficult to diagnose by available diagnostic methods. Group of scientists from JNCASR, Bangalore studying the *Plasmodium falciparum* Autophagy protein PfATG18 have demonstrated that this parasite protein not only participates in Autophagy pathway but is also involved in trafficking of host haemoglobin to the food vacuole.

**National HIV Cohort Program - Cohorts of HIV Resistance and Progression in Indian Children and Adults (CoHRPICA):** The Program aims to bring together Centres of Excellence with interdisciplinary expertise (clinical, socio-behavioural and biomedical) across India that has enabled establishment of a consortium of CRCs that leverages on their individual strengths to accelerate population-based studies for informing effective management of HIV/AIDS. Further to the completion of the preparatory activities for the study (including finalization of study documentation), these CRCs were assessed for their readiness to initiate recruitments for the study. Based on this, 7 of the 8 sites (proposed to be activated for the study), have now been activated for initiation of recruitment of participants in the study. A brief snapshot of the CRC network, their responsibilities and their current activation status for CoHRPICA is provided below:

**National Liver Disease Biobank, ILBS, New Delhi:** National Liver Disease Biobank (NLDB) is a first of its kind national biobank, executed by the joint initiative of Department of Biotechnology (DBT) and Institute of Liver & Biliary Sciences for translational research in Liver and allied Diseases. NLDB provides the opportunity of open resource sharing across the nation. NLDB has established a network and operating based on the SOPs and storing human biological samples to ensure their optimum quality, harmonization and security, and the ethical and legal requirements guaranteeing the rights of donors.

## MATERNAL AND CHILD HEALTH

Ensuring the well-being of mothers and children is extremely important as it lays the foundation for generations to come. Several initiatives and collaborative efforts have been undertaken by the Department towards advancing research and scientific knowledge in areas encompassing preconception to adolescence. Emphasis is given on

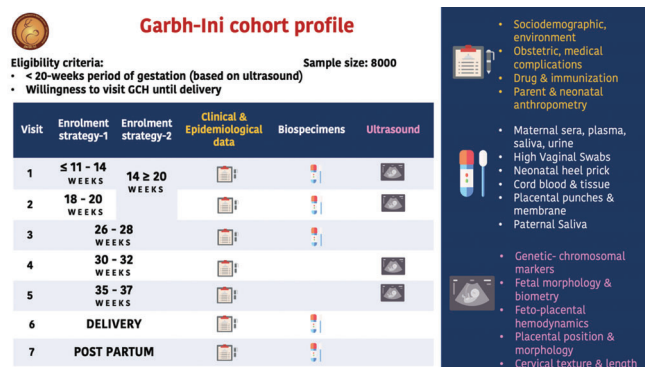
supporting research activities related to pregnancy complications, factors of adverse pregnancy outcome, antenatal development, congenital anomalies and problems and diseases of early childhood.

This year, against the call for proposals in the area of Developmental Disorders and Diseases of Infancy and Early Childhood, 118 proposals were received and 40 were shortlisted for developing into full proposals. The full proposals are being reviewed. Under the call for Letters of Intent (LOIs) in the area of Problems associated with Women's Health, 428 LOIs were received. Of these, over 50 have been shortlisted to be developed into full proposals which would be reviewed next year. Major network programmes have been supported in the area of placental biology after completion of proof of principle studies for isolation of placenta derived nanovesicles, as these provide a non-invasive window to the otherwise inaccessible placenta to determine foetal health and gestational outcomes. Efforts are also being made to identify real time molecular signatures of placenta during pregnancy using multi-omics approaches. Identification of these nodes could be used as diagnostic markers for monitoring the optimal placental functioning for healthy pregnancy, help triaging pregnant women at risk and manage them differently. A major effort this year has been around developing a multidisciplinary, multi-institutional network program on Neonatal sepsis which is one of the leading causes of neonatal deaths in India.

**Grand Challenge Research Programme on Preterm Birth:** Under this program coordinated by an interdisciplinary research group christened as GARBH-Ini (interdisciplinary Group for Advanced Research on Birth outcomes), a unique pregnancy cohort comprising more than 8000 women has been established comprising methodologies of clinical, epidemiological, statistical, genetic, proteomic and imaging sciences to study Pre Term Birth (PTB). The GARBH-ini platform now comprises of a biorepository (*Rakshita*) of well characterized clinical phenotypes with 750,000 bio-specimens and 450,000 ultrasound images. The program has provided some important insights into the whole problem of PTB. The frequency of preterm birth has been found to be around 13%, which is higher than those reported from economically developed (8.6%) or the low-income countries in Northern (7.3%) or Sub-Saharan Africa (12.3%). In addition to the well-known risk factors such as history of PTB, short



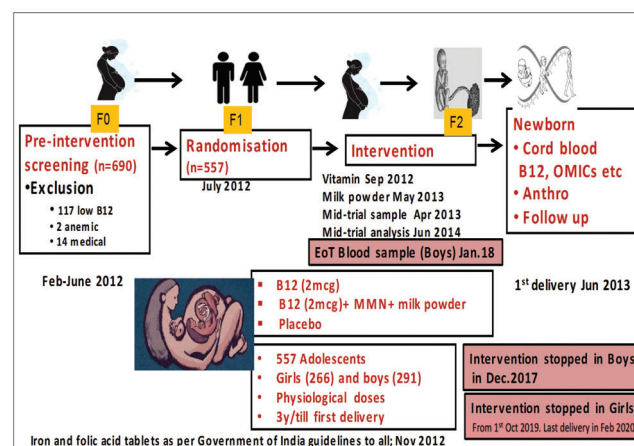
inter pregnancy interval and short cervix at the 3<sup>rd</sup> trimester, some less reported factors such as biomass fuel use and exposure to passive smoking as risk factors of PTB have been identified. Particularly interesting is BMI at enrolment which showed a U-shaped association with both underweight and overweight/obese women having a higher risk of PTB. A first trimester dating formula (called *Garbhini-1*) has been developed from the biometry of the foetus from mothers enrolled in the GARBHINI cohort which is more sensitive & accurate than global formulae. For identification of molecular determinants of pregnancy and risk stratification of PTB, a multi-omics approach is being used. Specific salivary and high vaginal proteins and vaginal microbiome have been found to alter across pregnancy. To continue our efforts for acquiring deep fundamental knowledge about PTB and find efficient and sustainable solutions for reducing associated mortality, immediate and long term morbidity, phase II of the GARBHINI program has been developed. In the phase II, a dynamic risk prediction model for PTB is proposed to be built using multi-dimensional data from clinical, epidemiological, ultrasound sonography imaging and multiple omics technologies.



**Foetal Programming Research:** Based on the Pune Maternal Nutrition Study (PMNS) and Pune Rural Intervention in Young Adolescents (PRIYA), this is a longitudinal study to test the hypothesis that intervention with vitamin B12, multi micronutrients and protein in adolescent girls from before conception will favourably influence foetal programming of 'diabesity' in the offspring. The study has highlighted that 'thin-fat' body composition of small Indian babies predisposes them to higher risk of diabetes, and that there is an association of maternal vitamin B12 deficiency and excess folate with child's adiposity and insulin resistance. The results

support the primary hypothesis that pre-conceptional B12 supplementation improves maternal and cord B12 status. The Vitamin B12 intervention the group has been found to perform better in the cognitive and language domains than the placebo control. Intriguingly, the Vitamin B12 intervention group also performed better than the group that received both Vit B12 and multiple-micronutrient supplementation. The hard outcomes in the offspring (size, body composition etc.) will be seen during the long-term follow up after delivery. Samples including blood (DNA, RNA, plasma, serum), urine, microbiota samples of mothers during pregnancy and delivery (breast skin, vaginal swab, and stool), and mothers and babies' samples in the first two years of life have been biobanked. These are being analysed to elucidate the molecular mechanisms of fetal programming.

### Pune Rural Intervention in Young Adolescents [PRIYA]



### Pediatric Renal Biology Program: Research on Nephrotic Syndrome:

Idiopathic nephrotic syndrome is an extremely important chronic kidney disease of childhood and is associated with significant morbidity related to disease relapses and immunosuppressive therapies. The project sought to develop a multicenter collaboration for research on nephrotic syndrome. More than 1400 patients with nephrotic syndrome have been enrolled in the longitudinal cohort and samples from 800 patients have been stored in the biorepository. Results of whole genome sequencing indicate a monogenic cause of syndrome in about 80% of patients with congenital nephrotic syndrome and in around 40% of patients with steroid resistant nephrotic syndrome. An App platform that provides details on management of

nephrotic syndrome and charts for monitoring for parents has been launched and is being tested. The well phenotyped biorepository created in the project is envisaged to be a valuable resource for studies into disease pathogenesis.

**Healthy Life Trajectories Initiative (HeLTI):** The Healthy Life Trajectories Initiative (HeLTI) was launched as a joint initiative between Canada, India, China and South Africa in collaboration with the World Health Organization to address the increasing burden of Non-Communicable Diseases (NCDs) – including obesity, diabetes, cardiovascular disease. It aims to test the hypothesis that integrated interventions administered pre-conceptionally and at appropriate points across the life-course (pregnancy, infancy and childhood) will reduce childhood adiposity, improve cardiovascular and metabolic health, and improve child neurodevelopmental outcomes. In the HeLTI EINSTEIN (Early Interventions to Support Trajectories for Healthy Life in India) study set in rural Mysore, women of reproductive age will receive a longitudinal multi-faceted intervention comprising of multiple micronutrients; a group parenting program; hygiene and infection prevention measures; reduction of environmental pollution exposure. So far, focus group discussions have been conducted in representative villages to ensure that the approach is acceptable and feasible. Basic anthropometric data and other information like socio-economic status, dietary habits, exposure to cooking fuel and pesticides have been collected. A high degree of harmonisation has been achieved across the four country sites with respect to the biospecimen sample collection and processing protocols as well as the variables for data collection case record forms.

## PUBLIC HEALTH NUTRITION

The programme has a mandate to provide technological and clinical solutions for public health nutrition issues. The Department continues its efforts to promote the area of Public Health and Nutrition towards addressal of Anaemia, Protein Malnutrition, Micronutrient deficiencies, Severe acute malnutrition through food fortification, Probiotics for human health and well-being, food safety, development of low cost foods/ supplements and capacity building in the field. Recently R&D on Agri Nutrition linkages has been undertaken to address the protein malnutrition prevalent across the country. The group has also supported research to tackle Vitamin D deficiency and related aspects.

### Process/Product/ Technology Developed

- i. Lead generated in development of Vitamin D Strip Test
- ii. Development of detection test for meat adulteration
- iii. Anthocyanin-curcumin-gold nanoparticle enabled strip-type indicator is a potential smartpackaging material for monitoring quality and safety of refrigerated chicken meat.
- iv. The ready to use frozen meat temperature abuse indicator based on Laccase- Guaiacol complex successfully indicated the temperature exposure history of frozen meat and thereby quality of meat.

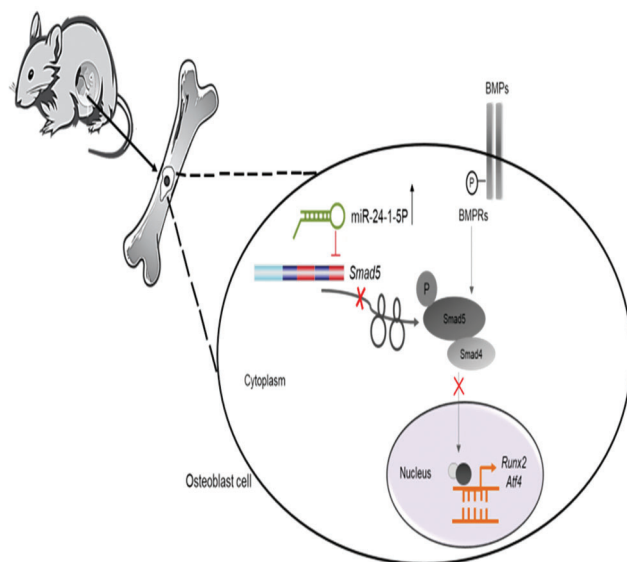
### New Initiatives:

- Strategic understanding of mechanisms that restrict grain yield, grain protein content and quality in rice through an interface between clinical nutrition and agriculture research.
- National Mission Mode Program on Nutritional improvement of digestible protein content and quality in rice.

### Salient Achievements:

Scientists from TIFR, Mumbai have showed that transcription of the hydroxylating enzyme CYP2R1 is dependent on SIRT1 and thus hepatic malfunctioning during obesity, diabetes, aging and age-related diseases may directly impinge on Vitamin D bioavailability. Clinical trial in individuals with Diabetes mellitus or who are pre-diabetic suggest a benefit from vitamin D administration with respect to improving or preventing the development of frank diabetes. In a multi-centric, randomized trial of cholecalciferol supplementation for CVD, inflammation and bone metabolism markers in CKD 340 patients have been screened at Post Graduate Institute of Medical Education & Research, Chandigarh. A total of 94 subjects have been enrolled and 70 of them have completed the run-in phase period. In a study supported at JSS Academy Mysore researchers has established that Vit. D3 but not metformin induced the caspase 3/7 in breast cancer cell lines. In a study supported at CFTRI Mysore scientists have shown that the offspring's born to HPD fed mothers had decreased bone formation and bone mass at birth. This

decrease in bone mass is not recovered even when they were switched to normal diet at weaning.



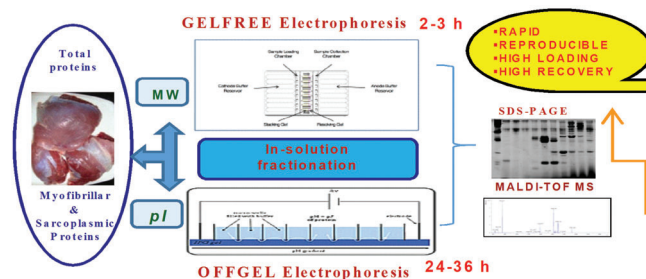
*Exposure to the maternal excess protein resulted in the increase in the expression of miR-24-1-5p*

In another study supported at SKIMS, Srinagar, investigators concluded that vitamin B12 deficiency was observed in 81.18% vegetarian women with PCOS as compared to 15.62% non-vegetarian women with PCOS. Further 67.8% healthy vegetarian women were having Vitamin B<sub>12</sub> deficiency as compared to 16.87% healthy non-vegetarian women, in the selected population. Baseline evaluation of markers of B12 deficiency reveals significantly higher values of serum B12, HTC and lower levels of serum Hcy among non-vegetarians as compared to vegetarians. They have also shown that concomitant supplementation of Vitamin B<sub>12</sub> with conventional drugs showed an overall improvement in serum total testosterone, fasting glucose, serum hs-CRP, serum TNF- $\alpha$ , serum Hcy, HTC as well as serum B12 levels, with B12+metformin being the most effective combination. Investigators at NDRI Karnal have developed a method for preparation of different milk proteins (both native and succinylated)-VA/VD nano-complexes. Milk protein-VA/VD nano-complex could be used as a VA/VD fortificant with better solubility, stability and bioavailability than free VA/VD (oily form).

In a high value project on Long Term (2 Years) Efficacy of Indigenously Developed Micronutrient Fortified Rice (Fortified with Iron, Vitamin B12 and Folic acid) in Improving Iron Stores

in School Children and Their Mothers, investigators have reported that the new dye for Vijayanagara rice variety was designed and fabricated. Technology up-gradation for Vijayanagara FRK was done using existing old dye. Further, the true density of FRK was matched while hardness was higher than the natural rice.

As part of the study towards development of rapid immune chromatographic assay kit for field level detection of meat adulteration, scientists from NRCM Hyderabad have evaluated and compared the novel GELFREE protein fractionation technique with OFFGEL electrophoresis as in-solution fractionation approaches for total and myofibrillar/sarcoplasmic proteins isolated from different food animals and poultry meat. They have demonstrated that both OFFGEL and GELFREE techniques are suitable for enrichment and separation of relatively low-abundant proteins and effectively reduces the sample complexity in 24-36 h and 2-3 h, respectively.



In another study, scientists from NRCM Hyderabad have undertaken research to develop a Time-Temperature Indicator (TTI) for monitoring meat quality and safety during storage conditions. Sticker type TTI was developed by optimizing the levels of enzyme-substrate (Laccase-Guaiacol). Scientists from CFTRI Mysore have established that the low fat, synbiotic ice creams demonstrated the effectiveness of a manno oligosaccharides in improving the survival of Lactobacillus sp. and also enhancement of the functional properties. As interim result of the study on effect of early stunting on body cell mass (BCM) and fat mass in term appropriate for gestational age (AGA) infants supported at SJRI, Bangalore, investigators have reported that there is no difference in the % body fat between infants who are having LGF vs those not having LGF.



## STEM CELLS & REGENERATIVE MEDICINE

DBT has identified stem cells as one of its thrust areas under the Biomedical research program since 2001. The overall aim is to promote basic, early and late translational research in the area of stem cells and regenerative medicine. Scientific strategies include: basic biology of all adult stem cells, early and late translational research, developing gene editing technology for possible therapeutic applications, creation of animal models for various human diseases, trainings and workshops, and formulation of regulatory framework for stem cell research in India.

In one such study it was demonstrated that the organization of the actin cytoskeleton is disrupted in cells that lack clathrin mediated endocytosis, which are in the process of exiting the pluripotent state. In a separate study, xeno free protocols were established for step-wise differentiation of pluripotent stem cells into definitive endoderm, anterior foregut endoderm, lung progenitors and then into airway and alveolar epithelial cells, as characterized by the expression of NKX2.1, FOXA2, Sox17 etc. The study on therapeutic potential of AAV-FVIIa vectors *via* gene-editing mechanisms in hemophilia B mice demonstrated for the first time, the utility of Neddylated modified AAV2 vectors for potential gene therapy of hemophilia B. The effect of curcumin on hematopoietic stem cells was studied showing that curcumin restores the expression of autophagy-inducing mRNAs in them and improves their engraftment capacity. Further the data suggests that curcumin specifically targets CD3<sup>+</sup>CD8<sup>+</sup> cytotoxic T cells in the spleen and also reduces the frequency of exhausted cytotoxic T cells as denoted by CD3<sup>+</sup>CD8<sup>+</sup>PD1<sup>+</sup> phenotype in the spleens of aged mice. Thus this study suggests that *in vivo* administration of curcumin rejuvenates aged HSCs when administered via, both, IP and oral routes, and makes them functional. It also prevents exhaustion of cytotoxic T cells, and thus, could be used to boost the immunity of aged individuals. A study undertaken to gain insight in the underlying cell-intrinsic mechanisms involved in mediating the inhibitory effects of pesticides on brain self-repair/neurogenesis revealed that exposure to cypermethrin (a pyrethroid pesticide) alters the NSCs self-renewal, fate choices and cognitive functions in the rat brain. Results demonstrate that PGC-1 $\alpha$  plays a crucial role in controlling the self-renewal, proliferation and switch of stem cell fate,

and might serve as potential targets to ameliorate cypermethrin induced neurogenesis deficits in the rat brain.

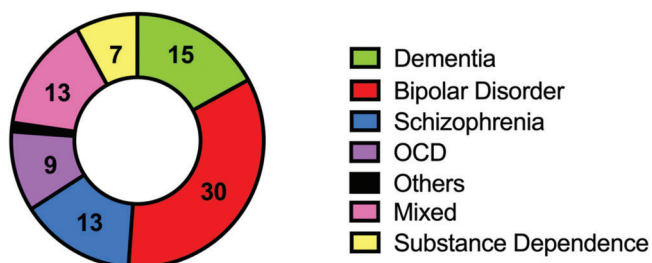
Attempts to isolate induced pluripotent stem cells (iPSCs) from orbital adipose mesenchymal stem cells was undertaken and these iPSCs were found to retain the germline RB1 mutation and expressed pluripotency factors. Overall the study suggested that iPSC lines could be generated from retinoblastoma patients using orbital adipose mesenchymal stem cells, however cannot be used for *in vitro* modeling of retinoblastoma using the *in vitro* retinal differentiation protocol. In a separate study it was demonstrated that foetal neural stem cells (FNSCs) can differentiate into oligodendrocytes (OL) over a period of 28 days. This is for the first time any lab in India has successfully developed well characterized human primary cultures of OLs.

### Programme on Accelerating the application of Stem Cell Technology in Human Disease (ASHD)

A major multi-institutional collaborative project with focus on two broad research components, namely “Accelerator program for discovery in brain disorders using stem cells (ADBS)” and “Novel approaches to hematological disorders (NAHD)” led to some interesting findings.

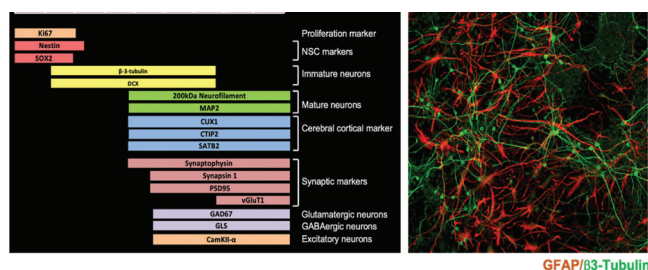
**ADBS program** has established a cohort of large dense families with major psychiatric disorders. A total of 4038 families were screened, and 540 large dense families have been systematically evaluated. Eight hundred and ninety-nine individuals have undergone detailed assessments including magnetic resonance imaging, psychophysics and neuropsychological tests. Healthy controls (N=119) have also been ascertained and evaluated. Preliminary analyses indicate the presence of shared and unique risk factors and endophenotypes across disorders. Abnormalities have also been identified in unaffected relatives, who need to be followed-up over time, to examine the developmental trajectory of psychiatric illness. A total of 88 HiPSC primary lines were generated at the ADBS program and banked as primary lines of MEF. The phenotypic distribution of patients from whom the lines were generated is shown in the Figure. These 88 HiPSC lines were from a total of 46 families. In addition to generating new HiPSC lines and validating their pluripotency, the ADBS biobanking group works towards

sustainable banking of these HiPSCs benchmarked to international standards.



*Distribution of the 88 HiPSC Lines Generated by the ADBS program According to Disease Types.*

Using a human stem cell line, a robust protocol for the generation of cortical neuronal cultures in the dish was established. Such cultures can now be routinely maintained for upto 120 days (3 months) *in vitro*. The protocol established under this project shows the following features: The expression of molecular markers (transcriptome and protein marker expression) that are comparable with that seen during human brain differentiation *in vivo* (Sharma et al., 2020).



*The differentiation of NSC into cortical neurons “disease in a dish” model.*

Further, using imaging of neuronal activity in the dish it was shown that such cultures are physiologically active *in vitro* displaying the development of calcium transients in a manner with that reported for development *in vivo*. Independently it was also shown that these cultures also demonstrate electrical activity; action potentials can be recorded from these and the developmental maturation of action potentials can be observed as a function of age in culture. In order to facilitate discovery of the genetic elements that contribute to SMI sequencing and analysis of exomes sequences of members from families where HiPSC are being generated were undertaken. A total of 276 whole exome sequencing

(WES) experiments were done. The ADBS program includes a strong component of capacity building in stem cell technology in India. The program organizes an annual training program in iPSC technology with the Centre for iPSC Research, Kyoto University (CiRA), Japan and also iPSC training programs at inStem, Bengaluru.

#### Novel Approaches to Hematological Diseases (NAHD):

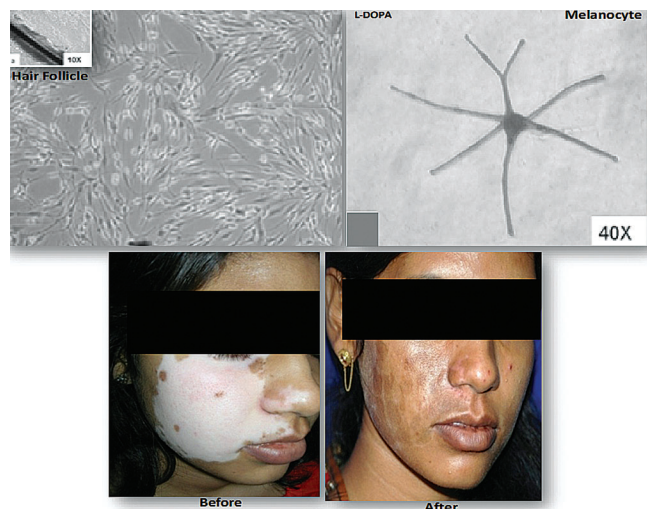
NAHD program involves developing modern methods including gene therapy technologies for hereditary blood disorders such as haemophilia, thalassemia and sickle cell disease. This program is led by Christian Medical College (CMC), Vellore and the Centre for Stem Cell Research (CSCR, a unit of inStem, Bengaluru), Vellore. Under this program, a novel hematopoietic stem cell based lentiviral vector mediated gene therapy product for possible treatment of haemophilia A is being developed. The product has been tested in pre-clinical mouse models and shown to be safe and effective. The GMP grade vector is also ready for use in a clinical trial. The protocols for HSPC purification, culture conditions and characterization from peripheral blood CD34+ cells from a mobilized healthy donor has been standardized. Gene editing conditions such as the dose and the nucleofection programs were optimized to introduce long deletions and generation of indels at the target regions. Using these optimized conditions, editing was performed for the target regions using RNP approach in mobilized peripheral blood CD34+ cells from at least two different healthy donors. The team at CSCR successfully generated an iPSC line with inducible Cas9 expression from the AAVS1 safe harbor site. The NAHD team at CSCR, CMC Vellore have also designed and validated CRISPR/Cas9 components for two monogenic diseases namely Diamond Blackfan anemia (DBA) and congenital dyserythropoietic anemia (CDA) and have achieved desired cutting efficiencies in iPSC. As a part of establishing a haplobank relevant to Indian population, so far blood samples from 235 HLA donors were collected from various regions of the country covering the top 10 haplotypes.

The control & management programme for Sickle Cell Anemia and Thalassemia has been implemented in the State of Odisha. This program has been initiated in six districts in Phase I, namely: Balasore, Bargarh, Cuttack, Jharsuguda,

Koraput, and Sambalpur. The major components of this program include comprehensive testing of the population at risk for carrier status with a single blood sample right up to genetic diagnosis and a major component of Behaviour Change Communication targeted activities using all forms of media to increase knowledge and awareness about these diseases among the general population. Towards increasing the capacity and capability for treatment of major haemoglobin disorders, several training workshops are being arranged at different levels (State/Regional levels) for doctors/other healthcare workers of Odisha. So far, over 300 medical doctors from various district hospitals and health centres have been trained from across Odisha.

#### Center of Excellence (CoE) on Stem Cell Research:

At this CoE at AIIMS, New Delhi, a pool of clinical grade MSCs have been established as per the guidelines of International Society of Stem Cell Research (ISSCR, 2017), and National Guidelines for Stem Cell Research (ICMR-DBT, 2017). These MSCs are currently being used for both basic and clinical research purposes thereby establishing a platform for translational research in the field of stem cells and regenerative medicine. Besides this, different induced pluripotent stem cells (iPSCs) clones have been generated, well characterized and now their potential for differentiation into melanocytes, corneal and retinal pigmented epithelial cells are being evaluated. Further, different scaffolds have been developed for translational research using MSCs in skin and bone tissue engineering. Physiochemical characterization of these scaffolds has been completed and preclinical studies are ongoing. A 3D printed scaffold with Human Amniotic Membrane (HAM) and Silk was constructed where HAM significantly improves the mechanical strength and adds to the stability and toughness. The composite membrane showed high biocompatibility towards MSC which provides easy transfer of these cells on the wound area. Tissue engineering for skin surgery has come up with dermo skin graft instead of tissue transplantation. Moreover, attempt was made to treat vitiligo with hair follicle derived melanocytes which are rich source of melanin pigmentation.



#### Centre for Neurodevelopmental Synaptopathies (CNS):

This collaborative programme at InStem has a major objective of creating stem cell-based models of brain disorders, leveraging expertise at NCBS and the University of Edinburgh. A strikingly novel lead has emerged from this study where interaction of glia and neurons have been explored and specifically whether co-culture with mutant astrocytes results in neuronal physiological abnormalities. Notably, control neurons when co-cultured with FXS astrocytes (iPSC or *FMR1* null ES with isogenic control neuron) show a bursting profile similar to that found in FXS neurons i.e. higher number, shorter duration bursts. In contrast, FXS neurons co-cultured with control astrocytes show a bursting profile similar to controls i.e. lower number, longer duration bursts. The potential importance of this result cannot be overstated. If the electro physiological phenotype of the FXS cortical neurons depends on the genotype of astrocytes, this provides an entirely new avenue for treating FXS. Furthermore, if the glial derived cell non-autonomous factor is a soluble molecule, it could represent an immediately applicable therapeutic for this relatively common disorder. A central question for neurodevelopmental disorders is whether brief, early pharmacological intervention can have permanent benefits. The research reveals profound deficits in complex associative memory in a novel rat model of FXS. However, a short regimen of lovastatin, applied before the normal developmental establishment of this associative memory capability, prevents the emergence of deficits in the FXS rats. Moreover, no regression of cognitive performance was observed in the FXS rats over several months after treatment. These findings provide the first proof-of-concept



that the impaired emergence of the cognitive repertoire in neurodevelopmental disorders may be prevented by brief, early pharmacological intervention.

**National Mouse Resource Research (NaMoR) :** The National Mouse Resource Research (NaMoR) has been established by the Department as a national state-of-the-art rodent facility including transgenic and knockout mouse models of human disease. Consistent with its mandate under the auspices of NaMoR, the animal facility has become a major hub of animal training in the country. The number of external scientists trained in various aspects of animal husbandry, mouse genome engineering techniques, embryo cryopreservation and rederivation, and many other state of the arts techniques has been growing substantially year to year. One highlight over the last year has been the development of mouse models to study the infection of SARS-CoV-2, the virus that causes COVID19. Having a local source for these mice will significantly accelerate national efforts to develop and test new vaccines and therapeutics to combat this pandemic.

## VACCINE RESEARCH & DEVELOPMENT

Vaccines are one of the most cost-effective health interventions for combating infectious diseases. Hence, over the past three decades, the Department of Biotechnology (DBT) has made concerted efforts to strengthen the Indian vaccine R&D ecosystem, through adoption of pioneering strategies like fostering active partnerships with relevant global leaders and implementation of innovative funding mechanisms. The most significant international partnership that contributed immensely towards development of indigenous vaccine science is the Indo-US Vaccine Action Programme (VAP), a bilateral programme being jointly implemented by DBT, and the National Institutes of Health (NIH), since 1987. The programme demonstrated major achievements like the development of the low-cost Rotavirus vaccine which became part of the universal immunization programme and development of vaccines for diseases like Malaria, Dengue and Tuberculosis. Horizon 2020 Programme is another initiative, wherein the Union Government and European Union (EU) have collaborated to develop cost-effective and affordable universal Influenza vaccine. The Ind-CEPI Mission was initiated in 2019, in partnership with the global foundation, the Coalition for Epidemic Preparedness

Innovations (CEPI), for supporting vaccine development for potential outbreak threats up to Phase II testing and enhancing inter-ministerial co-ordination for rapid vaccine development. Innovative funding mechanisms are being facilitated through the National Biopharma Mission (NBM)-an Industry-Academia collaborative Mission, being implemented by BIRAC, a Public Sector Undertaking of DBT.

## Initiatives under the Auspices of Indo-US VAP:

- i. The 'India-U.S. Collaborative Research Grants on Vaccine Adjuvant Development' was a new initiative that was started to foster collaborations between Indian and U.S. investigators to accelerate vaccine adjuvant research. Under the initiative, four proposals have been shortlisted for financial support, focussed on (i) heparinoid based adjuvants for flavivirus vaccine development, (ii) development of adjuvanted vaccine for FMDV, (iii) identification of combination adjuvants for RSV vaccine, (iv) development of endogenous STING agonist adjuvanted BCG vaccine for tuberculosis.
- ii. A new initiative to strengthen capacities in biomedical research ethics was initiated, in collaboration with the Department of Bioethics, National Institutes of Health (NIH) Clinical Center, USA. Under this initiative, a series of webinars on 'Clinical Research Ethics for the Autumn of 2020', are being organized. 04 webinars focussed on ethical perspectives in clinical research were held since September, 2020.

**Initiative to Support Vaccine Development for COVID-19:** DBT and BIRAC issued a RFP for COVID-19 Research Consortium" as part of the comprehensive efforts to facilitate development of indigenous research solutions to tackle COVID-19. 19 proposals with 14 from industry and 5 from academia have been shortlisted under the call, for development of vaccines based on different platforms. The academia based proposals being supported include development of a VLP based vaccine by NIBMG, development of intranasal mucosal vaccine at ICT Mumbai and development of full length cDNA clones of SARS-CoV-2 for use in vaccine development, by CCMB and SNU.

The details of DBT efforts on Covid-19 vaccine development are given in the Covid-19 chapter of this report.

### Partnerships for Accelerating Clinical Trials (PACT):

The PACT Initiative was initiated for supporting COVID-19 vaccine development activities in partnering countries, and is being implemented by BIRAC and CDSA, under the National Biopharma Mission and Ind-CEPI Mission. The activities being undertaken include (i) trainings for strengthening clinical research capacity in neighbouring countries and (ii) facilitating phase III clinical trials of Indian COVID vaccines in neighbouring and friendly countries.

### Significant Achievements:

#### a. Achievements under Indo-US VAP

##### i. Candidate Vaccine Development

The Indo-US VAP is supporting development of candidate vaccines in various stages of pre-clinical and clinical development, for cholera, dengue, influenza, malaria, pneumococcal infection, chikungunya and tuberculosis. Details are provided below:

Pre-clinical	Phase I	Phase II & III
Cholera Vaccine, BIBCOLD & THSTI	Dengue Vaccine-TV003, SIIPL	Pneumococcal Vaccine, Pneutger-15, Tergene
Dengue Vaccine TV003/TV005, IIL		Chikungunya Vaccine, Bharat Biotech
Dengue Subunit vaccine, Sun Pharma		TB Vaccine, VPM1002-SIIPL
Universal Flu Vaccine, Mynvax		
Universal Flu Vaccine, Pentavalent Life		
JAIVAC 2 Malaria Vaccine, ICGEB		

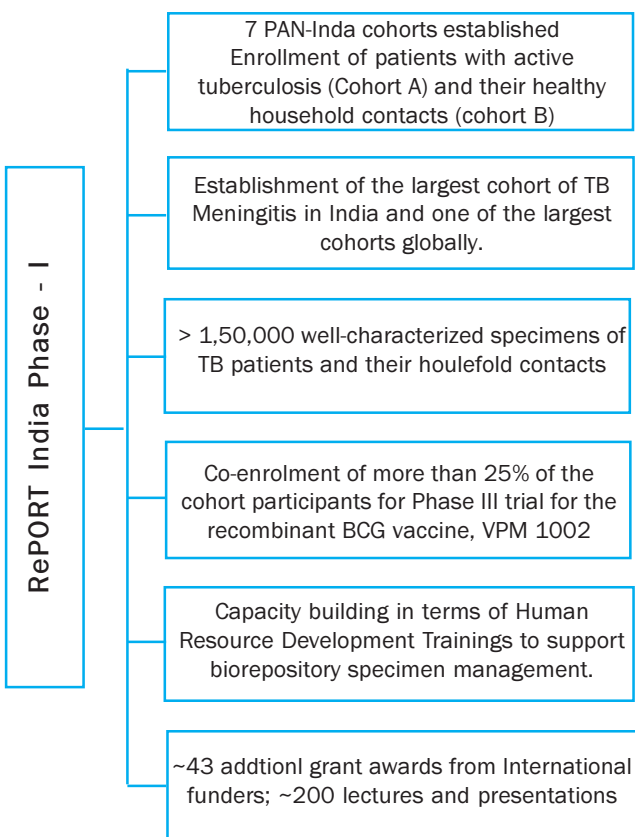
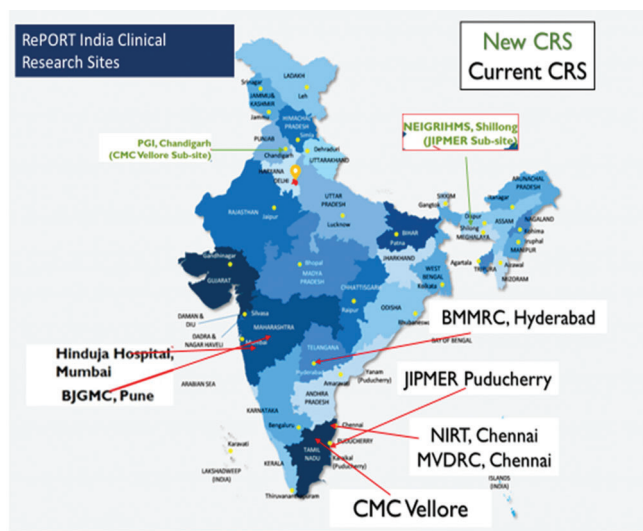
##### ii. Indo-US Collaborative Research on Human Immunophenotyping in Collaboration with Human Immunology Project Consortium (HIPC):

The programme, being implemented under the VAP, supports human immunology research in India through collaborations of Indian investigators with U.S.-based investigators in the Human Immunology Project Consortium (HIPC) of the National Institute of Allergy and Infectious Diseases (NIAID). Phase II of the Programme with DBT-NIAID joint funding support was initiated in 2018/early 2019, as part of which, 5 projects are currently being supported. Nearly 15 scientific/ research staff are being supported and about 4 good quality publications have emerged, in the last one year. Chandele *et al.*, are working on undertaking B cell responses or their receptor repertoire on disease severity in primary versus secondary dengue infections. They found that neutralizing antibodies (NT-Ab), binding antibodies and Memory B Cells were detectable in 86%, 86.56% and 81.63% of the subjects respectively. Among the neutralizing positive subjects, 58%, 27%, 5% and 10% neutralized all four, any three, any two and any one dengue serotypes respectively. Vyakaranam *et al.*, have demonstrated that revaccination of latent TB subjects was potentially beneficial. They observed that IFN- $\alpha$  and/or IL-2 Ag85A- and BCG-specific CD4+ and CD8+ T cell responses were boosted by revaccination at 4 and 34 weeks, respectively, and were > 2-fold higher in IGRA+ compared with IGRA- vaccines. The study is the first of its kind in India with implications for public health and vaccine development strategies.

##### iii. Regional Prospective Observational Research in Tuberculosis (RePORT) India:

The RePORT India Initiative is a bilateral collaborative effort initiated under the Indo-US VAP, in 2013, to advance tuberculosis research in India. The major aim is establishment of a TB consortium with PAN-India representation, involving long term longitudinal cohorts of TB patients in India. The remarkable success of Phase I RePORT India has been followed up with implementation of Phase II of RePORT India. Phase II would see the addition of two new cohort research units from Northern and North-Eastern India to achieve pan-India geographic representation. RePORT India Phase II aims at the utilization of harmonized data elements and specimen collection SOPs for gaining

insight into TB pathogenesis, generate newer diagnostics and identification of novel improved biomarkers for targeted therapy.



#### b. Achievements under Ind-CEPI Mission:

Significant achievements have been demonstrated under the Ind-CEPI Mission, whereby, two major vaccine development projects are being supported. These include GMP manufacturing of inactivated vaccine for chikungunya and an mRNA based vaccine for COVID-19 and pre-clinical and clinical development, upto Phase I/II trial of an mRNA vaccine for COVID-19. Also, under the PACT Initiative, e-training sessions on strengthening clinical trial research capacity in neighbouring countries are being organized, with participation from Afghanistan, Bangladesh, Bhutan, Maldives, Mauritius, Nepal and Sri Lanka. The training sessions are focussed on Good Clinical Practice, Ethical considerations in clinical research, Good Clinical Laboratory Practice and Large vaccine field trials.

#### National Biopharma Mission:

**Vision:** To enable and nurture an ecosystem for preparing 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.

The Industry-Academia Collaborative Mission of Department of Biotechnology (DBT), Govt of India for accelerating discovery research to early development for Biopharmaceuticals was approved by the Cabinet for a total cost of INR 1500 Cr and 50% co-funded by the World Bank. The program referred to as National Biopharma Mission (NBM), is being implemented by Biotechnology Research Assistance Council (BIRAC) and this program is aligned with the national mission of Make-in India. PMU NBM published about 15 Requests for proposals in this year to solicit Pan-India applications from academia and industry across different thematic areas like Vaccines, Bio therapeutics, Indigenous Development of Technologies for Affordable Biomanufacturing, Medical Devices and Diagnostics, Translational Research Consortia for Hep E and RSV, Clinical Trial Network and the COVID-19 Research Consortium. To strengthen the technology transfer capacity in the country, five (05) Technology Transfer Offices were established with NBM support. The Mission also engaged in three consultancy assignments: CDSA, Faridabad was engaged for Clinical Trial Regulatory Advisory & Data Safety



Consultancy; Sathguru Management Consultants for Technology Transfer Offices while International AIDS Vaccine Initiative (IAVI) was taken on-board as the technical knowledge partner. 5 Patents were applied and 13 technologies were commercialized under the NBM mission.



### Significant Achievements:

- a. **Vaccines:** Currently 11 vaccine candidates for Flu, Cholera, Dengue, Pneumonia, and COVID, under different stages of development are being supported under the Mission.
- b. **Biotherapeutics:** The Mission supports therapeutic proteins and monoclonal antibodies (mAbs) that are currently under development by the industry with an aim to bring them closer to market. About 12 mAbs which are not presently existing in Indian market and 03 clones for diseases like cancer, diabetes, psoriatic arthritis, wet macular degeneration and lung infections caused by RSV are being supported. Additionally, one antibody-drug conjugate (ADC), one novel biologic, one recombinant monoclonal and one bio-better are also being supported.
- c. **Medical devices & Diagnostics:** With a view to reduce import dependency, improve affordability and increase the innovation quotient, the Mission is supporting development of products in the areas of hospital-use equipment, diagnostic imaging, implants, wound-care products etc. Many diagnostic devices and reagents used for diagnostic kits are also supported including Molecular diagnostics, ELISA, LFT, sample transport reagents etc. Currently 17 devices and 13 diagnostics are being supported.
- d. **Translational Research Consortia:** The Mission has supported two consortia- (i) TRC for Dengue: 3 clinical sites and 5 premier institutes across the country led by ICGEB, Delhi. (ii.) TRC for Chikungunya (CHKV): 4 hospitals and 3 premier research institutes across the county, led by Manipal Academy of Higher Education.
- e. **National facilities:** Creating an enabling ecosystem for affordable product development in the country viz-a-viz creation of GLP, GMP, GCLP facilities besides cell line repositories and facilities for medical device testing and prototyping. The Mission is currently supporting establishment of 19 national facilities, out of which 04 are already operational. Andhra Pradesh MedTech Zone (AMTZ), Visakhapatnam has been supported for a manufacturing capacity of 3 lakh RT-PCR kits/month, 1 lakh RNA extraction kits/month and 1 lakh Viral Transport Medium (VTM)/month under the DBT-AMTZ COMManD [COVID Medtech Manufacturing Development] strategy. The facility at AMTZ has manufactured the following products:
  - RT-PCR tests – 22 lakh tests
  - Viral Transport Medium – 8 lakh units.
  - IR Thermometers – 2200 units.
  - Ventilators – 2800 units.
- f. **Clinical Trial Network (CTN):** CTN for hospital-based trials in patients for testing biologicals in different specialties of oncology, diabetology, rheumatology and ophthalmology. Currently, 05 consortia including 36 hospitals are being supported. Strengthening the capacity of vaccine clinical trials via epidemiology studies for dengue and chikungunya, in already existing Demographic Surveillance sites and establishing new sites is another major focus area. Ten (10) Field Sites have been prepared for the same.
- g. **Strengthening Technology Transfer Capabilities:** Five (05) TTO's have been established with a view to strengthen the technology transfer capacity of the country. These are located at: IKP Knowledge Park, Hyderabad; Centre for Cellular and Molecular Platforms (C-CAMP); KIIT Technology Business Incubator, Bhubaneswar; Biotechnology Business Incubation Facility (BBIF), Foundation for Innovation and

Technology Transfer (FITT), New Delhi; Entrepreneurship Development Center (EDC), Pune.

- h. Skill Development:** The Mission supports trainings and workshops as per its mandate. Workshops in the areas of clinical research, regulatory compliances,

technology transfer, biopharmaceuticals and medical devices have been majorly supported. 1406 candidates have been trained under Mission supported trainings with about 37.12% female participation up till now about 644 candidates trained with 46.89% female representation in 2020-21.



### Ind-CEPI Mission

The Ind-CEPI Mission is an India centric collaborative mission of Department of Biotechnology (DBT), Govt. of India, aligned to the global initiatives of CEPI (Coalition of Epidemic Preparedness Innovations). The Mission aims to strengthen the development of vaccines for the diseases of epidemic potential in India as well as build coordinated preparedness in the Indian public health system and vaccine industry to address existing and emergent infectious threats in India. DBT is supporting the implementation of the Ind-CEPIs mission “Epidemic preparedness through rapid vaccine development: Support of Indian vaccine development aligned with the global initiative of the Coalition for Epidemic Preparedness Innovations (CEPI)”, through a dedicated Program Management Unit (PMU) at Biotechnology Industry Research Assistance Council (BIRAC). The Ind-CEPI Mission was approved on 27th March 2019 with a total cost INR 312.92 crore. The Ind-CEPI Mission is currently supporting 2 vaccine projects:

Disease Area	Platform	Title	Applicant	Duration	Endpoint
SARS-CoV-2	mRNA vaccine	“Next-generation mRNA vaccine against COVID-19 to provide long-term protection to the population within its national/ international territories”	Company Gennova Biopharmaceuticals Limited, Pune	18 months	Manufacturing of vaccine candidate, and safety and immunogenicity in Phase I/II clinical trial.
Chikungunya	Inactivated virus	“Global Chikungunya Vaccine Clinical Development program” (GCCDP)	Bharat Biotech International Ltd (BBIL)	24 months	GMP manufacturing of the vaccine in India and subsequent manufacture of clinical trial materials.

## Significant Achievements:

### a. Vaccine Development:

Current Progress	
SARS-CoV-2 Vaccine	Chikungunya Vaccine
<ul style="list-style-type: none"> <li>✓ Proof-of-concept established</li> <li>✓ Pre-clinical studies in nonhuman primates for optimum dose identification conducted.</li> <li>✓ Data for three consistency batches to demonstrate process consistency, quality, and stability generated.</li> <li>✓ Pre-clinical toxicology at 25 µg and 125 µg doses completed.</li> <li>✓ Plan to submit dossier to DCGI for approval.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Vaccine batches for phase 2/3 clinical trials in India are under testing in CDL, Kasauli for batch release.</li> <li>✓ Clinical phase 2/3 protocol changes made to harmonize the trial design between India and ex-India trials.</li> <li>✓ Submitted CMC documents for International Vaccine Institute's RA submissions in Thailand/ Panama and Columbia.</li> <li>✓ Reproductive toxicity studies are in progress to be completed by December 2020.</li> </ul>

- b. **Skill Development:** An orientation session to e-course series "Strengthening Clinical Trial Research Capacity in Neighbouring Countries" was conducted on 22<sup>nd</sup> Sep 2020 through an online platform. This training envisages an in-depth coverage of Good Clinical Practice, Ethical considerations in clinical research, Good Clinical Laboratory Practice and Large vaccine field trials. Program 1 on GCP (9<sup>th</sup>-29<sup>th</sup> Oct 2020) and Program 2 on Ethical Consideration in Clinical Research (6<sup>th</sup>-13<sup>th</sup> Nov 2020) received very encouraging response and wide participation from Afghanistan, Bangladesh, Bhutan, Maldives, Mauritius, Nepal and Sri Lanka.

## COHORT STUDIES, BIO-BANKS, BIO-REPOSITORIES AND CLINICAL TRIALS

During the recent past, the Department has supported various cohort studies; establishment of Bio-banks; Bio-repositories and Clinical Trial facilities for various diseases across the country. Cohort studies on cerebral stroke biology, adult health and brain aging, dementia, stem cell technology, TB, HIV, maternal & child health, young adolescents, trajectories for healthy life, renal biology, chronic kidney diseases, cancer, systemic lupus erythematosus and genetics of healthy people have been supported by the Department under various ongoing programs. Along with support to cohort studies, the Department extended its support for the establishment of Biorepositories on these diseases. Biobanks/bio-repositories

supported by the Department in various disease areas are as follows:

### Bio-bank/ Bio-Repository Facilities

Dementia Science Programme	NBRC, Manasar
Oral Cancer under ICGC program	ACTREC, Mumbai
Translational Research for Cerebral Stroke	AIIMS, New Delhi
AMR Specific Bio-Repository	NCMR, NCCS, Pune
ASHD – Indo Japan	inStem, Bangalore
HIV BioBank under CoHRPICA	NARI, Pune
TB Bio-Bank under RePORT India	NIRT, Chennai
National Liver Disease Biobank	ILBS, N.Delhi

Cohort studies supported by the Department in various disease areas are as follows:

### Cohort Studies

Infectious Diseases	<ul style="list-style-type: none"> <li>• Cambridge-Chennai Centre Partnership on Antimicrobial Resistance in Tuberculosis: Focus on Novel Diagnostics and Therapeutics</li> <li>• National HIV Cohort Program (CoHRPICA) DBT-ICMR-IAVI</li> <li>• RePORT India</li> </ul>
Neurological Diseases	<ul style="list-style-type: none"> <li>• Translational Research for Cerebral Stroke Biology</li> <li>• Dementia Science Programme</li> <li>• Joint Cohort study on Adult Health and Brain Aging</li> </ul>
Maternal And Child Health	<ul style="list-style-type: none"> <li>Garbh-Ini Program at THSTI, Faridabad</li> <li>HeLTI/ Early Interventions to Support Trajectories for healthy life in India (EINSTEIN)</li> <li>Pune Rural Intervention in Young Adolescents (PRIYA) program</li> </ul>
Chronic Diseases	<ul style="list-style-type: none"> <li>• Pediatric Renal Biology Program</li> <li>• Indian Chronic Kidney Disease Study, ICKD</li> </ul>
Stem Cell Biology	Accelerating the application of stem cell technology in human disease ASHD – Indo Japan
Population Biology	Kalyani, Cohort

Considering, bio-banking as an essential tool to provide access to high quality human biomaterial for fundamental



and translational research, the Department facilitated the establishment of bio-bank on microbial cultures, antimicrobial resistant pathogens and liver diseases. Similarly, Clinical Trials for various diseases are also being supported by the Department as per the need.

These studies and facilities need to be considered as national assets and there should be provision to support them on long term basis. This will help the Department to leverage these for future R&D projects and programs. Towards this direction, various consultation meetings have been conducted

to prepare a roadmap and national guidelines for long term sustainability of such kinds of studies and biorepositories for future research endeavors.

Further, the department is also extending its support to facilitate and coordinate various activities to harmonize the process, protocol and activities of these existing studies and facilities. Considering the immense potential of these studies and facilities for future R&D endeavors, the Department is willing to extend the support on other gap areas of national concerns with long term handholding.

## KNOWLEDGE GENERATION, DISCOVERY RESEARCH, NEW TOOLS AND TECHNOLOGIES

Knowledge Generation, Discovery Research, New Tools and Technologies focuses on enhancement of scientific productivity by multifaceted interventions. This area encompasses Basic Research in Modern Biology, Nanobiotechnology, Genome Editing Technologies & their Applications and Theoretical and Computational Biology (Bioinformatics, Artificial Intelligence and Big Data etc.) Conceptualization of ideas, their developments and shaping them into the functional leads for applied research is the core strength for knowledge driven biotechnology research and development in the country. Development of newer tools and technologies for faster translation of the leads become a need of time in today's world. Efforts have been made to align nanotechnology, genome editing technologies. DBT is supporting research oriented to find application/translation value of direct benefit to the citizens under the Nanobiotechnology. DBT is focusing on promoting research and innovation in the area of genome editing technologies and their applications in various sectors. This department is also making the efforts to accelerate and transform the life science research, especially the pharmaceutical as well as the Agricultural Sector by extending the continuous support in the field of Computational Biology, Bioinformatics and Artificial Intelligence.

Knowledge Generation, Discovery Research, New Tools and Technologies at a glance	
Ongoing projects supported	517
New projects supported	57
Manpower trained	2704
Research publications	1022
Technologies/ software/ database developed/ transferred/ commercialized	8

### BASIC RESEARCH IN MODERN BIOLOGY

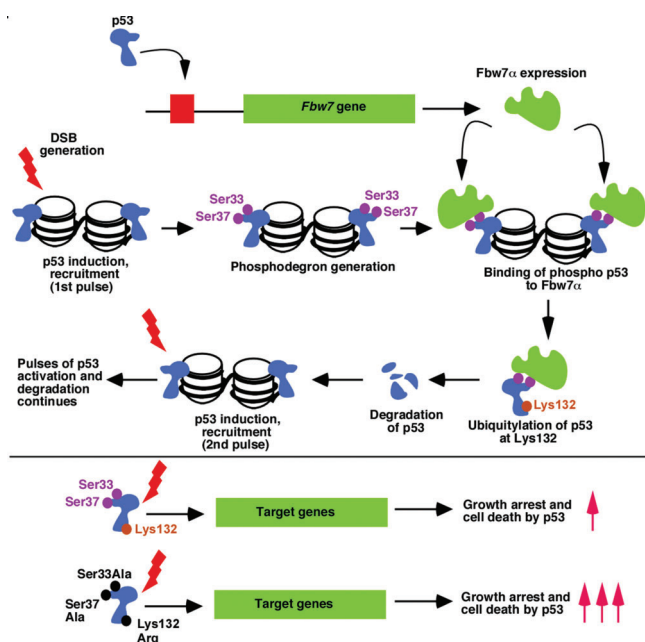
Basic research in Biology is essential for nurturing the expansion of knowledge. The basic research for biotechnology is directed not only towards understanding the

fundamental biotechnological challenges based on fundamental processes & mechanism of cellular biology as well as their application for the benefits of the mankind. Hence, Basic Research is considered as the main strength for driving the economy through technology and innovation. The Department through Basic Research in Modern Biology has been funding basic research in a variety of biological science fields with a goal of generating new knowledge to enhance, transform and translate the new leads. During the period Department has supported more than 140 projects which resulted in of several good publications in high impact journals. In addition, the division has also supported 8 centers of excellence that provide long-term support to outstanding scientists with specific goal to enhance the innovative ability of the institutions and investigators in specific areas of biotechnology. DBT-IISc Partnership Program Phase-II at IISc, Bengaluru has been supported for upgrading the core and other support facilities essential for modern biology research to nurture biology research and human resource training and cater to the needs of researchers from all over the country.

#### Key Technology/Process Developed/Discoveries

- New E3 ligase for tumour suppressor p53 has been identified
- A unique sequence motif in the ligands that interact with PSMD9 a proteasomal assembly chaperones was identified
- Drug-repurposing against main protease of SARS-CoV2 using data analysis techniques and proposed potentially strong candidate drugs
- Developed an automatic computational pipeline referred as NoD (New uses of Old Drugs) to make freely available in World Wide Web.
- Potential COVID-19 vaccine formulations developed jointly with Mynvax Private Limited
- Development of metabolically stable peptides, with low toxicity profile that efficiently kill both Gram-negative and Gram-positive pathogens.
- Indian SARS-CoV-2 viruses are enriched with G and I clades in addition to 50% samples with unknown genetic variations.*

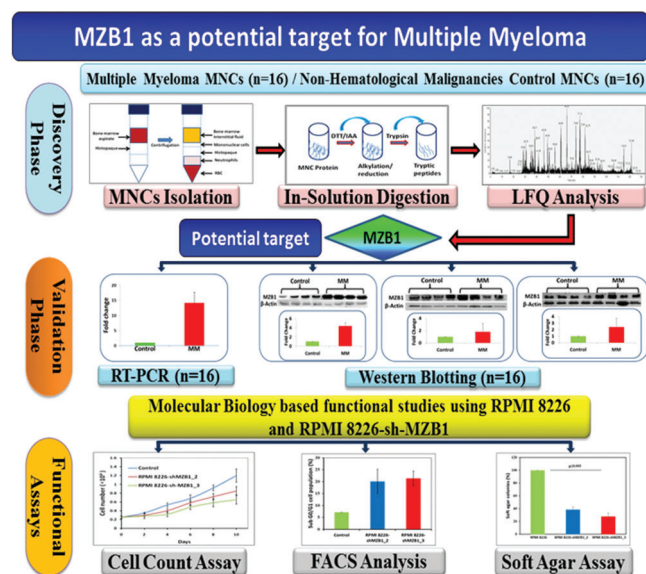
A study was carried out at NII, New Delhi for understanding the mechanism by which a newly identified E3 ligase degrades tumour suppressor p53 during DNA damage. Tumor suppressor p53 trans-activates Fbw7 and if appropriate modifications in p53 are made, it will then not undergo Fbw7a mediated degradation. Hence this so-called “super p53” can become a valuable tool to fight cancer.



Schematic diagram showing the inter-regulation between p53 and Fbw7a. (Top) Fbw7a recognizes the phosphodegron, degrades it thereby allowing subsequent p53 pulses to occur. (Bottom)

A study conducted at NCCS, Pune elucidated the role of HSPA8.1 and DNAJB8 proteins in regulation of HIV-1 replication and infectivity by over expression and silencing studies. It was found that the overexpression of Nup98 prevented both synthesis and release of HIV-1 virions from HEK293T cells.

In another study at NCCS, Pune proteomics data revealed a total of 192 differentially regulated proteins in which 79 proteins were up-regulated and 113 proteins were found to be down-regulated in Multiple Myeloma (MM) mononuclear cells as compared to non-hematological malignant samples. The functional studies revealed that higher expression of MZB1 gene is associated with promoting the progression of MM pathogenesis and could be established as a potential target for MM in the future.



A flowchart depicting experimental design and overall results obtained for Multiple myeloma MNCs proteomics analysis.

A study was conducted at IISc, Bengaluru on elucidating the role of neuropeptides in the locomotory behavior using *Caenorhabditis elegans* as a model system. It was found that loss of Cell surface immunoglobulin super family, RIG-3 gives rise to increased glutamate receptors and a concomitant increase in locomotory reversals made by the animals. This study allows to gain fundamental insight into the workings of small peptides sent out by neurons in the nervous system.

Illustration of the role of Interneurons and Sensory neurons in maintaining reversals in *C. elegans*

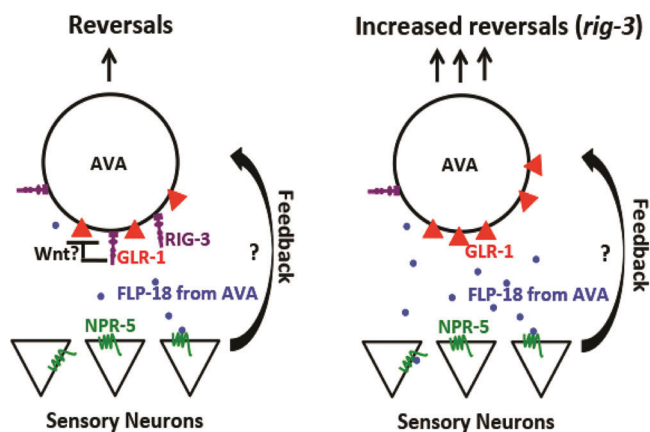
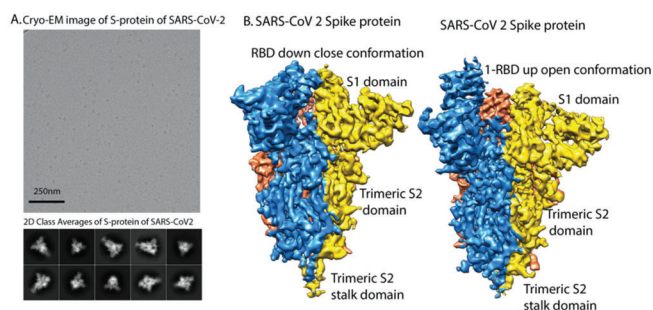


Illustration of the role of interneurons and sensory neurons in maintaining reversals in *C. elegans*

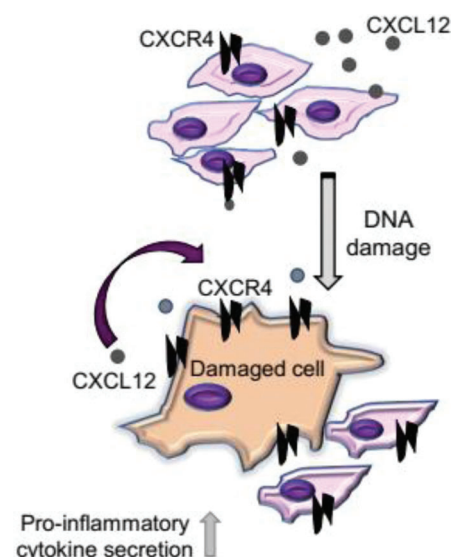


Another study conducted at IISc, Bengaluru have characterized the 3D structures of spike-protein, the major glycoprotein of SARS-CoV-2, responsible for binding with hACE2 receptor. The 3D structures of spike-protein with different inhibitors are calculated using the cryo-EM at cryo-EM facility at IISc (<http://mbu.iisc.ac.in/SDLab.htm/>). This is the first cryo-EM structure of the spike-protein from SARS-CoV-2 from India.



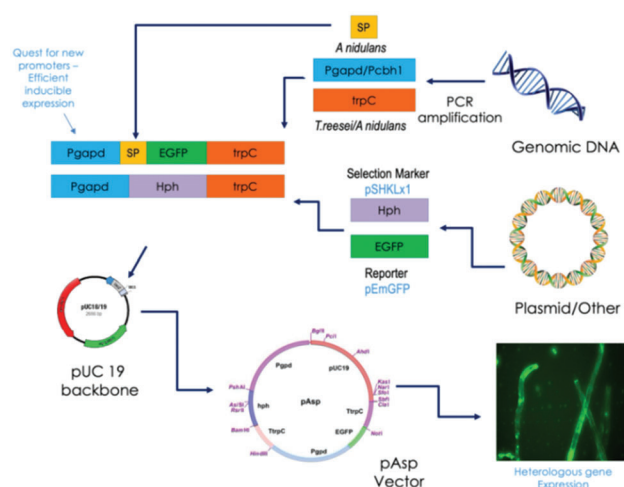
A. Cryo-EM image of S-protein of SARS-CoV-2 and 2D class averages of S-protein. Data is collected at MBU IISc-Bangalore at Advanced Center for Cryo-Electron Microscopy Facility (ACCEM-IISc). B. 3D structures of spike-protein at atomic resolution. Three monomers of S-protein are designated by blue, yellow and salmon colour.

Another study at IISc, Bengaluru focused on characterization of the regulatory role of CXCR4 cytokine receptor in cellular senescence and pro-carcinogenic senescence-associated secretory phenotype. They reported the role of a GPCR in regulating inflammation during aging or anti-cancer therapy. Receptor levels increased in response to DNA damage can be targeted to reduce inflammation and collateral damage during anti-cancer treatment and aging. Blocking the functions of this protein and the associated pathway reduced the inflammation to less harmful levels. This discovery could potentially enable safer and more effective anti-cancer therapy by protecting non-cancerous cells surrounding tumors from lethal inflammation.



Role of a GPCR in regulating inflammation during aging or anti-cancer therapy is reported. Receptor levels increased in response to DNA damage can be targeted to reduce inflammation and collateral damage during anti-cancer treatment and aging.

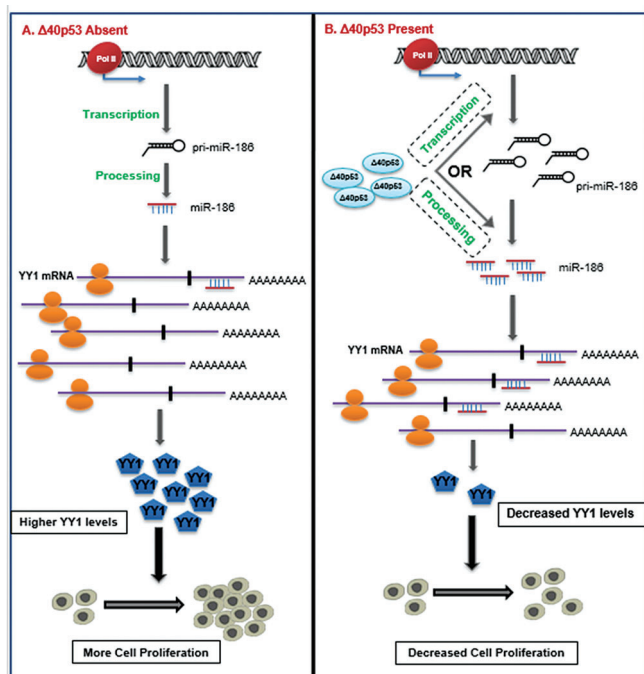
A study on development of a gene expression platform for recombinant protein production in filamentous fungus was conducted at IIIST, Trivandrum using *Aspergillus unguis*, capable of induction using cellulosic substrates. This system can be used for high volume, low value enzymes /proteins which is not economical in other host systems. The implications, though indirect are tremendous and can even decide the fate of economic operation of certain plants like that for biofuels.



Shows the strategy followed for creation of fungal expression vector

A work was carried out at RCB, Faridabad the PI have crystallized LrpB (pilus proteins from *Lactobacillus ruminis*). Understanding the mechanism of pilus assembly and pili-mediated adhesion is critical in targeting pili-mediated interaction for combating infection and promoting health effects.

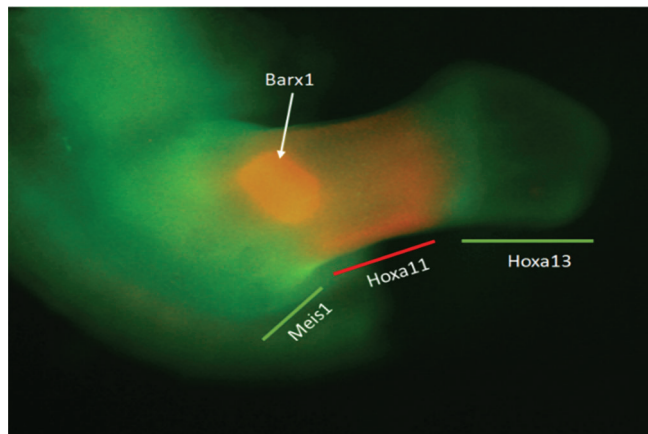
A study was carried out at National Institute of Biomedical Genomics, Kalyani to elucidate the role of p53 translational isoforms and their responsive non-coding RNAs in regulation of cellular gene expression. It was found that "40p53 showed antagonistic regulation of miR-186-5p as compared to either p53 alone or combination of both the isoforms. It was also informed that small and long non-coding RNAs are both regulated by p53 translational isoforms, which has a major impact on cellular gene expression.



Antagonistic regulation of miR-186-5p and "40p53

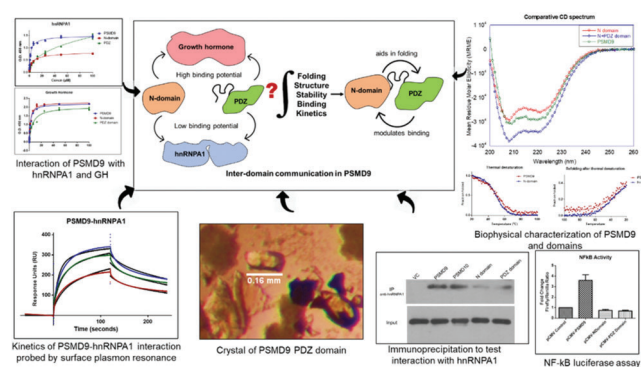
A study at IIT, Kanpur was carried out to investigate the molecular mechanism of cartilage segmentation during early chick embryonic development. It was noted that the relationship between the expression domains of Meis1, Barx1 and Hoxa11 is determined through triple Hybridised Chain Reaction (HCR) RNA in situ hybridization as shown in Fig.. Fundamental understanding of limb skeletal segmentation is a completely uncharted territory and the

knowledge of molecular mechanism of joint site specification and joint formation would enable us to better understand the molecular aetiology of these diseases and develop therapeutics accordingly.



Hybridised Chain Reaction (HCR) RNA in situ hybridisation demonstrating the relative expression domain of Meis1, Hoxa11, Hoxa13 and Barx1 in a day 5.5 chick limb bud.

A study was carried out at ACTREC, Mumbai determined the structure, domain architecture and interactions of PSMD9, an NFKB activator. A model for PSMD9-hnRNPA1 interaction involving protein conformational changes induced binding was proposed. The work identified a unique signature motif dictated by a P-2 Cysteine so far unreported for high affinity interaction with the PSMD9 PDZ domain. This would be used as a template for the design of peptide-based inhibitors for blocking PSMD9 functions such as in (cancer) therapy induced NF-kB activation.



Structural and functional studies of PSMD9, an NFKB activator

## DBT-IISc Partnership Program (Phase II)

The DBT-IISc partnership program has supported the collaborative activities between the faculty of the Division of

Biological Sciences and the faculty from various other science and engineering divisions. These collaborative efforts have resulted in the development of newer drug options for the treatment of tuberculosis which continues to be a major societal problem in the country. The collaborative efforts have also been useful in developing newer devices to monitor life parameters of various animal models useful in carrying out discoveries relating to one health. Besides, the program was able to support various activities to set-up the Covid-19 testing laboratory. The efforts of the colleagues in the program have also been useful in predictions for drug repurposing using various computational biology tools. The program will continue to develop newer technologies relating to the SARS-COV-2 pandemic.

### GENOME EDITING TECHNOLOGIES & THEIR APPLICATIONS

The development of genome editing technologies has opened up the possibility of directly targeting and modifying genomic sequences in almost all eukaryotic cells. Recent advances in developing programmable nucleases, such as Zinc-finger Nucleases (ZFNs), Transcription Activator-like Effector Nucleases (TALENs) and Clustered Regularly Interspaced Short Palindromic Repeat (CRISPR)–Cas-associated nucleases, has greatly expedited the progress of gene editing from concept to practice. With these advancements, genome editing has the potential to positively impact sustainable development, environmental management, and food security and has significant applications in the development of affordable diagnostics and therapeutics for various diseases, apart from furthering the understanding of biological systems. The DBT has been engaged in promoting research and innovation in the area of genome engineering technology and their applications with a vision to foster innovation and promote development of Genome-wide Analysis and Engineering Technologies to make them accessible and affordable for wider use in Life Sciences. Overall, the program is focused on promoting research and innovation in the area of genome editing technologies and their applications in various sectors. During the year, some of the important projects supported are: labelling multiple endogenous actin binding proteins in single neurons by CRISPR/Cas9-mediated targeting, development of diagnostics and experimental therapeutics using CRISPR-based technologies, CRISPR-

Cas13-mediated engineering of endogenous long non-coding RNAs for fluorescent tagging to study RNA dynamics, CRISPR-Cas9-mediated gene editing to generate geminivirus resistant tomato, and repurposing endogenous CRISPR-Cas type-I machinery for efficient markerless genome editing tool in *Leptospira interrogans*. At present, about 80 ongoing projects are being supported and more than 50 research publications have emanated out from the R&D projects supported under the program. 150 JRF/SRF/RA/ Training Fellowships have been supported under various R&D projects of this program. 5 patent applications have been filed.

#### Significant Research Outcomes:

- ❖ *Using CRISPR-Cas-based gene editing system, the Role of Plasminogen Activator Inhibitor Type-1 (PAI-1) in the pathogenesis of tissue fibrosis –the excessive scarring of tissue which compromises its function has been established.*
- ❖ *Using shRNA-mediated gene silencing, phosphatases and kinases playing significant role in lysosome function, Endoplasmic Reticulum stress, protein trafficking and cellular senescence have been identified.*
- ❖ *A method has been developed using CRISPR-Cas for the targeted tracking of oncogenes in living cells through live-cell imaging approaches.*
- ❖ *Genome editing tools have been utilized to unravel the regulatory mechanism for the accumulation and degradation of  $\beta$ -carotene in fruit-pulp of Banana and to modify certain genes to develop pro-vitamin A biofortified Banana varieties.*
- ❖ *CRISPR-based technologies in combination with single-effector nucleases are being utilized for development of diagnostics for viral diseases, such as AIDS and Hepatitis, and experimental therapeutics for genetic and complex diseases*

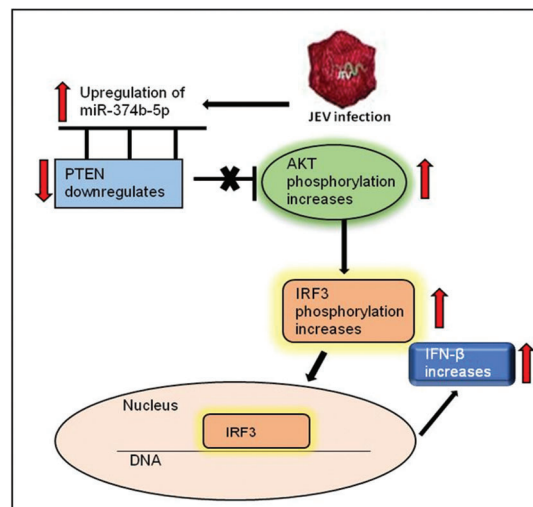
Specific call for proposals was given for facilitating R&D on development of new methods, tools, processes & platforms for genome-wide studies and novel applications & improvement of genome wide technology platforms as well as genome-editing methods. Expert Committees have



recommended about 45 research proposals for financial support which are being processed for sanction and implementation. Some of the salient scientific and technical outcomes from the R&D projects supported under the program during the year are highlighted below:

CRISPR-on-in System for simultaneous differential repression and induction of target genes in vertebrate model organisms has been developed at CCMB, Hyderabad. The aim of this study was establishing a CRISPR-on-in system in ES cell lines and in Mice to induce heterogeneous expression of target genes. To this end, the investigators generated a CRISPR-on-in ES cell line and validated its functioning using sgRNA for Oct4 promoter. The induction and repression of Oct4 in different cells confirmed the working of CRISPR-on-in system in ES cells. Further, the investigators have generated CRISPR-on-in in mice by blastocyst injection of the CRISPR-on-in ES cells and also generated CRISPR-on-in-sgRNAOct4 mice. The validation experiments in the early mice embryos suggested that the CRISPR-on-in system works well in the embryos. Taken together, the results show that the dysregulated expression of Oct4 leads to induction of NANOG in outer trophoblast cells and alters their fate; however, this has no impact on the specification of the inner epiblast cells.

A study supported at BHU, Varanasi, has unraveled the role small non-coding RNAs known as microRNAs in the Japanese Encephalitis Virus (JEV)-mediated neuropathogenesis. The results of this study, indicate that JEV modulates the expression of the microRNA mir-432 leading to the inhibition of the JAK-STAT signaling pathway, which plays critical role in orchestrating of immune system majorly via modulating cytokine signaling, and the miRNA miR-374b-5p to modulate the PI3K/AKT signal transduction pathway in microglial cells. Both these microRNAs have been found to regulate the expression of interferon-related genes which may help in multiple processes relate to viral neuropathogenesis and immune evasion. Besides, the investigators have found several miRNA-mRNA pairs that can potentially function in JEV-mediated neuroinflammation. Taken together, this study provides new insights on the underlying mechanism involved in molecular pathogenesis of JEV and is expected to aid the development of antiviral strategies against JEV.



**MicroRNAs mediated modulation lead to the global change in the expression of immune regulatory genes during Japanese Encephalitis Virus (JEV) pathogenesis.** JEV infection increase the miR-374b-5p and suppress the PTEN expression. PTEN being a negative regulator for PI3K/AKT pathway increases the Interferon (IFN- $\beta$ ) response at the early stages of JEV infection. The elevated interferon response helps in JEV internalization and replication.

In the project on translational genomics of paediatric eye diseases being carried out at AMRF, Madurai, integrated approaches are being studied with clinical, genetic and computational analyses to dissect out the molecular causes of paediatric eye diseases. An indigenous pipeline for the exome sequencing has been established and candidate genes for Leber Congenital Amaurosis (LCA) were identified in 90% of patients using this efficient pipeline. This is a promising result for the patients as some of them with RPE65 mutations are eligible for gene therapy which can potentially lead to recovery of vision. Investigators have also resolved a mysterious case of retinoschisis with mutation in BEST1 but not with RS1 gene for the first time in India. The molecular cause of chemoresistance is deduced in childhood tumor RB, which is now being validated in cell culture models. Besides, a novel mutation in LRPPRC gene was identified in LHON. Through this comprehensive approach, a composite panel of known ocular disease genes along with novel candidates has been developed which will be ready to be used with further validation.

CRISPR-Cas system of genome engineering is the most effective and simple to use method as compared to other known platforms of genome editing. The improvement of CRISPR/Cas9 system with respect to achieving higher editing efficiency is warranted. To address the unmet need of a

functional high-throughput assay, in a DBT-supported ongoing study, a team of investigators from IISER, Bhopal designed a reporter (mGFP)-based system that can be used as a functional determinant of CRISPR-mediated genome editing in live cells. The modified GFP reporter can indicate the editing (as seen by the loss of fluorescence upon editing) as early as at 24 hrs time point. This would facilitate high-throughput screening protocols in a shorter time window.

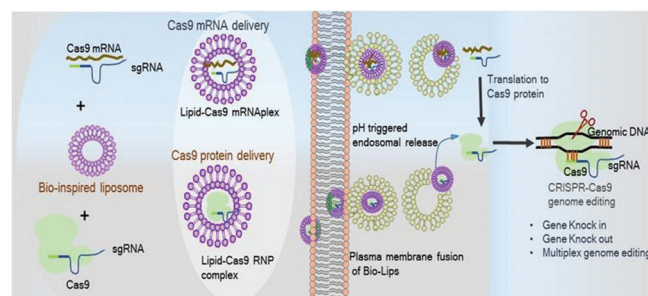
In a study on investigating potential regulatory mechanism involved in AGTR1 mediated breast cancer progression and metastasis carried out at IIT-Kanpur, a novel regulatory mechanism involved in AGTR1 overexpression in Breast Cancer (BCa) and glioblastoma (GBM) has been unravelled. The findings demonstrate that miR-155 post-transcriptionally regulates AGTR1 expression and elicits pleiotropic anticancer effects such as inhibition of angiogenesis in chick chorioallantoic membrane (CAM) assay and significant regression (~ 95%) of tumor burden in xenograft mice model. Besides, the results of the study implicate the tumor-suppressive role of miR-155 in BCa and GBM by downregulating AGTR1 expression leading to abrogation of AGTR1-mediated oncogenic properties, such as cell proliferation, invasion, foci formation and soft agar colony formation, and attenuation of ERK/MAPK signaling, epithelial to mesenchymal transition, stemness and induction of apoptosis.

Plant genome editing with CRISPR/Cas9 to develop herbicide resistant plants for effective weed management is being carried out at ICGER, New Delhi. Investigators have completed screening and identification of genome edited rice plants with selective codon substitution in 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase and acetolactate synthase (ALS) encoding genes. Experiments for segregating out the genome editing tools in the next generation are under progress.

CRISPR/Cas mediated genome editing of genes for high provitamin A accumulation and its stability in banana is being done at NABI, Mohali. Single vector having sgRNAs against each of the three target genes CCD4 (carotenoid cleavage dioxygenase 4), BCH3 ( $\beta$ -ring carotenoid hydroxylase 3), and LCY- $\beta$  (lycopene  $\beta$ -cyclase) has been designed and Agrobacterium mediated genetic transformation of CRISPR/Cas vectors to target these genes has been performed in cv. Grand Naine. Further studies are in progress.

A study on utilizing genome editing tools for nutritional improvement in wheat at NABI, Mohali has been supported. The major aim of the study was nutritional improvement of wheat for enhancing iron content and carotenoids in wheat grains. Multiple gRNAs were designed. The gRNA constructs were validated for targeting multiple genes including genes TaIRO3, TaHYD1, TaHYD2, and TaLCYE. Agrobacterium-mediated Wheat transformation was performed using immature embryos. Final mutant progeny is being analyzed.

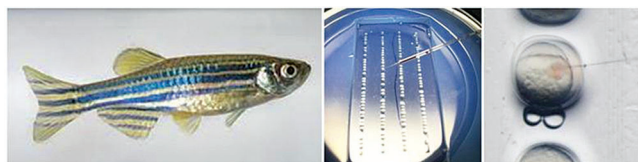
In a study supported at CMC, Vellore, with the aim to develop a highly efficient system for intracellular delivery of genome editing tools for Gene Therapy, a novel bio-inspired lipid nanocarrier system for efficient intracellular delivery of CRISPR-Cas9-based genome editing tools has been developed. The lipid nanocarrier system was found to show significantly higher efficiency in delivering large therapeutic molecules including DNA, mRNA and proteins as compared to the other commercially available reagents. The technology is being validated. The development of bio-inspired lipid nanocarrier delivery system would open new vistas for devising novel gene therapy-based therapeutic solutions for various rare and genetic diseases.



*Mechanism of Bio-liposome mediated CRISPR/Cas9 delivery*

Developing new disease models for screening and evaluating the efficacy of drugs plays a pivotal role in development of novel drugs. In this direction, in a study supported by DBT at LVPEI and CCMB, Hyderabad, retinal degeneration models of zebrafish have been developed using gene editing techniques to understand the basic biology of retinal dystrophy. Mutant models of various retinal dystrophic and blinding conditions such as Leber Congenital Amaurosis (LCA) which affects young children, Retinitis Pigmentosa (RP) which affects young adults and also Retinoblastoma (RB), a form of retinal cancer that affects children below 5 years were developed in this study. Apart from understanding of the

pathobiology, such disease models would also be useful for testing and validating newer drug towards the management and treatment of human disease.



*Zebrafish embryo manipulation and generation of mutant retinal disease models using genome editing tools*

Development of a high throughput genome editing pipeline based on an orthologous CRISPR/Cas9 system (FnCas9) and its application in the generation of 3D organoids for disease modeling and correction is being supported at IGIB and AIIMS, New Delhi. FnCas9 has been cloned, expressed purified and characterized especially with reference to its genome editing efficacy. Towards generating iPSCs and organoid models, subjects for the study have been recruited and iPSCs have been generated from one of them. Organoids will be generated next, along with spheroids to find a model that can capture most of the features of MLC. Additionally, investigators have standardized organoid generation protocols from murine and human stem cells. Clones were established by reprogramming peripheral blood derived mononuclear cells from a healthy donor. Further studies are in progress.

**Indo-US Genome Engineering/ Editing Technologies Initiative (GETin) Program:** The 'Indo-U.S. Genome Engineering/Editing Technologies Initiative (GETin) for Overseas Fellowship has the objectives of providing opportunity to Indian students and scientists to gain exposure and access to world class research facilities in leading US institutions, capacity building in the frontline area of Genome Engineering/Editing Technologies and building long-term R&D linkages and collaborations with US institutions/ researchers. This fellowship also has provision of visiting fellowship for US faculty or foreign post docs presently working in US in a field having an interface with genome engineering / editing technologies. The department has provision to provide support to 5 individuals in each category. This program has successfully completed two years and is currently in the third year of implementation. So far, under the program 10 PhD student Interns, 9 postdoctoral Fellows & 2 visiting Fellows have been selected for being fostered and trained in U.S.

laboratories. They collectively represent 20 different Indian higher education institutions across different Indian cities. For the U.S. side, the program has engaged 22 faculty mentors across different universities & departments. 12 fellows for next batch have been selected. However, training of new fellows could not be started in the year 2020 due to Covid-19 pandemic. It is expected that the new batch will start their training from January 2021.

In the coming year, the Department is planning to invest more in advancing research & fostering innovation, making genome technologies accessible, establishing centre of excellences, human resource development through workshops & specialized training for capacity building in the cutting edge areas of genome engineering technologies and their applications. DBT and BIRAC have jointly started working for devising mechanism to acquire licensing of genome editing technologies and work out mechanism to further sub-license them to the Indian organizations who want to use this technology for Research & Development. Efforts are also being initiated for setting up Centres of Excellences on Genome Editing Technologies or empower existing Centre of Excellences in areas of Health, Agriculture and Bioresources. Besides, development of human resource through specialized training program, workshops and symposia; and creation of virtual knowledge centre to interface research community for interaction and exchange of knowledge are also being planned.

## NANOBIOTECHNOLOGY

Since inception in 2007 the earlier focus was on exploratory type of projects, which is currently shifted to support the projects oriented to found application/translation. Since beginning, department has supported more than 200 projects, many of them came out with important leads specially in the field of drug delivery, therapeutics and drug development. Efforts made in this area also made in the significant achievements with respect to skilled human resource development in this emerging field of science. Considering the potential of nanobiotechnology on the basis of assessment of outcomes of the previously funded research, the programme area is adopting to support the translational research in nanobiotechnology from last few years. The approach of the group is to exploit the nanobiotechnology as enabling technology, relevant for

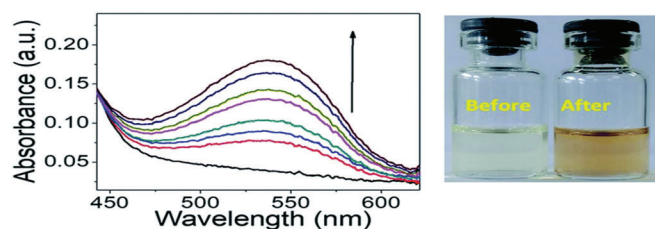


diverse sectors, such as chemicals, consumer products, health, energy, medical, agriculture and other allied disciplines. In recent years, programme division is engaged in supporting the citizen centric initiatives with product development target oriented programmes based on nano-interventions in health and agriculture sector. Some of the key achievements of some of the projects are presented below:

### Development of metabolic activity marker for Cancer diagnostics applications

Scientists from IISER, Bhopal have designed a probe for instantaneous and efficient detection of serum albumin, one of the important transport proteins in the presence of other biologically relevant proteins. The detailed spectroscopic studies revealed that the probe is binding to site-II of BSA and was further supported by the competitive binding and molecular docking studies. This probe can be employed for the detection of abnormal serum albumin levels in the patient's body fluids and as metabolic activity marker for diagnostics applications.

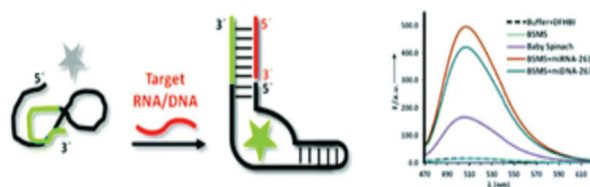
Scientists from NIT Kurukshetra in the project, aimed to develop functionalized self-assembled nanovesicles, for photo induced release of NO, has reported the development of nanoscale vesicles functionalized with a nitric oxide (NO) (Ves-NTA) releasing molecule 4-nitro-3-(trifluoromethyl) aniline, which shows an effective photo-release of NO upon irradiation with blue light at 410 nm. This nanoscale NO donor vesicles (Ves-NTA) has several advantages including smooth preparation in water, capability to release NO in aqueous medium, photo-controlled NO release, bio-compatibility and capability to modulate the NO donor loading to achieve an essential amount of NO.



Griess assay of Ves-NTA (50 iM) with Griess reagent (B) Colour change of Griess reagent in presence of Ves-NTA before and after NO release

### Baby Spinach based Minimal-modified Sensor (BSMS)

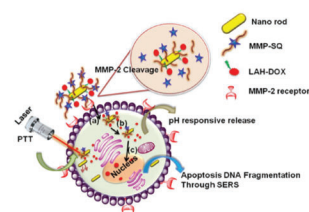
As an outcome of the project supported at IISER, Tirupati and Vision Research Foundation, Sankara Nethralaya, have come up with designing of a sensor for nucleic acid detection using light-up aptamers. This is named as Baby Spinach based Minimal-modified Sensor (BSMS) that can detect both DNA & RNA including miRNA in low nM range. The sensor gives fluorescence output when binds to nucleic acids and is label-free, which means it does not require any chemical labeling. BSMS comprises genetically encodable unmodified RNA and has been shown to function at ambient temperature, and thus is anticipated to provide nucleic acid monitoring in vivo.



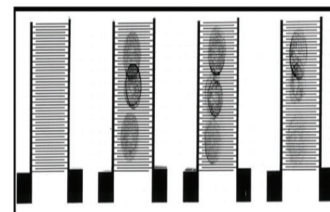
Schematic of Baby Spinach based Minimal-modified Sensor (BSMS)

### Fabrication of multi-modal theranostic nanoprobe:

Scientists from NIIST Thiruvanthapuram in the project supported by this department under nanobiotechnology division, have constructed a targeted theranostic nanoprobe (MMP-SQ@GNR@LAH-DOX) which can spot selectively MMP expressing cancer cells and execute safe photothermal chemotherapy based on photothermal effects of GNRs and site specific action. They have also incorporated the anti-cancer drug Doxorubicin (Dox) for simultaneous chemotherapy. The overall therapeutic effect has been monitored in cellular level by Raman spectral analysis through SERS platform.



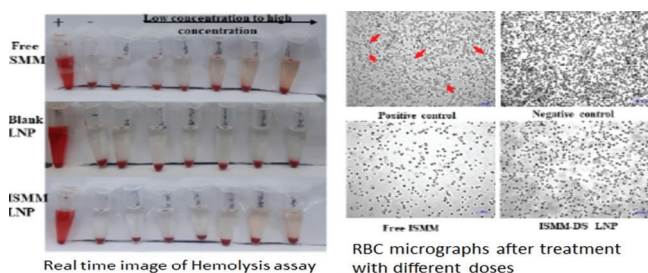
Schematic representation of targeted MMP detection probe for simultaneous imaging and chemophotothermal therapy



Nanofiber dispersion on Au-Ti metal electrodes (example of three deposition). Images of sensor system on the glass slide.

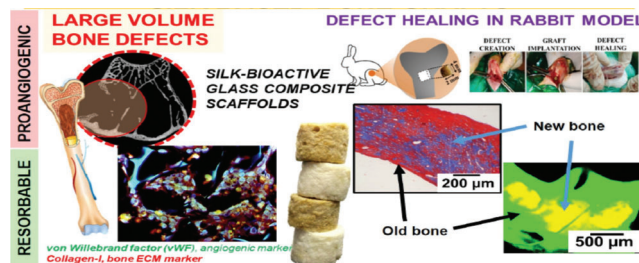
**Development of Dissolved Oxygen Sensor:** Scientists from IIT, Hyderabad has prepared a dissolved oxygen sensor inside a microfluidic channel. This device is purposed to detect change in the dissolved oxygen in aqueous media. The oxygen sensor can be used for 4-5 hours in aqueous medium. Cells can be grown by the side of the ZnO-Co based sensor. This shows the biocompatibility of the electrode and ZnO fiber.

**Prototype formulation of trypanocidal drug-loaded nanoformulations:** To enhance the efficacy and to combat the drug resistance, scientists from NRCC, Bikaner and BITS Pilani has obtained a new lead in development of a platform technology for lab scale prototype formulation of hydrophilic trypanocidal drug-loaded Nano formulations. During In Vitro cytotoxicity studies drug-loaded SLN were compared and found safer than free drug at different concentrations. Technology may have translational potential in providing the nano based solution for effective management of Trypanosomiasis in humans and domestic as well as wild animals.



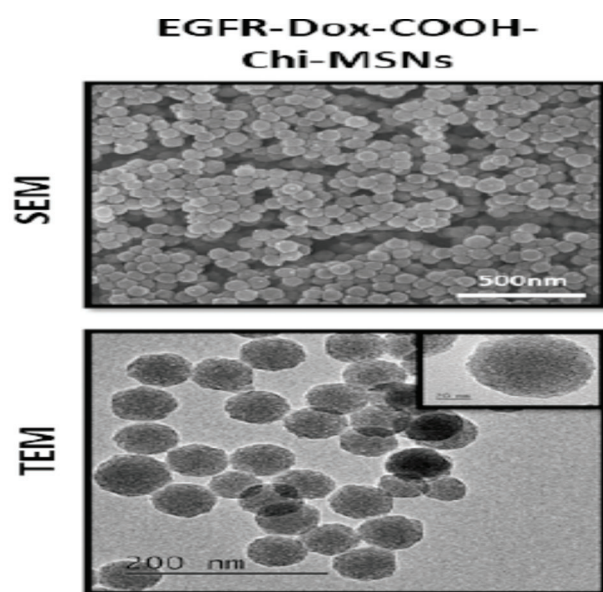
**Development of composite bone grafts:** In the study supported under the nano interventions in orthopedics, scientists from IIT Guwahati and AIIMS, New Delhi has been come out with development of composite bone grafts using silk-bioceramics based composites, which mimics the micro-architecture of bone. Scaffolding matrices used in the study, were derived from mulberry (*Bombyx mori*) and endemic North-east Indian non-mulberry (*Antheraea assama*) silk fibroins.

The bone grafts exhibited compressive strength similar to cancellous bone with good stability under cyclic mechanical studies. These composite matrices significantly promoted neo-osseous (new bone) tissue formation in volumetric femur defect in rabbits with periosteal restoration. The findings have a potential of clinical translation.



Multifunctional silk based composite bone grafts developed to replace large volume bone defects

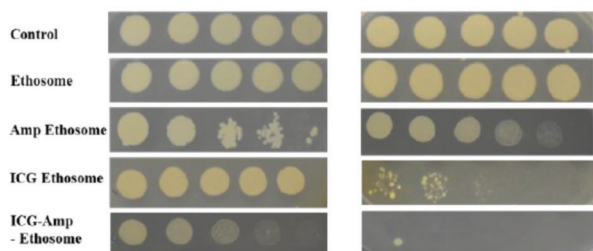
In an attempt to find out solution for resistance against single agent therapy in treatment of HER2 positive cases of breast cancer scientists from IIT Kanpur has come out with development of a nanoformulation based drug delivery system for targeted treatment of Triple negative breast cancer patients. Findings has been patented and published in the official Journal of the patent office. This drug delivery system has commercialization potential, as the developed technology can be licensed in future.



SEM and TEM images of aptamer conjugated Dox loaded MSNs

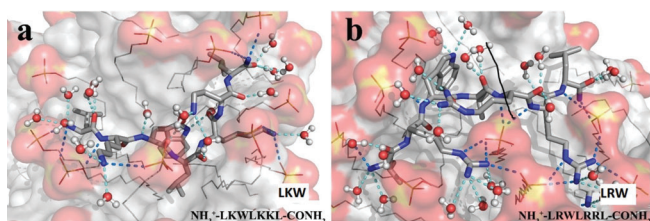
In an effort to enhance the pharmacological effects of herbal medicines, scientists from IIT Hyderabad has developed the innovative application through modified liposomes (Ethosomes) to increase the penetration of the drug by altering the with ethanol. During the process, the vesicles might break up in the superficial layer of cornea, allowing drugs to permeate into the deeper layer alone, thus allowing the phospholipid to be retained in the epithelium.





Spot Assay of *C. albicans* on SDA Plate

Several groups of AMPS have been designed and their mode of action, structure activity relationship have been investigated in details using several experimental (biophysical, spectroscopic, microscopic) techniques as well as MD simulation techniques. These designed AMPS have many common attributes like Broad spectrum antimicrobial properties Salt tolerance, non-cytotoxicity, non-hemolytic activities.



Interaction of LKW and LRW with SDS micelle surface as seen from MD simulations.

### Guidelines for Evaluation of Nano based Agri-input & Food Products in India

Dr. Harsh Vardhan, Hon'ble Minister of Science and Technology, Health and Family Welfare and Earth Sciences and Shri Narendra Singh Tomar, Hon'ble Minister of Agriculture and Farmers Welfare have released the "Guidelines for evaluation of nano-based agri-input and food products in India" prepared by this Department in collaboration with Ministry of Agriculture and Farmers' Welfare and Food Safety and Standards Authority of India. Shri Parshottam Khodabhai Rupala, Hon'ble Minister of State for Agriculture and Farmers Welfare was also present on the occasion.

The innovative nano-interventions in agriculture and food sector could generate low-cost, high-efficacy solutions in terms of products and processes, especially suitable for developing countries. However, the nano-based products (such as any new product) are needed to be evaluated for



## GUIDELINES FOR EVALUATION OF NANO-BASED AGRI-INPUT AND FOOD PRODUCTS IN INDIA



Department of Biotechnology  
Ministry of Science & Technology  
Ministry of Agriculture and  
Farmers Welfare





adverse effects, if any, in humans and for the environment. The activity, efficacy and impact of NMs depend upon interaction of their physico-chemical parameters with diverse environmental factors; hence require a multidisciplinary approach for development of new alternative strategies and methods for their evaluation. The guidelines will be useful to the researchers, industry and regulators. These 'Guidelines' are applicable to nano-agri-input products (NAIPs) and nano-agri products (NAPs). These 'Guidelines' also apply to nano composites and sensors made from NMs and those that require direct contact with crops, food and feed for data acquisitions.

### THEORETICAL AND COMPUTATIONAL BIOLOGY (BIOINFORMATICS, AI AND BIG DATA)

Computational Biology, Bioinformatics and Artificial Intelligence are data driven and algorithm intensive research areas which presents an enormous opportunity to transform the life sciences and especially the pharmaceutical as well as the Agricultural Sector. Recognizing the importance of information technology for pursuing advanced research in modern biology and biotechnology, Bioinformatics is supported by DBT since its inception as one of the thrust areas. The programme has played a pivotal role in establishing the Bioinformatics infrastructure in the country including the 'Supercomputer Facility'. Under the programme, one of the largest Bioinformatics network has been created in the country comprising nearly 150 Universities/ Colleges/ Institutions. The network has nurtured state of art infrastructure, human resource development and Capacity Building in the country for carrying out research and development activities in bioinformatics and computational biology. Several projects have been supported in the thrust areas such as NGS data analysis, structural bioinformatics of proteins and nucleic acid; computational analysis of metabolic pathways; large scale network analysis; computational image analysis; large scale data-mining, analysis, integration, curation and storage.

**Biotechnology Information System Network (BTISNet):** Biotechnology Information System Network, or BTISNet, is the first major S&T network in Biotechnology of India, networking more than 150 Bioinformatics Centres in various Universities and Research Institutions spread across the country. This network has been instrumental

in infrastructure development, capacity building and human resource development in the country. It enabled to establish a link between diverse groups of scientists working in various interdisciplinary areas of Biotechnology. The network encouraged sharing knowledge and more productive interaction amongst the scientific community, irrespective of their respective geographical location in the country. The centres were divided into five major categories viz. Centres of Excellence (CoE), Distributed Information Centres (DICs), Distributed Information Sub Centres (Sub-DICs), Bioinformatics Infrastructure Facility (BIF) and North Eastern State-Bioinformatics Infrastructure Facility (North-Eastern State BIF). According to last 5 five-year data, each year, the Network has been continuously publishing more than 400 research articles, 5 patents/databases and carried out the training of more than 3000 personals including students and scientists. Some of the most cited web servers developed in the network are VirulentPred, PredictBias, Bhageerath, Sanjeevini, ChemGenome 2.0 and CylinPred etc. Other softwares and apps developed in the network are presented in Table-1.

Table 1: Softwares/ Apps/ Databases developed in BTISNet

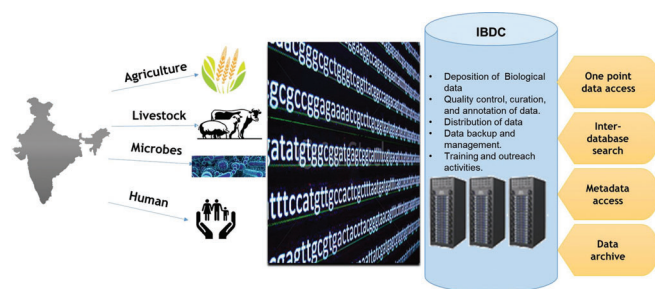
Sr. No.	Software type	No. of software
1	Databases	206
2	Web servers	72
3	Standalones (Databases: 5; Others: 35)	40
4	Apps	7
	<b>Total software developed</b>	<b>325</b>

However, keeping in view of the modern-day technology developments and data intensive projects being supported in the country, during the year, the Department has revamped this BTISNet for establishment of Bioinformatics and Computational Biology Centres involving data driven research, applications of artificial intelligence, machine learning and high-throughput data related informatics etc. in various sectors of life sciences. This revamping of BTISNet is being carried out to engage best of the expertise in development of advanced computational tools and technologies for translational purposes and benefitting the

research society. Currently, 49 new centres are being established in the different domain areas of life-sciences like medical, agriculture, pharma, aquaculture, animal biotechnology and genomics.

#### Indian Biological Data Centre (Pilot Phase):

Department is supporting pilot project for setting up Indian Biological Data Centre to access the modalities and assessing the amount of data generated and developing methodologies, standards, procedures, SoPs, required formats, terms and conditions of data deposition etc. This pilot project will help in establishing Indian Biological Data Centre (IBDC) for deposition, storage, annotation and sharing of biological data generated in the country through extensive funding from various Government Organizations including revamped BTISNet Centres in Hub and Spoke model. It will enable researchers to deposit biological data in IBDC and store all biological data in the country perpetually.

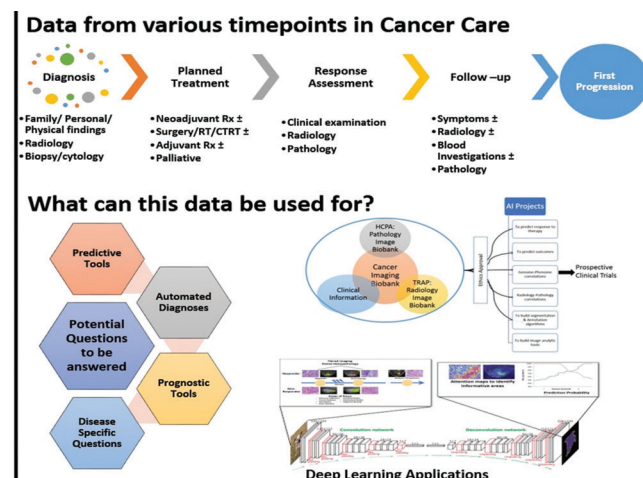


Impact of "Indian Biological Data Centre"

#### Applications of Artificial Intelligence for Affordable and Accessible Healthcare - Big Data and Genomics:

Department is supporting the projects for application of AI in according to the NITI Aayog's Policies of #AIforAll wherein proposals regarding applications of Artificial Intelligence Artificial Intelligence for Affordable and Accessible Healthcare. Some of the key research innovations being supported are in the area of cancer, tuberculosis and pulmonary diseases, diabetic & cardiovascular diseases, ophthalmological diseases, neurological disorders and methods/ drug development in the research institutes and Universities throughout the country for the development of predictive models and diagnostics and assistive devices. A project on Imaging BioBank for Cancer has also been supported with an intent to develop AI tools and database for advance research in cancer and will also be aimed at cancer diagnosis/ prognosis and cancer care . Currently, case/Patient selection

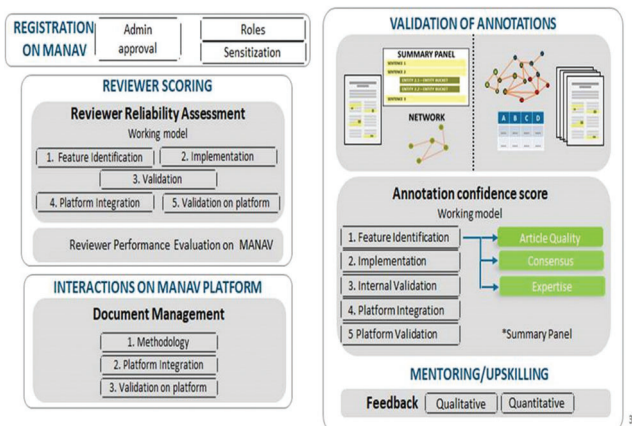
and clinical data curation of >1000 cases of head neck cancer cases have been completed. Pathology slide selection and Radiology Image curation is ongoing.



Imaging BioBank for Cancer

**Manav: A Human Atlas Initiative:** Department has implemented MANAV: Human Atlas Initiative project to construct a comprehensive and integrated human map by assimilating all the known macro-level and micro-level information from scientific literature and public databases. The project has utilized an open source hybrid annotation application (Hypothesis; open source application) and developed over it to add various modules to enable the Manav manual annotation methodology for facilitating biocuration and integrating various algorithms for categorization of the corpus of scientific articles into subject and complexity categories. The Manual Annotation tool along with the categorization algorithms have undergone a beta testing wherein performance of this algorithm was found ~80-85% accurate at various validation methods. The Quality Assurance & Review Systems have been designed to ensure that scientific data of high quality is curated and provided to the user. The team has also developed an end-to-end pipeline for auto annotation and relation building which leads to a query able knowledgebase.

## REVIEWERS/ EXPERT REVIEWERS/ ADVISORY REVIEWERS



Quality Assurance and Review System

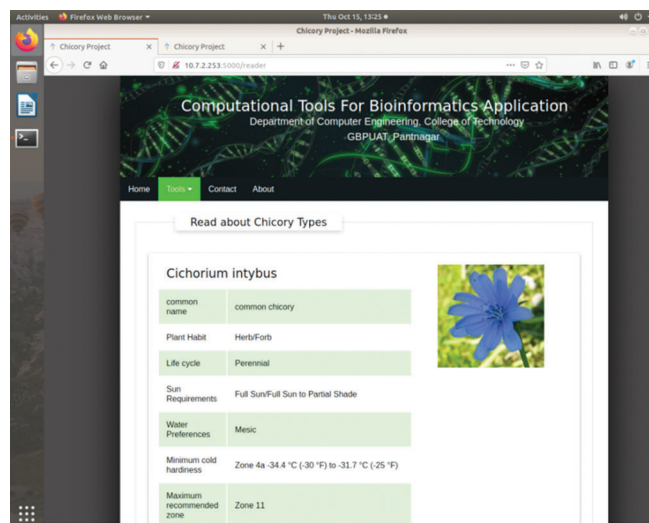
**DBT-AIST International Centre for Translational and Environment Research (DAICENTRE):** DBT and AIST had set up a joint laboratory DBT-AIST International Centre for Translational and Environment Research (DAICENTER) to promote close and effective collaboration. DAICENTER was established at AIST, Japan, Tsukuba Campus with Indian Research Institution as SISTER (Satellite Institutes for Special Training Education and Research) laboratories at RCB, Faridabad, IIT, Delhi, Sikkim University, Sikkim and IIT, Guwahati. The programme is being Coordinated by IIT, Delhi. During the current year AIST (Japan) team has demonstrated that Withanone from Ashwagandha, and CAPE from honeybee propolis possess anti-COVID potential. Experimental analyses also showed that Withanone treated cells exhibit substantial decrease in the expression of TMPRSS2 that is essential for entry of Corona virus to cells. The RCB team has developed a recombinant CHIK virus that produces EGFP upon infecting mammalian cells and identified Withanone as anti-CHIKV compounds. The four teams are collaborating to investigate anti-cancer and anti-Covid 19 potential of several selected natural compounds so as to help in the current pandemic of new corona virus.

**North Western Himalayan Bioinformatics Grid:** A project on North Western Himalayan Bioinformatics Grid is being carried out at GBPUAT, Pantnagar Uttarakhand. During this period following development have been observed in the project:

- The seeds of two hundred different accessions of *Ramdana* (*Amaranthus hypochondricus*) from North

Himalayan region have been collected. The Genomic DNAs were isolated from 100 *Amaranthus* accessions and sequenced and are being analyzed for snp content and their association with phenotypic data of *Amaranthus*.

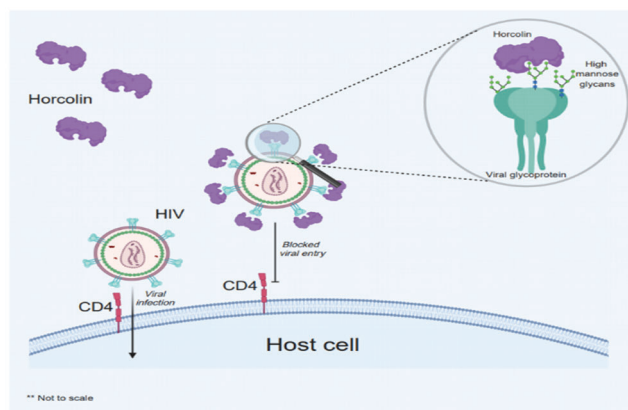
- Badri cattle resources available in nearby hilly regions and about 100 chicory (*Cichorium intybus*) plants collected from different locations of Uttarakhand are also being subjected to GBS analysis.
- A Web Repository of *Cichorium intybus* and *Amaranthus* developed using automated web scrapping technologies which will help in the creation of data bank aggregating heterogeneous information about the plant from a wide number of diverse sources over the internet.



Development of computational tool for finding information of Chicory intybus

**R&D in Bioinformatics:** In a study carried out at IISc, Bengaluru, lectin named horcolin has been found to lack mitogenicity owing to the divergence in the residues at its carbohydrate-binding sites, which makes it a promising candidate for exploration as an anti-HIV agent. Horcolin, in contrast to other lectins, lacks mitogenicity making this lectin's potential as a desirable component of microbicides against HIV.

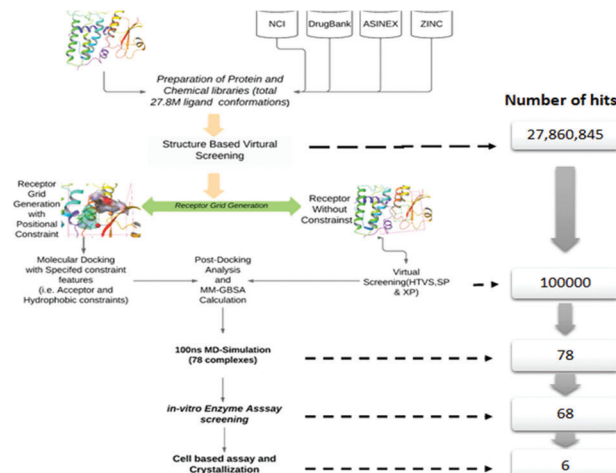




Schematic representation of the role of Horcolin in inhibiting HIV envelop protein and the Host cell interactions

In a project carried out at C-DAC, Pune, GenoVault (cloud-based Genomics Repository) was launched in the Accelerating Biology 2020: SNIps to SPINs, held in Pune. GenoVault shields biological researchers from the complexities associated with large data storage and provides easy access to high-performance computing clusters. Users can upload the sequence data onto the Cloud using Web or JavaFX based interface of GenoVault along with metadata which will be stored in a distributed manner on the cloud. This feature enables swift and efficient retrieval of the data. This centralized repository would be of enormous importance for healthcare and would be of great use in personalized medicine.

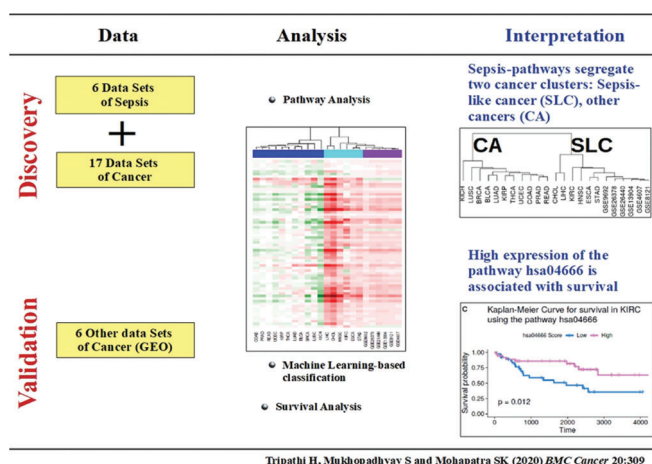
A study at ICgeb, New Delhi, aimed to discover potential inhibitor against soluble Chloride Intracellular Channel (CLIC1) that recycles ascorbate from dehydroascorbate for anti-cancer therapy. They performed systematic structure-based virtual screening of chemical libraries (i.e. NCI, ASINEX, Drug Bank and ZINC) against CLIC1. These screened compounds were validated using enzyme inhibition assays and further in vitro validation using SPR and cell-based assays. They have identified six potential hits from library of 27.8 Million compounds, by *in-silico* virtual screening and *in-vitro* validation.



Schematics of in-silico and in-vitro screening strategy being employed for identification and validation of potent inhibitors against Human Chloride intracellular ion channel-1 (CLIC1).

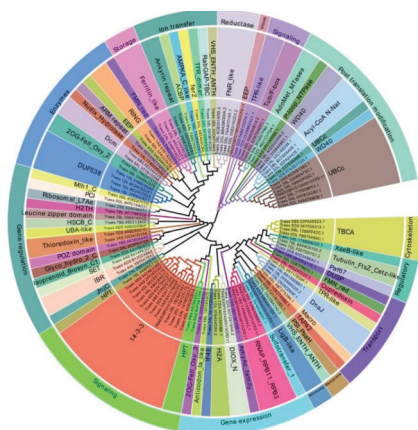
In a study at IISc, Bengaluru researchers have developed a robust computational framework to infer the mechanism of drug action from transcriptomic data. For validation, the analysis was run for a variety of drugs, with appropriate datasets, and the results were compared to available literature regarding the primary and the off-target effects of the drug. The said work will lead to an understanding the mode of action of any drug, drug-candidate, or lead-molecule. This also provides significant insights about the basis for adverse effects of the given drug. Many of these drugs may exert their effect by modulating multiple targets and act as 'polypharmacological agents'. Identifying the targets and inferring the mechanism of action of these compounds therefore becomes a key step in rationalizing their known effects.

A study was carried out at NIBMG, Kalyani regarding unified web-portal for analysis, integration and visualization of multi-omics data. Using a systems biology approach, PIs have identified the pathways that are perturbed in both sepsis and cancer. Clustering of genes separates two groups of tumors. This study helped discovery of an interesting connection between two diseases of high mortality and morbidity. Using systems biology and artificial intelligence, they have shown that there exist a group of cancers that are similar to sepsis, and the patients suffering from these cancers can be identified with high accuracy.



#### Analysis, integration and visualization of multi-omics data

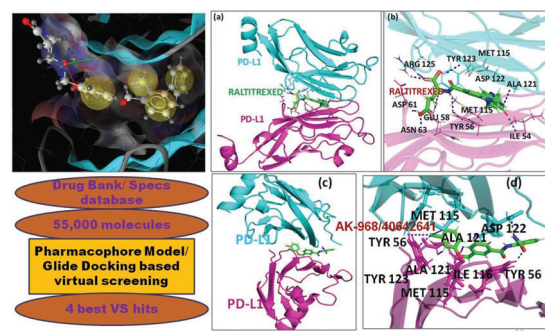
A study was carried out at Babasaheb Bhimrao Ambedkar University, Lucknow aimed to investigate and explore the proteome wide identification metal binding proteins in bread wheat. Out of 602 putative iron-binding proteins, 130 were able to produce reliable structural models by homology techniques and further analyzed for the presence of iron-binding structural motifs. The identified proteins were further classified into their protein folds, families and functional classes ranging from structure maintenance of cellular components, regulation of gene expression, post translational modification, membrane proteins, enzymes, signaling and storage proteins. This comprehensive report regarding structural iron binding proteome provides useful insights into the diversity of iron binding proteins of wheat plants and further utilized to study their roles in plant growth, development and physiology.



Functional classification of the core set iron-binding proteins in the bread wheat proteome. Sequences of the proteins with iron ion binding structural motifs were clustered using maximum

A study at THSTI, Faridabad, Haryana was aimed to develop an integrated proteomics big-data framework to implement multiple search algorithms with quantitation and alleviate the time considerations of using database search and quantitative tools separately. It was informed that during the period, QuantWiz<sup>Q</sup> and Pluggable score were developed. QuantWiz<sup>Q</sup> is a tool for isobaric tag quantitation of the mass spectrometer data. It measures the quantity of peptides and thus proteins by utilizing the information of iTRAQ or TMT labelled peptides. For validation of the implemented scoring systems, the score calculated by in-house module was compared with the open source tool that was implemented. The results show excellent correlation thus validating the tool. The development of such a tool persuades the researchers to use the platform and perform time efficient large proteomics data analysis without the need of assigning extra work force. For a more individual perspective, a user-friendly and over-all framework automated tool reduces the probability of human error making the output more reliable.

A study carried at Amrita Institute of Medical Sciences and Research Centre, Kochi aimed to develop a structure-based 3D pharmacophore model for PD-L1 protein and subsequently virtual screening (VS) of commercial small molecule databases to identify potential PD-L1 inhibitors. There *in silico* and *in vitro* study has the potential industrial significance towards drug discovery program for the treatment of cancer and sepsis disease. *In silico* strategy adopted to identify the new chemical entity from different small molecule databases has significant practical contributions and in combination with the *in vitro* experimental protocols can eventually discover new leads for *in vitro* testing and further clinical trials towards these diseases. The developed inhibitors if effective will help to reduce the mortality rate of patients suffering from sepsis.



a) 3D Pharmacophore model at the PD-L1 active sites; b.) Mode of binding of best hit Ralitrexed and AK Specs molecule at the PD-L1 active sites.

**DBT Electronic Library Consortium (DeLCON):** The DBT Electronic Library Consortium (DeLCON)' is a major initiative of the Department of Biotechnology (DBT) Govt of India to provide unlimited access to most of the relevant periodicals to the researchers at participating institutions. It is a national initiative for providing access to scholarly electronic resources including full-text and bibliographic databases in all the life sciences disciplines to the DBT institutions. It facilitates the

access to high quality e-resources to the faculties, scientists, research scholars and students in the country to improve teaching, learning and research. DeLCON consortium has 35 members at present and provides access to 1000+ online e-journals. These include well known publishers such as Elsevier, Wiley, Springer, Oxford University Press, etc. as well as archival access to more than 1176 core peer-reviewed journals.



## BIOTECHNOLOGY SCIENCE CLUSTERS

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

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

### NCR Biotech Science Cluster, Faridabad :

NCR Biotech Science Cluster was established with a mandate to create a synergistic ecosystem for accelerating discoveries and facilitating translational research and to provide, in terms of infrastructure, state-of-the-art technology such as advanced technology platform center, animal facilities and bio safety containment laboratories as shared resources between the partnering institutions so as to enhance the collaboration and coordination amongst them in seamless manner and make them ready to play a larger and much important role of partnering on national programmes and missions. The partnering institutions at this cluster are: Translational Health Science Institute, Faridabad; Regional Center for Biotechnology, Faridabad; National Institute of Immunology, New Delhi, National Institute of Plant Genome Research, New Delhi, and National Brain Research Center, Manesar.

The state of- art facility established here are namely the Advanced Technology Platform Centre (ATPC), Containment laboratories, Small and large animal facilities, Bioincubator and a BSL-3 facility. The Cluster is regularly organizing

workshops and training courses on available technology platforms and these trainings are open to researchers across the country. So far, 20 companies have been incubated at the Bio-incubator.

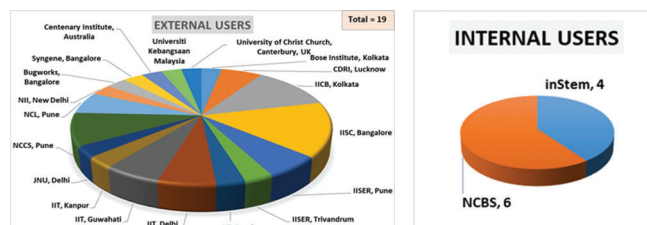
The Small Animal Facility at NCR Cluster measures 4939.69 sq. m and is spread over four floors. Currently, it houses about 5500 mice and a relatively small number (less than 100) of rats. These includes immunodeficient and transgenic strains which may serve as suitable animal models for auto-immune diseases, infectious diseases, cancer biology, gut inflammation, cardiovascular and metabolic disorders, muscle development and disorders and hemolytic diseases.

A Biorepository has been established at this Cluster that presently has over 8.5 lakh different samples. The Biorepository is an essential resource for the Cluster institutions for their research, but is also linking to companies, other commercial laboratories, the Foundation for Innovative New Diagnostics to serve as a resource to fulfill public health research needs and product development.

### Bangalore Life Science Cluster, Bengaluru:

The Bangalore Life Sciences Cluster aimed at building the necessary infrastructure, and human resources to enable research and innovation activities across life sciences and biotechnology domains with emphasis on Structural Biology and Bioinformatics tools. The partnering Institutions are: Institute for Stem Cell Science and Regenerative Medicine (inStem) Bangalore; National Centre for Biological Sciences (NCBS), Bangalore and Centre for Cellular and Molecular Platforms (C-CAMP), Bangalore

The major infrastructure created, is that of the National Electron-Cryo Microscopy Facility. So far there has been a total of 33 users, both internal and external users. Around 15 users (projects) have collected full data sets (both single particle and tomography); 13 completed screening.



Users of the National Cryo-EM Facility at Bangalore Biocluster

One of the recent findings using cryo-EM facility has been a biochemical characterization and structure determination of a bacterial enzyme that breaks down Dimethyl Formamide (DMF) an industrial solvent used in many chemical industries including biopharma. The work opens up the possibility of exploring ways by which the enzyme can be developed as a bioremediation tool to clean up DMF from the environment. The structure determination of this protein took around 10 days from the time of cloning and with only a day of data collection.

Altogether, a comprehensive resource to clone, express, purify proteins and complexes, sample preparation for microscopy, data collection on the microscope as well as computing resources for analysis of initial data have been established. In addition, inStem also has separate space set ups with workbenches for use by visiting scientists (students, post-doctoral fellows and faculty) to carry out the experiments. There is also space set aside for visiting faculty offices and a common computing room with computers connected with high-speed networks to the central storage and computing systems.

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

In the Systems Medicine approach, instead of focusing on each disease individually, the aim is to account for the complex gene-environment, socio-economic interactions and co-morbidities that lead to individual-specific complex phenotypes. The infrastructure required for the varied nature of biological experimentation, high-throughput data generation, big data analyses, validation in cellular and animal model systems, interrogation of validated pathways by chemical and other means, testing efficacy in the human, understanding adverse events, etc., are the most important reasons for formation of an institutional cluster to bring together a pool of researchers with diverse expertise and with a keen interest to make Systems Medicine a reality, and finally to expand the pool to sustain and accelerate the

realization of systems medicine. Kalyani Cluster was thus established with following partnering institutions: National Institute of Biomedical Genomics (NIBMG), Kalyani; Tata Memorial Center (TMC), Kolkata; Indian Institute of Chemical Biology (CSIR-IICB); Bose Institute, Kolkata; Indian Statistical Institute (ISI), Kolkata; and Indian Institute of Science Education & Research (IISER), Kolkata.

The Cluster is focusing on research on oral and cervical cancers that involves epidemiology — general and clinical genomics, transcriptomics, epigenomics at the whole human genome level, immunology and proteomics, structural and molecular biology (BI), animal studies, microbiome, statistical and computational modelling and algorithm development, database creation and management.

One of findings relate to a medical diagnostic application where a gene panel for identifying susceptibility of an individual to oral cancer and to predict the clinical progression of an oral cancer patient has been developed at this Cluster and will shortly be tested.

The research findings of this Cluster have been published in international journals of high impact in about 20 scientific papers. In addition, about 200 people have been trained at various levels in aspects of epidemiology, biotechnology, and project-management.

### Pune Bio-Cluster:

The Biotech science cluster at Pune has been conceived as a hub for interactions amongst scientists of Pune and nearby locations. Two critical components of a successful biocluster are leadership and high-end expertise. Thus, the two leading institutes at Pune, namely: National Center for Cell Science (NCCS) and Indian Institute of Science & Engineering Research (IISER) have collaborated to develop shared facilities and expertise. The focus of this cluster is on molecular and cellular imaging extending to whole animal disease models and establishment of a proteomics facility to investigate molecular correlates of human diseases.



**04**

**PROMOTING  
ENTREPRENEURSHIP  
AND INDUSTRIAL  
GROWTH**



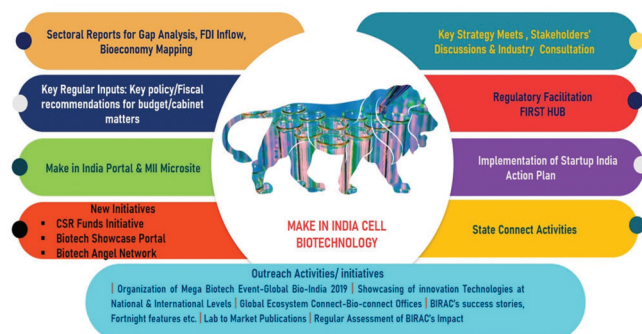
## PROMOTING ENTREPRENEURSHIP AND INDUSTRIAL GROWTH

The DBT along with BIRAC is playing a crucial role in implementation and delivery of the flagship programs of the Government of India, such as 'Make-in-India' and 'Startup India'. DBT recognizes the necessity for entrepreneurship development among the youth in the country and hence has taken initiatives to build, support and promote Indian biotech ecosystem in healthcare, agriculture, and industrial biotechnology. DBT also intends to build a strong eco-system for nurturing innovation and startups in the country that will drive towards sustainable economic growth and generate large-scale employment opportunities. The Government through these initiative aims to empower startups to grow and flourish through innovation and design. The Department has also established Biotechnology Parks/Incubators across the country to translate research into products and services by providing necessary infrastructure support. These Biotechnology Parks offer facilities to scientists, and Small and Medium sized Enterprises (SMEs) for technology incubation, technology demonstration and pilot plant studies for accelerated commercial development of biotechnology.

### MAKE-IN-INDIA PROGRAM IN BIOTECHNOLOGY

DBT is spearheading Make in India (MII) program in biotechnology sector through facilitation cell created at BIRAC. This is one of the flagship programs of Government of India through which multiple initiatives for supporting the Biotech innovation ecosystem, developing the manufacturing sector and promoting, foreign direct investments have been started. The Make-in-India Cell ensures wider dissemination of the Government programs and other information relevant to the establishment and growth of startups, SMEs and companies in the country.

The Cell guides the investors, startups and entrepreneurs onto the gamut of business-related issues in biotechnology such as regulatory landscape in the country, entry options and procedures, investment opportunities and routes, FDI/ EXIM/ Industrial policies.



Activities Snapshot of Make in India Facilitation Cell at BIRAC

### Major activities of Make in India Cell in 2020-21

#### ➤ Strategy Meets & Stakeholders' Discussion

- I. **COVID Impact on Startups' Sustenance: Risk Mitigation Stakeholder's Discussion Meeting:** To discuss current challenges faced by Startups & remedial measures to support Startup survival through this difficult time. Startup ecosystem stakeholders including Mentors, Experts, Angel Investors, Venture Funds, Incubators representatives, MD, BIRAC and Make in India, BIRAC officials participated in deliberations and shared their opinion on the subject matter.
- II. **Stakeholders Meet for Establishing Technology Clusters:** To discuss the implementation strategy for establishing Technology Clusters in the country. The meeting was chaired by Dr. Renu Swarup, Secretary DBT and Chairperson BIRAC.

#### ➤ Webinars on COVID Solutions

- I. **Start-up Ecosystem: Navigating through COVID-19 crisis on 28<sup>th</sup> May 2020:**

The webinar was conducted with Start-ups, Investors, Incubators, Mentors, Industry, Policy makers as the target audience. Speakers from Indian Angel Network, Social Alpha, Ainvent Capital, Endiya Partners and Kotak Group discussed to re-strategize our current strategies for sustaining start-ups through next 6-12 months and the measures to manage budgets in reduced fund in-flows current times.

## II. New Trends in Investment for Healthcare Startups: Investors' Perspectives on 29<sup>th</sup> May, 2020:

The discussion topic of the webinar was what COVID-19 has changed, what would be the new normal and how to generate funding for COVID and Non- COVID solutions.

### ➤ Regulatory Facilitation to Startups/ Entrepreneurs & SMEs

#### I. FIRST (Facilitation of Innovation & Regulation for Start-ups and Innovators) Hub:

**FIRST Hub Webinar on COVID-19** was conducted for queries seeking regulatory guidance for the development of COVID-19 solutions. About 350 Startups registered to seek Regulatory guidance for development of COVID solutions from CDSCO, ICMR, BIS, NIB, DBT, BIRAC and eGEM. **Special Session of FIRST HUB for COVID-19 Solution Weekly:** BIRAC is conducting special dedicated sessions of FIRST HUB every Friday of the week since 3<sup>rd</sup> April only for COVID-19 solutions and has handled 100 +queries of the innovators, Start-ups.



#### II. The Regulatory Information and Facilitation Centre (RIFC):

RIFC is a joint initiative of Venture Centre and BIRAC under the BIRAC Regional Bio-Innovation Centre (BRBC) program. The RIFC aims to assist bio-entrepreneurs in

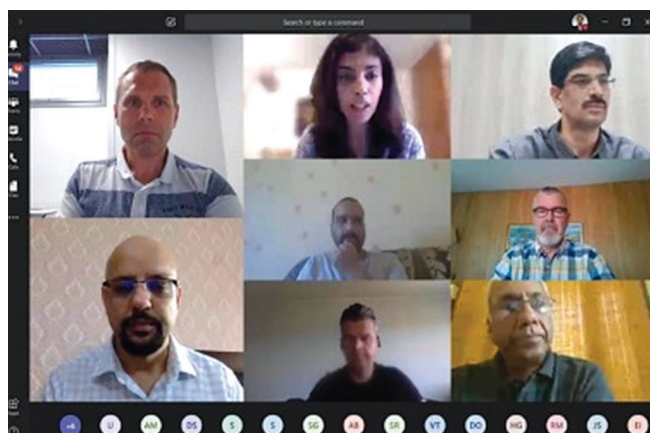


planning, seeking and securing regulatory approvals by providing information in an entrepreneur-friendly manner, providing access to experts and regulators, providing access to practical insights from other entrepreneurs, providing services and organizing relevant and useful events.

### ➤ Outreach Events: Showcasing at International Platforms

#### I. Webinar on Advancing Collaboration Across India - Finland -Estonia:

The international webinar was organized by MII Cell of BIRAC along with Embassy of India in Finland and Estonia in partnership with Invest India. The webinar was organized to showcase Indian, Finnish & Estonian Biotech Ecosystem strengths for introducing opportunities of Biotech collaboration.



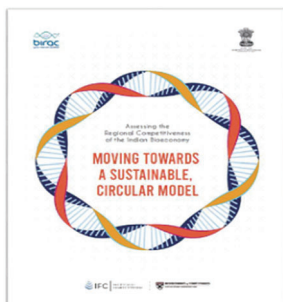
**II. Latitude 59 Estonia - August 2020:** BIRAC along with its 05 supported Startups virtually participated in Latitude59. BIRAC's delegation to the event was represented by Dr. Bhuvnesh Shrivastava, Manager Make in India Cell.

### ➤ Sectoral Reports/Publications

I. Release of Two Sectoral Reports in March 2020:

a. Assessing the Regional Competitiveness of the Indian Bioeconomy: Moving Towards a Sustainable, Circular Model -

2019-20 by Institute for Competitiveness (IFC). The report analyses the competitiveness of the overall Indian bioeconomy position among its peers the performance, policy drivers and core growth drivers with special emphasis on its regional bio-clusters.



#### b. India BioEconomy Report 2020

by Association of Biotechnology-Led Enterprises (ABLE). The report is an effort to map India's BioEconomy and monitor the extent to which policies adapt to growth, resilience and sustainability needs.



#### c. Release of Report on 'Biotech Investment Potential for Indian States' by Institute for Competitiveness (IFC) is in progress.

### II. Release of Make-in-India Flyer at BIRAC's 8th Foundation Day on 20th March 2020



III. **BIRAC Compendium: DBT-BIRAC Supported Products & Technologies:** On National Technology Day (11th May), BIRAC launched COVID-19: DBT-BIRAC Supported Products & Technologies Compendium showcasing Products in Market, Products to be in Market in 3-6 Months & COVID-19 Research pipeline additional facilitations.



### New initiatives of Make in India Cell in 2020-21:

**Setting up of Project Development Cell (PDC):** As per the Cabinet decision of setting up of Project Development Cell (PDC), Department of Biotechnology has delegated the responsibility to Make-in-India Cell for handling the activities of Project Development Cell for Biotechnology Sector. PDC is being set up for the development of investible projects with coordination between the State Govt and Central Govt. to grow the pipeline of investible projects in India and to attract domestic & FDI inflows.



## STARTUP INDIA INITIATIVE

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

### Major Activities under Startup India Initiative:

- **Startups supported:** Supported 1000+ Startups, Entrepreneurs & SMEs creating Intellectual wealth (210+ IP filed) and a robust pipeline of 130+ commercialized products and technologies across the country.
- **Bio-Incubators:** 50 Bio incubators have been set up across India creating a total incubation space of 5,48,719 sq. ft. for budding entrepreneurs. More than 650 incubates have been supported through the scheme so far. Six BioNEST clusters have also been recognized to promote networking & resource sharing among BioNEST incubators.
- **Equity Funding:** Fund of Fund – Biotechnology Innovation Fund AcE (Accelerating Enterprises) is mandated to encourage private equity mobilization for Biotech Startups through co-investing in SEBI registered AIF. The assistance to a start-up will be up to INR upto 7 crores against equity. SEED, LEAP and AcE Fund of Funds schemes are operational to provide equity-based capital assistance to start-ups and act as a bridge between promoters' investment and venture/angel investors.
- **Biotech Clusters:** Biotech Clusters has the core emphasis on innovation is critical for the growth of biotechnology entrepreneurship. DBT has supported 4 Bio-clusters (NCR, Kalyani, Bangalore and Pune) till date.
- **Regional Centers:** BIRAC has created 4 Regional Centers (BRIC, BREC, BRBC, BRTC-E&NE) has extended arms to implement BIRAC's mandate in the country.
  - (i) BRIC at IKP Hyderabad
  - (ii) BREC at C-CAMP Bengaluru
  - (iii) BRBC at Venture Centre Pune
  - (iv) BRTC at KIIT-TBI Bhubaneshwar
- **Bio-Connect offices:** Five bio-connect offices have been established
  - (i) CCAMP, Bengaluru with California Institute for Quantitative Biosciences (QB3)
  - (ii) CCAMP- Sister Innovation HUB with Roslin Innovation Centre, University of Edinburgh, UK
  - (iii) CEIIC BioNEST with European Union
  - (iv) KIIT BioNEST – with TECHNOPORT SA – BELVAL Business Incubator, Luxembourg
  - (v) KIIT BioNEST – with Start-Life Centre, Wageningen University Netherland
- **Technology Transfer Offices:** Technology Transfer Offices (TTOs) were established to enhance academia-industry inter-linkages, strengthen biocluster ecosystem and provide increased opportunities for academia to translate knowledge into products and technologies. 05 TTOs have been established till date.
  - (i) FITT, Delhi
  - (ii) C-CAMP, Bengaluru
  - (iii) IKP Knowledge Park, Hyderabad
  - (iv) KIIT-TBI, Bhubaneshwar
  - (v) EDC, Pune

## BIODESIGN PROGRAMME

Biodesign is a highly interdisciplinary programme, initiated by the Department to foster collaborative R&D activities between medical and engineering institutions which were earlier working in isolation. It also focuses on entrepreneurship development by promoting MedTech Innovators to launch a start-up company.

**School of International Biodesign (SiB):** School of International Biodesign (SiB) is a flagship program of DBT implemented in collaboration with AIIMS, IIT Delhi and international partners in Australia and Japan, since 2015. SiB is built on the success of Stanford India Biodesign program. The focus is on innovation and early stage development of affordable and accessible medical device technologies. This is facilitated through Fellowship programme, which is a year-long, international, interdisciplinary, team-based, experiential hands-on training programme. In 2020, two teams of SiB Fellows started to work on projects to address the underlying Covid situation. The projects entitled “Indigenous Production of Novel Personal Protective Equipment for Healthcare Personnel” and “A non-invasive ventilation device for patients with chronic obstructive pulmonary disease” were selected under the DBT-BIRAC COVID-19 Research Consortium Call.



*Technologies developed under School of International Biodesign Program*

**Healthcare Technology Innovation Centre (HTIC):** IITM’s Healthcare Technology Innovation Centre (HTIC) is currently a leading med-tech centre in the country and seen widely as a model to be emulated in other IITs. With its unconventional approach of bringing together 30+ medical institutions, industry partners and government agencies, since its inception in 2012, it has successfully, translated 5 technologies into 6 commercial products, with 2 products in global market, 5 patents granted and 20+ pending filings, 160 globally leading conference and journal publications, raised Rs. 120 crores of public and private funding. It has executed over 35 projects, including 6 international projects in collaboration with leading institutions from 5 countries, incubated 30 med-tech start-ups, graduated 22 PhDs and MS scholars, and trained 100+ interns. Today HTIC has a vibrant core team of 80+ research and engineering staff, 30 PhD and MS scholars, and 7 IITM faculties.

## Major Initiatives:

- Launch of Post-discharge monitoring of high-risk new-borns post discharge from NICU, which is a major challenge today for mothers, new-borns, families, hospitals and health system. The public health project is supported by Cognizant Foundation. The 3-yr project will be an end-to-end intervention involving tertiary hospital, mother, new-born, local PHC through the wireless fever monitoring device and connectivity platform. The pilot project will cater to 10,000 babies spread across 9 districts, discharged from 4 leading tertiary public institutions, 1 private institution, and will involve around 5000 Village Health Nurses at the local level.
- Completed technology development of image guided robotic spine surgery system; Beginning cadaver studies in collaboration with Madras Medical College.
- Completed product development of indigenous bronchoscope in collaboration with industry partner Mitra Medical; Commercial manufacturing is underway.
- Successful commercialization of “Oxy-2”, a clinically accurate remote patient monitoring device. It is miniaturized multi-parameter patient monitoring system that measures the basic vital parameters like, SpO<sub>2</sub>, Pulse Rate, Temperature and Respiratory Rate, along with Perfusion Index and Plethysmograph with

## Medical grade Wireless Multi-Parameter Monitor with Remote monitoring Capability

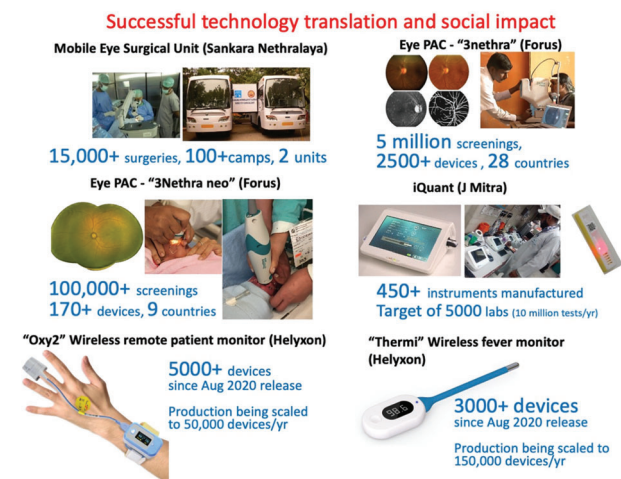


clinical accuracy. “Oxy-2” for COVID has been highly successful and has reached over 5000 installations in less than 2 months and is scaling rapidly. The device is completely self-contained, portable, wireless and an easily be clipped to patient’s finger.

- HTIC’s Mobile Eye Surgical Unit, MESU™, a first-of-its kind technology in India that focuses on the unaddressed need for cataract surgeries in rural India. It is an innovative engineering solution in the form of a stable, self-sufficient and mobile platform that provides a controlled and sterile environment for performing high quality cataract surgery even in rural locations with no basic amenities. The successful clinical pilot of MESU in rural Tamil Nadu with no post-operative complications led to GoI approval from Ministry of Health and Family Welfare to use this technology as a delivery model for cataract surgeries. Till date, the two units of MESU has conducted around 15,000 surgeries in over 100 rural locations and is continuing operations in states of Tamil Nadu, Andhra Pradesh, Karnataka, and Jharkhand.
- HTIC developed an ophthalmic image computing technology, Eye PAC™, which is creating global impact and has reached 2500+ installations in 28 countries so far with around 5 million eye examinations. The technology powers a revolutionary med-tech product, “3nethra” by Forus Health. Eye PAC platform powers 3nethra to achieve its goal of eye screening without dilatation, thereby reducing the cost and crucial skill barrier required previously. This technology is powering a new product for new-born eye screening, “3nethra neo”, which has been recently introduced into the market and has reached 170+ installations in nine countries so far with over 100,000 eye examinations for new-borns. This is the first indigenous technology that is available in market for screening retinopathy of critical premature new-borns.
- In collaboration with J Mitra, a leading domestic diagnostics company in the country, HTIC has developed the country’s first indigenous point of care technology and product for quantitative immunodiagnosics. The product addresses the unmet market needs and requirement of small to medium labs in the community

for affordable test kits for non-communicable diseases such as HbA1C (diabetes), Vitamin D, B12, CRP (infection, cardiac), etc. The product has completed pilot manufacturing of 450 instruments and has a target to reach 5,000 labs in the country.

- Thermi, a wireless fever monitoring device developed by HTIC, IIT Madras and Helyxon (a start-up company), during COVID outbreak has an outreach of more than 3000 device users since August 2020 and production being scaled up to 150,000 devices per year.

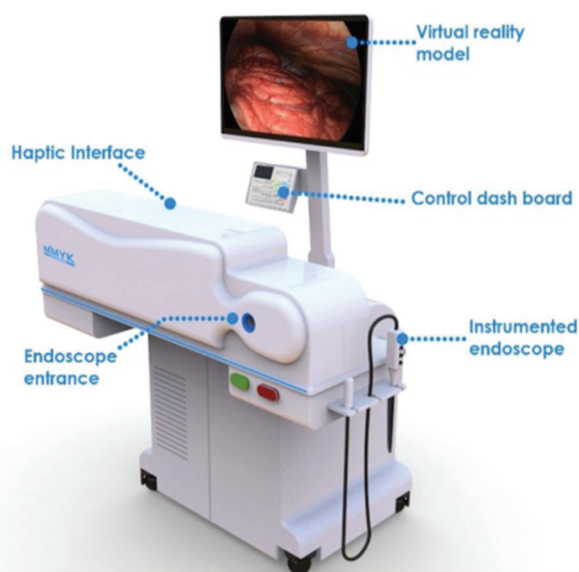


**Bioengineering and Biodesign Initiative (BBI2) at IISc, Bangalore:** Based on the success of the Phase I of the programme, Phase II of Bioengineering and Biodesign Initiative (BBI2) was continued at IISc Bangalore. The phase II programme has resulted into training of 75 manpower, 18 publications in peer review journals and organized five workshop/conferences. An NPTEL course on “Introductory Neuroscience & Neuro-Instrumentation” has also been developed by the centre. In one of the projects entitled “Development of a prototype device incorporating voice and breath sound analysis for quantification and monitoring of asthma” nearly 100 patients’ voices and similar number of healthy subjects has been recorded. The team has performed spectral characteristics-based classification of asthma and healthy subjects and simulation software is being developed.

EndoMimyk: an endoscopy simulator has been developed at IISc in one of the projects and the system is under technology development process by Mimyk, a company incubated at IISc. The MD simulation tool has been developed for complete



analysis of Hemoglobin Variants. These studies show that the covalently bound SH moiety could exist in two dominant conformational state in GSHbS where one is more deeply entrenched in the interfacial groove than the other. A 3D cell culture chip for drug screening studies has been fabricated in one of the projects, which would help in the replication of the continuous interaction that exist between tumor cells and non-tumor cell elements of the tumor microenvironment through direct cell-cell or cell-matrix contact.



Building on the experience and successes on the success in these Biodesign centres and DBT's intent to expand this program, a call was announced to support and establish Biodesign centres in the country and implement projects aimed to create MedTech innovators and build robust & indigenous healthcare technologies.

## BIOTECHNOLOGY PARKS & INCUBATORS

To promote equitable opportunities in biotechnology sector across the scale of the country, the Department of Biotechnology partnered with various State Governments to establish Biotech Parks since 2003 and helps to translate research into products and services by providing necessary infrastructure support. The parks have been facilitating networking amongst various biotech stakeholders and providing entrepreneurial opportunities even in remote places of India. These parks are successfully accelerating the commercialization of new technologies, nurturing, and

maintaining emerging ventures and assisting new enterprises to forge appropriate linkages with other stakeholder of biotechnology sector including academia and Government.

So far, DBT has established 9 Biotech Parks across the country. They are in the States of Uttar Pradesh, Tamil Nadu (2 parks), Karnataka, Kerala, Telangana, Assam, Jammu & Kashmir, Chhattisgarh. An exclusive biotech park for women entrepreneurs is functional in Tamil Nadu. There are 150 workers which includes 50-60% of women both skilled/unskilled. The total annual turnover is Rs. 5 Crore. Biotech Park at Lucknow is primarily a technology incubator. Biotechnology Incubation Centre, Cochin, Kerala has major infrastructure facilities and houses 24 incubatees. Biotech Park Technology Incubation Centre, Guwahati, Assam has currently 9 incubatees and 12 graduated and has major infrastructure facilities for fermentation, micropropagation, herbal extraction, bioprocessing unit. Industrial Biotechnology Parks (IBTPs), Jammu & Kashmir- 2 Industrial Biotechnology Parks have been recently set-up focusing on medicinal & aromatic products, enzymes/value-added biomolecules. Chhattisgarh Biotech Park interfaces research institutes with industry for bio-resource based product commercialization. These parks are 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 2017 based on the experience, the DBT has modified the scheme for establishment of biotech parks and had announced the "*National Biotechnology Park Scheme*" wherein a private sector can partner with State Governments for support by DBT. This is to encourage State Government to come forward to scale-up activities related to biotechnology sector which in long run will contribute to improving the socio-economic development of the region. These new guidelines have been operational w.e.f. April 2018. As per National Biotechnology Parks Scheme, DBT would provide financial support up to Rs. 30 crores per Park or 75% of the cost of project (excluding cost of land and building) whichever is less and the remaining cost including civil construction should be arranged by the State Government. The State Government should however, mandatory make available the required land which should be as a clear title in the name of the State

Government promoted Special Purpose Vehicle (SPV) (not for profit society) and the SPV should be a separate legal entity responsible for managing the Park. As per guidelines, the Department initially would support new BT Park for 3 to 5 years after review of their business plan and detailed project report. It is expected that afterwards, the unit would work towards becoming self-sustainable and will take care of maintenance and upkeep the assets created.

**An overview and the present status of Biotechnology Parks supported by DBT are as follows:**

**BIOTECH PARK, LUCKNOW, UTTAR PRADESH:** Biotech Park, Lucknow, first technology incubator was set up jointly by the Department of Biotechnology, Government of India and Government of Uttar Pradesh. With the core objective to promote the budding biotechnology related entrepreneurs and innovators, Park is now home of 7 companies and 34 companies have graduated out successfully with the support and guidance of the Park. The Park is well equipped with state of art modular laboratories, suitably accredited analytical services, meeting, and conference facilities. The focus of the Park is to assist knowledge creation and promote biotech entrepreneurs through a service driven framework. There are 13 persons working for the Biotech Park, however this park has generated around 600 employments. More than 30,000 biosciences students trained (1-6-month courses). The Park is a concourse for students and young entrepreneurs. It plays a significant role in Human Resource Development in Biotechnology to generate adequate and appropriate skilled manpower required for Biotechnology sector in the country. During January – February Park trained 70 students till 15<sup>th</sup> March 2020. The Park provided a one window service for analytical and extraction services, quality assurance, development of protocols, consultancy, IPR assistance and a forum for deliberations. During the period under report, 127 sample testing work were executed at the unit on payment basis which has helped many entrepreneurs and industry. An Awareness Workshop on “Bio-resources and their Utilization” was organized at Biotech Park, Lucknow on 4<sup>th</sup> February 2020. An Online Training cum Workshop on Herbal Products and Essential oils & their uses in Aromatherapy was organized during 8 – 10 September 2020. An Online Awareness Programme on Corona Virus Disease (COVID-19) – entitled “I Protect You-You Protect Me” for School Children was jointly organized by Biotech Park, Lucknow, The

National Academy of Sciences, India -Lucknow Chapter & Hiranya Medical Centre, Mahanagar, Lucknow on July 1<sup>st</sup> 2020. Biotech Park, Lucknow organized a three-day Training on ‘Plant tissue culture of selected economically important plants’ under Skill and Entrepreneurial Development of the Tribal Youth sponsored by The National Academy of Sciences, India. 30 tribal youth of Sirsiya Block, Sarawasti District, U.P. participated in the training programme during 8 -10 January 2020.

**BIOTECHNOLOGY INCUBATION CENTRE, HYDERABAD, TELANGANA:** This Incubation Centre has been established by CSIR-IICT and Govt. of AP with support from DBT and is owned by the Society for Biotechnology Incubation Centre (SBTIC). World class facilities have been created for use by entrepreneurs on use and pay basis. There are 12 labs of 350 sq. ft each which is given out to companies. DBT has provided support for current good manufacturing practices (cGMP) compliance for Pilot plant facilities, required for quality manufacturing and for minimizing contamination. The biotechnology incubator facility would have research laboratories, knowledge-based service centres and utility generation facilities. It is mainly designed for development and scale up of bio processes and technologies. A pre-BTIC Process Generator (PBPg) component of BTIC was set up at IICT, Hyderabad to act as a front-end facility to provide lab and bench scale process technologies for biotech processes. With its state-of-the-art R&D infrastructure, furnished laboratories & office space, utilities, support services and amenities, the BTIC has emerged as the best Incubation Centre not only in genome valley but also in India. There are 11 incubatees which are graduated out from the park and operationalise successfully. Tergene Biotech moved out from this Park is the first Indian Company to conduct research on Polysaccharide Base/Conjugate Vaccines for Humans and developed Pneumococcal Conjugate Vaccine.

**TIDCO CENTRE FOR LIFE SCIENCES (TICEL) BIOTECH PARK, CHENNAI, TAMIL NADU:** The Park was established by Tamil Nadu Industrial Development Corporation Ltd. (TIDCO), an undertaking of the TN State Government with support from DBT. DBT sanctioned grant for purchasing equipment towards establishing a Biotechnology Core Instrumentation Facility (BTCIF). Laboratory facilities at BTCIF include Microbiology, Molecular Biology, Fermentation, Downstream Processing, Purification, Analytical Support,

Animal Cell Culture Facilities and Utilities. This Park has created infrastructure for Biotech R&D on 5 acres of land in Chennai. It has now achieved 100% occupancy with National and International clients. The tenancy area has 74 modules of 1525 sq. ft. each, available for clients to develop their own customized R&D labs of BSL2 standards, upgradeable to BSL3, in accordance with GLP standards. Clients can install their facilities appropriate to perform their independent research. TICEL is offering the equipment for utilization by Companies / Scientists / Entrepreneurs on non-exclusive basis for their scientific activities / process & product development / sample analysis. The consumables and chemicals / reagents for the operation of the equipment are being sourced by the clients as per their specifications and requirements. The charges for utilizing equipment will be collected from the clients. TICEL clients and external Companies / Scientists are using the equipment at BTCIF for their scientific activities. The detailed brochure on BTCIF, Charges for utilization of equipment and Booking form are available on our website, [www.ticelbiopark.com](http://www.ticelbiopark.com).

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

**BIOTECH PARK TECHNOLOGY INCUBATION CENTRE, GUWAHATI, ASSAM:** The Biotech Park Technology Incubation Centre has been sanctioned by the DBT at a total cost of Rs.27.99 crores in 2009 with the aim to develop and

commercialize bioprocess and products by serving as a centre for entrepreneurship and through development of partnership with innovators from universities, national R&D institutes, academic institutes and industry to help companies quickly commercialize the new technologies and contribute to the strengthening of the local and national economies. The Technology Incubation Centre will provide state of art multi-tenanted plug-and-play modular, equipped laboratory space where start-ups and researchers can nurture and develop their business ideas and research in biotechnology and allied areas. The Technology Incubation Centre will provide lab space for individual scientist entrepreneurs and start-up companies with supporting facilities such as library, conference room and cafeteria etc. The Technology Incubation Centre is intended to help entrepreneurs convert their ideas into commercializable technologies and upgrade their existing technologies. The Guwahati Biotech Park Incubation Centre of Guwahati Biotech Park is currently operating in a temporary campus of 20,000 sq.ft. area within the IIT Guwahati premises on rental basis offering ready-to-use modular laboratories (size ranging from 200 sq.ft. to 1000 sq.ft.) equipped with modern laboratory work stations and other utilities to startup 3 entrepreneurs/companies interested in pursuing their R&D activities in biotechnology and related areas. 87% of the construction work of the Technology Incubation Centre (Phase I) in the permanent campus has been completed and the remaining work is in progress. 30% of the development work of the common infrastructure of Business Enterprise Zone of Guwahati Biotech Park has been completed. Remaining work is in progress. Biotech Park Technology Incubation Centre, Guwahati, Assam has 9 incubatees. This park has generated employments and continuous efforts are being made to use human resource generated in the park. Terra Blue XT company which is now graduated out has generated more than 40 employments.

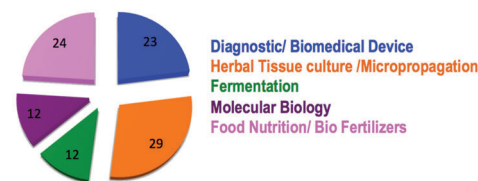
**BIOTECHNOLOGY PARK, BANGALORE, KARNATAKA:** The project was sanctioned at a total Project Cost of Rs 32.26 Cr; with contribution from Karnataka Biotechnology & Information Technology Services (KBITS), Department of IT, BT and S&T, Government of Karnataka and Department of Biotechnology, Government of India. Bangalore Bioinnovation Centre (BBC) is envisioned to be a state-of-the-art Bioinnovation Centre catering to the needs of start-ups in the broad areas of Life Sciences and facilitate Innovation



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

**KRIBS BIONEST, KOCHI, KERALA:** The Department of Biotechnology has set up a Biotechnology Incubator Center (BTIC) at Kerala Biotechnology Park in 4 acres of land with a total built up area of 50,000 sq.ft. It has been established for accelerating and supporting the research process of entrepreneurs. The incubator titled KSUM-RGCB Innovation and Bioincubation Society (KRIBS) was formed between KSUM and RGCB. At present KSUM supports the infrastructure and basic utilities and RGCB completely oversee all scientific, administrative, finance and start-up related activities of the facility. Therefore, established with the support of both central and Kerala state government the facility has reached full incubation space occupancy by the end of 2019, and is able to support start-ups, R&D facility for various institutes, employment opportunities and industry training for students. The vision to accelerate innovation towards scientific discovery and product development is becoming a reality. Biotechnology Incubation Centre, Cochin, Kerala has major infrastructure facilities and houses incubatees. At present there are 28 incubates operating as start-ups occupying a total area of 17,000 sq. ft and 3 start-ups provided with virtual incubation facilities. About 40% of the companies incubating at BioNest are developing herbal products and depend on the facility for initial testing. In addition to more than 25 products in the market and 20 in the pipeline, companies have registered patents for their products. Important achievements include, OmicsGen Life sciences Pvt Ltd which developed the 'Smarlyse' gadget wipes has transferred its technology to Dettol and Avisa Biotech Pvt Ltd which has developed the production of Melanin using *Glioclcephalotrichum simplex* utilizing the fermentation and Bioprocess facility of BioNest has obtained 200,000 USD seed fund for application development from US base Biotech Accelerator Indiebio.

Distribution of Incubation space for various verticals



#### INDUSTRIAL BIOTECHNOLOGY PARKS (IBTPS), JAMMU & KASHMIR:

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

**CHHATTISGARH BIOTECH PARK:** Chhattisgarh Biotech Park -interfaces research institutes with industry for bio-resource based product commercialization. This park has been sanctioned by the DBT in July 2018 with the overall aim to provide facilities for interface of research institute with industry for better utilization of technology and available bio-resources in New Raipur in the State of Chhattisgarh in collaboration with Govt. of Chhattisgarh. The total project cost is Rs. 2968.39 lakhs for Biotechnology Incubation Centre to be shared between DBT (1473.05 lakhs) and Govt. of Chhattisgarh State (1495.34 lakhs) for a period of two year. DBT has released first year instalment of Rs. 4.49 crores. The Government of Chhattisgarh has allocated Rs. 3.00 crore for building construction of Biotech Incubation Centre in the

financial year 2020-21. The main purpose of the project Biotech Incubation Centre under CG Biotechnology Park is to provide facilities for interface of research institute with industry for better utilization of technology and available bio-resources in the State in collaboration with Govt. of India & Govt. of Chhattisgarh. Chhattisgarh Biotech Promotion Society is an implementing agency of Biotech Incubation Centre. Indira Gandhi Krishi Vishwavidyalaya is the technical partner of Biotech Incubation Centre. At this stage, steps are being taken for construction of incubation centre and is starting an Incubation centre at temporary site. Two acres of land in the IGKV Campus for establishment of Biotech Incubation Centre

have been identified. 3500 sq ft. Building space has been provided by IGKV, Raipur to start Biotech Incubation Centre temporarily, till the construction of a new building as per the proposal. The proposals for incubatees have been screened and three potential incubates have been identified. The procurement of equipment process is almost completed. The Park already planned trainings and workshops by utilizing the resources at IGKV campus. Infrastructure for incubating five incubates in the identified thrust sectors along with two central instrumentation and analytical testing facilities is ready in the temporary provision of Biotech Incubation Centre.



**05**

**BUILDING  
INTERNATIONAL  
COLLABORATIONS AND  
PARTNERSHIP**



## 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 programme supports extensive 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 Agriculture and allied sciences. Apart from these areas, during the year, various R&D initiatives under the programme were taken to address challenges of the COVID-19 pandemic including efforts related to understanding the pathophysiology, epidemiology, development of vaccine, diagnostics and therapeutics. These initiatives pertaining to the COVID-19 pandemic has been mentioned in a special chapter.

International Co-operation at a glance	
New International Partnerships forged	5
Joint International call for proposals	13
New international collaborative research projects	32
Ongoing International collaborative research projects	179
Fellowships/awards in DBT-BMGF-BIRAC	16
Biomedical Research Career Programme (DBT-WT/India Alliance)	89
Technologies developed	10
Research Publications	120

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. Department of Biotechnology endeavours to leapfrog scientific advancement in the country both in capability and capacity by partnering with the best in the world. Partners include Government S&T organizations, research/academic institutions, councils, philanthropic organizations, and NGO's. Currently, the

department maintains active **Bilateral Partnerships** with Australia, Brazil, Canada, Denmark, European Union, Finland, Germany, Japan, Russia, Spain, Sweden, Switzerland, South Africa, U.K, USA and The Netherlands; and **Multilateral Partnerships** with BRICS, HFSP, EMBO, TaSE, and Globalstars (EUREKA). Under the scheme Department also partnered with **Philanthropic Organizations** (Bill & Melinda Gates Foundation (BMGF)-the USA, Wellcome Trust (WT)-UK), **Cancer Research UK (CRUK)**, **Universities** (Cambridge University UK, Monash University Australia, and Heidelberg University Germany), and other **NGOs** (Nobel Media, Prakashlabs).

### Process/Product/ Technologies Developed

- Technology on spore-based strip for rapid detection of 50ÅP-lactam group in milk: Paper Strip assay has been developed for the specific detection of β-lactam group of antibiotics in milk which works on the induction principle.
- Technology on antibiotic residues screening in fish, shrimp & feed samples using spore-based kits
- New milling technology based on cool milling (identified and developed at Kool mill, UK) has been validated in the real environment. It was validated for its efficiency (milling rate, power consumption, broken percentage) and producing nutrition rich rice.
- Use of waste cassava starch available in India to make thermoplastic blends and hybrid films for storage of fresh agri produce to extend the storage life of fruits and vegetables (developed at lab level)
- Production and subsequent processing of large amount of food grade meat and seafood products generates a large amount of wash water with high concentration of soluble proteins. A process was developed for removal of soluble protein from this wash water using isoelectric precipitation.
- Process for preparation of Protein Hydrolysate from fish head and Viscera; and skin and bones: Enzymatic hydrolysis of Rest Raw Material (RRM) of Pink Perch (*Nemipetricus japonica*) RRM (head & viscera and skin & bones) was optimized using endogenous

enzyme and four commercial enzymes (alcalase, bromelain, papain and trypsin) for high yields and good nutritional quality, which can be used for development of high value food products.

- First in world: Intraosseous route implantation of MSCs for the treatment of Osteogenesis Imperfecta- A new stem cell therapy to help children with 'Brittle Bones'-The protocol for intraosseous injection of fetal Mesenchymal Stem Cell (MSC) infusion as a therapy for Osteogenesis Imperfecta (OI) is developed. 2-year-old male child with severe type III OI received his first dose of intravenous ( $3 \times 10^6$  MSC per kg body weight) and intraosseous ( $0.4 \times 10^6$  per kg) infusion of fMSC (female donor) into all 4 long bones. The patient did not experience any adverse reaction during or after MSC infusion and is now currently under 3-months follow-up.
- The prototype sensor developed by Tampere University of Technology (TUT), Finland is being tested in the joint project study at TERI, New Delhi. This sensor gave very good signal in the range at par with that observed with reference sensor and has huge application for emission studies for accurate measurements. Also, Bioprocess technique has been developed for bioethanol production from different feed: low cost industrial grade sugar, Water hyacinth and Corn cob, biomass, blackstrap molasses by using *Picheastipitis* and 'Candida tropicalis strain TERI-DC. Furthermore, Mixotrophic alga cultivation process is developed for Chlamydomonas.

## BILATERAL PARTNERSHIPS

**United Kingdom:** The department actively partners with Biotechnology and Biological Sciences Research Council (BBSRC), Medical Research Council (MRC), Innovate the UK, Natural Environment Research Council (NERC), Economic and Social Research Council (ESRC); under the ambit of UK Research and Innovation (UKRI).

Additionally, the department started new partnerships with British Council for Researcher Link Workshops to offer extensive training, information sharing collaboration, and networking opportunities for early career researchers from India and the UK in emerging areas of life sciences. The

department will support five interactive 3-5 days workshops with equal participation from the UK and Indian young researchers in an interactive environment under the mentorship of established researchers from both countries.

The department also strengthened partnership with the Academy of Medical Sciences (AMS), UK to launch the AMS-DBT Newton International Fellowship (NIF). This unique opportunity will offer a 3 year fully supported post-doctoral fellowship for Indian scholars to pursue clinical and patient-oriented research in the UK and India under joint mentorship. This fellowship will facilitate the transition of exceptional scholars from budding young researchers to early-career independent researchers with strong international mentorship and training experience.

Under an ambitious initiative with UKRI, the department supported five projects focused on "AMR in the Environment from Antimicrobial Manufacturing Waste". These projects will help understand and assess the futuristic threats of AMR pathogens due to environmental pollution with anti-microbial compounds. The understandings from these projects will help guide the policy interventions to reduce this potential threat.

A project jointly supported by DBT and the UKRI is trying to put into practice the theoretical principle of one health to address AMR and using an inter-disciplinary approach to identify a diverse range of stakeholders. The project being led by researchers at the University of Edinburgh and V. P. Chest Institute, New Delhi is exploring the domains of hospitals, the pharmaceutical sector, OTC antibiotics sale, and antibiotic use in the poultry sector to holistically understand the "one health" perspective. The project has used qualitative research methods to capture emerging new innovative ideas for potential innovative regulation and suggestions to address the optimum use of antibiotics and AMR in India.

Another project supported by DBT and UKRI; and led by the University of Edinburgh and IIT Delhi is trying to develop innovative diagnostics to curb antimicrobial resistance. The project brings together nine leading academic institutions, five from India and four from the UK. The study includes medical researchers, diagnostic innovators, economists, and social scientists to create cutting edge, rapid diagnostic solutions to fight AMR in settings as diverse as community healthcare, dairy farms, and aquaculture.

A project lead by the Indian Institute of Chemical Technology, Hyderabad and Aberystwyth University; and jointly supported by DBT and UKRI is investigating the potential of sugarcane industrial waste viz., Bagasse and Spent wash as a potential feedstock for the valorization of biobased products in biorefinery format. The study showed that the production of microcrystalline cellulose from sugarcane bagasse yielded higher productivity with low environmental impact. The project aims at developing processes to obtain value-added products from waste streams (spent wash) from ethanol production and sugarcane bagasse (SCB fibre) of the Indian sugarcane industry.

DBT and Medical Research Council, UK supported a crucial study that is looking at the impact of dietary modification and improved physical activity on the onset of Gestational Diabetes in expecting mothers. The research teams lead by the University of Oxford and Christian Medical College, Vellore have been able to quantify exercise done by women during pregnancy, and their ability to increase step counts. The team is now waiting to see the impact of probiotic yoghurt and physical activity on the rising trend in Gestational Diabetes in pregnancy which has become an important health hazard that affects the newborn and its future health.

In partnership with Natural Environment Research Council (NERC), UK; the department has launched two cohorts for establishing quantitative exposure-response relationships for air pollution and maternal (birth-weight), child (acute respiratory infections and child growth) as well as adolescent (asthma exacerbations) health outcomes in the Delhi-NCR area. Longitudinal exposure/health/biomarker measurements have been completed on nearly 130 asthmatic children and 160 pregnant women. The project lead by Sri Ramachandra University, Chennai, and the University of Edinburgh, UK has thus far built considerable experience in calibration and field deployment of low-cost Particulate Matter (PM) and gas sensors for personal and micro-environmental monitoring within the two cohorts. It has provided exposure information at a high spatio-temporal resolution to allow estimation of exposure attributions of micro-environments and/or sources to facilitate recommendations for exposure reduction. Biomarkers of exposure and early biological effect being analyzed are expected to provide inputs for long-term exposure and health effects surveillance for air pollution in the Delhi-NCR.

The department along with Innovate UK supported multiple projects to develop technologies for the reduction of post-harvest losses. One such project lead by Sheffield Hallam University, UK, and IIT Roorkee has successfully implemented and demonstrated novel rice milling technology with better efficiency to reduce the broken rice percentage significantly. Another project supported under this partnership is using waste Cassava starch available from India to make it suitable for blending with thermoplastic polymers that are used in the packaging of fresh agricultural produce. The chemical treatment of cassava starch reduced its viscosity and increased its whiteness. Plasticization by PEG made it more effective than glycerol or sorbitol. The modified process offered significant improvements in storage life from 3 days to 9 days for vegetables stored in certain films in ambient conditions. Vegetables such as ivy gourd, green chilli, capsicum, and mushroom could be stored at ambient room temperature conditions for much longer durations than unpacked conditions. Pilot-scale trials were carried out to make large size films and shrouds. This project lead by the University of Greenwich and Maharashtra Institute of Technology, Pune can potentially bring new technological advancement in the food packaging industry.

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

**European Union:** The department has developed a strong partnership with the European Union in the area of research and innovation in life sciences over the years. The Department under an ambitious initiative with the EU supported 3 multi-partner, multi-institution, consortia projects to enable the development of the “Influenza vaccine for the world”. These projects aim to approach influenza vaccine development through various approaches to offer long term immunity in a diverse population.

Focusing on the threat of climate change, the department collaborated with European Union for the “Green Deal” under Horizon 2020 framework to help build a low-carbon, climate-resilient future. The department will support joint research and innovation initiatives focused on Clean, affordable, and secure energy, Industry for a clean and circular economy,





- 2 novel broadly neutralizing antibodies (bnAbs) isolated in India
- Potential combination of cytokine biomarkers identified in India for prognosis of active TB.

**Russia:** Program of Cooperation between DBT and Ministry of Science & Higher Education, Federation of Russia has been extended till 20<sup>th</sup> October 2022. Currently supported projects under this agreement are focusing at *in vivo* bio-imaging methods using novel luciferase-luciferin pairs; Rapid detection of bacterial resistance to antibiotics based on changing optical properties of nanosized labels; Development of disease diagnostic platform based on plasmonic biosensors and nanoparticle tracking analysis; and Development of alternative biomarkers for diagnosis of diabetes using proteomic technologies.

**South Korea:** The department along with Ministry of Science and ICT (MSIT) of the Republic of Korea invited Indian and Korean research groups to submit proposals towards establishing Joint Network Centre(s) in the area of “*Artificial Intelligence utilization in the field of Biotechnology*”.

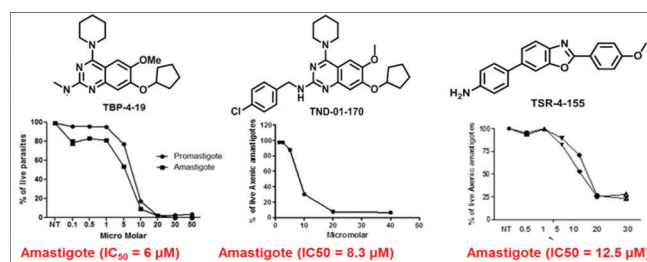
**United States of America:** The Department has been implementing collaborative programmes with the National Institutes of Health (NIH), the USA since inception. The major programmes being supported include (i) Indo-US vaccine Action Programme (VAP) and (ii) Indo-US collaboration on Vision Research,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

The VAP is a bilateral programme between Department of Biotechnology (DBT), and National Institute of Allergy and Infectious Diseases (NIAID), USA, to support a broad spectrum of activities for the development of new and improved vaccines, for diseases of importance to India. The Candidate Vaccine Advisory Committee (CVAC) constituted under the aegis of VAP provides oversight for candidate vaccine development activities.

A new Initiative to strengthen capacities in biomedical research ethics was initiated, in collaboration with the Department of Bioethics, National Institutes of Health (NIH) Clinical Center, USA. Under this initiative, 04 webinars focussed on ethical perspectives in clinical research were held, since September 2020. The Department of

Biotechnology (DBT) has signed a Statement of Intent on Indo-US Collaboration on Expansion of Vision Research with the Department of Health & Human Services, Government of the United States of America, with the objective of translating research outcomes to develop potential interventions to reduce eye disease burden in India and the USA. The mandate of this collaboration is to strengthen research focusing on ophthalmic disorders, diabetic retinopathy, genetics of ophthalmic diseases and ocular inflammation. The projects supported so far have generated insights into the molecular basis underlying visual disorders and identifying optimal methods of disease management. Current studies are focused on identifying novel genetic loci and delineation of pleiotropic effects for diabetic retinopathy and macular edema, through whole-genome sequencing studies in Indian population.

**Australia:** The Indo-Australian Biotechnology Fund (IABF) supports Indian and Australian Scientists, from both the public and private sectors, to collaborate in cutting edge research in the area of science & technology. So far, this partnership has supported 56 joint projects in various areas of life sciences. A study supported under IABF at IICB (Indian Institute of Chemical Biology), Kolkata has identified advanced hit molecules with anti-Leishmanial activity based on the life cycle of the parasite. In vitro pharmacokinetics studies resulted in two potential lead molecules which have been selected for in-vivo pharmacokinetics and in vivo VL disease model study.



Selected Lead molecules with anti-Leishmanial activity

In a project at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru studies conducted on markers associated with salinity tolerance (India), drought resistance (India) and AB resistance (Australia) and deployed stress-resilient improved chickpea varieties. Five genes from the “*QTL-hotspot*” region were found to contain substantial

allelic variation between individuals for each trait separately. The Project has also contributed to release of first MABC drought-tolerant line for commercial cultivation in India.

**Germany:** The German Federal Ministry of Education, Science Research and Technology (BMBF) and Deutsche Forschungsgemeinschaft (DFG) are active partners of the Department of Biotechnology in the areas of the biotechnology. The department has successfully implemented 37 joint projects till now through various joint calls with the focus on Medical Biotechnology, Agricultural Biotechnology, Innovative Food and Nutrition Technology, Medical devices and bioengineering and Environmental biotechnology areas through active collaboration with German funding agencies (BMBF and DFG).

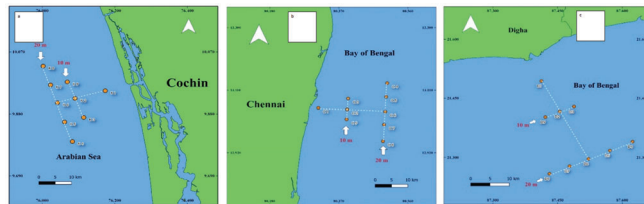
The Biogas driven cold storages for sub-zero applications in India (BIGASTORE) has been developed by the TERI under Indo-German joint collaboration that is to be used to preserve the fresh perishable food products such as meats, fish, vegetables and fruits. It will avoid the losses held due to reduced shelf life of the agricultural produce and to enhance the food security through renewable energy. This biogas-driven cold storage system has containerized biogas plant and a skid mounted chiller plant design with advanced modelling software.



View of the containerized biogas plant and chiller system at biogas plant research facility of TERI

The DBT-BMBF led joint collaborative study has for the first time proved that the genetically modified *Corynebacterium glutamicum* can be used for the production of alpha, omega-diamines as well as alpha, omega-amino acids using the sugars derived from agro-residual biomass as the raw material (carbon source). The biological route and the bioprocess conditions successfully scaled up and the production of these value-added chemicals could be an added advantage for achieving economic feasibility in the Biorefineries focusing on bioethanol (2G ethanol) production from biomass.

The PODCAST project utilized ocean colour remote sensing in the public health sector via *in situ*, satellite, and citizen science data in developing a regional model for mapping conditions favourable/unfavourable for *Vibrio cholerae*. Antibiotic resistance of environmental *Vibrio cholerae*, their varied tolerance to a range of salinity and temperature, ability to associate with phytoplankton and other suspended matter increases the threat of an epidemic outbreak in areas with poor sanitation facilities.



*In situ* sampling locations in the coastal waters of India - (a) Kochi - west coast (b) Chennai and (c) Digha - east coast

The Department of Biotechnology (DBT) in joint collaboration of DFG led a multi-centric project for studying Rural-Urban Interface of Bangalore: within the Space of transition in Agriculture, Economics and Society. Some of the salient findings under several sub projects have been reported below.

- Education, urban dummy, diabetes, and blood pressure were the significant factors influencing the nutritional status of women.
- Wealth index, per capita income and vegetable consumption are positively influencing nutritional status of adolescent girls.
- Diabetes and hypertension are commonly prevailing diseases across the rural-urban gradient.
- Dual burden malnutrition is more among female across the rural-urban interface of Bengaluru.
- High species diversity in the urban domain than rural and transition. Ornamental tree species are planted in the urban domain and religious/multi-purpose trees species are found towards rural and transition domain.
- *Mangifera indica*, *Psidium guajava*, *Ficus glomerata*



and *Pongamia pinnata* were found comparatively tolerant amongst other species against air pollution.

- Urban region recorded lower insect species richness as well as abundance.
- Urban spaces are home to rare bee species, many of which are solitary by nature.

The department is also implementing the Phase-II of DBT-DFG joint collaborative multi-institutional network project, which is going to encompass the dynamics of agriculture mediated economic changes focused on societal impact in urban, peri-urban and rural areas of Bangalore with policy-oriented impact. The department will be supporting five new joint projects on blue sky research under 2<sup>nd</sup> DBT-DFG joint call on fundamental research in biotechnology. The department had also announced the 3<sup>rd</sup> DBT-DFG joint call on fundamental research in biotechnology in the rolling format during 2020.

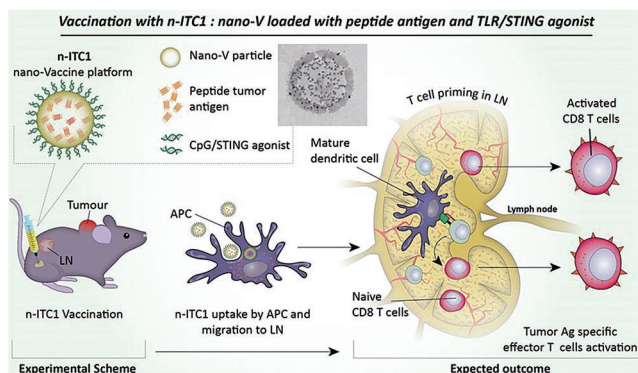
**Spain:** The Department has an active PoC for technological cooperation in biotechnology with Centre for the Development of Industrial Technology (CDTI), Government of Spain. This joint cooperation is mandated to promote market-driven research and technology development as well as to encourage partnerships and business-led R&D&I collaborative projects in the field of biotechnology. The department had announced 6<sup>th</sup> joint call with CDTI in areas of biotechnology including health biotechnology, industrial biotechnology, nano-biotechnology, Agri-biotechnology, biofuels, bioenergy, bioinformatics and biomedical engineering.

In one of the joint projects, investigators are developing a technology for conversion of Lignocellulosic Wastes into Biofuels and Bioplastics. This project has shown that the lactic acid can be produced from rice straw by acid treatment followed by fermentation with suitable lactic acid-producing bacteria. This holds the potential for producing polylactic acid, a biopolymer used in food packaging.

**Switzerland:** The department has an active ongoing bilateral partnership with Swiss National Science Foundation (SNSF), Switzerland for promoting science and technology in areas of strategic relevance to India and Switzerland. Under this collaboration, the department has ten ongoing projects

under Blue Sky Research/ Basic Research in the life sciences.

A research group at Amrita University under Indo-Swiss collaboration byutilizing immunology expertise of Swiss team of the University of Lausanne has optimized novel nano-adjuvant material compositions and implantable nano-gel systems for the sustained and enhanced activation of immune cells against cancer cells for their application in cancer immunotherapy.



#### *Combinatorial activation of anti-tumour immunity using innovative multi-targeted nano-immunotherapeutics*

The labs of CSIR-IIIM and the University of Basel, Switzerland are trying to use small molecules for unravelling the complex biology of CTCs, identification of novel therapeutic targets and agents targeting metastasizing CTCs. This study has identified potential CTC targeting hits PL69 (IC<sub>50</sub> 772nM); US464 (IC<sub>50</sub> 466nM); US464 (IC<sub>50</sub> 523nM) and IIIM 368 (IC<sub>50</sub> 386nM) which will be used for identification of SAR of these hits and exploration of the vulnerable biological targets of CTCs using these chemicals.

A research group at IIT-Madras by partnering under Indo-Swiss cooperation with a lab at EPFL is using *chlorella vulgaris* as model microbe to standardize the Bio-photovoltaics (BPV) measurements which shows that the dark current during respiration process is quite significant compared to the photosynthetic current. Further, they are also working for bioengineering of cyanobacteria.

## MULTILATERAL COOPERATION

**DBT-EUREKA:** The department along with EUREKA under 'GlobalStars Initiative' through joint call on One Health is implementing three projects with UK, Netherlands and Spain. The EUREKA is an intergovernmental organization for publicly

funded market-driven industrial R&D involving 44 countries. Further, to strengthen multilateral joint collaboration, the department had announced the 2<sup>nd</sup> GlobalStars India joint call with EUREKA within the scope of “key enabling technologies for healthcare, agriculture and water” with Austria, Belgium (Flanders Region), Finland, France, the Netherlands, Sweden and Switzerland.

**DBT-BRICS:** The DBT along with DST launched a multilateral joint call dedicated to the COVID-19 under the BRICS STI Framework Programme with two-year project duration to fund proposals as a proof of concept for basic, applied and innovative research projects facilitating cooperation among the researchers and institutions in the consortia which consist of partners from at least three BRICS countries.

**DBT-TaSE:** The TaSE (Towards Sustainable Earth) initiative is a multilateral joint collaborative platform between The Natural Environment, Economic and Social, Arts and Humanities Research Council of UK Research and Innovation; Japan Science and Technology Agency; National Natural science Foundation, China and The Swedish Research Council for Sustainable Development with the DBT through ‘Human-Environment Interactions and the Sustainable Development Goals’ jointly implementing six projects.

The Social-Economic-Environmental trade-offs in managing the Land-River-Interface (LRI) with the impact of water bodies viz., rivers, dams etc. on/alongside the Sutlej-Beas river basins through suitable technology interventions has been carried out at Goshal, Shanag and Lower Badah villages. The project facilitates transferring scientific technology related to horticulture, agriculture and livestock management to the farmers of the study area which will help mitigate the adverse effects of LRI and leading to the attainment of the SDGs.

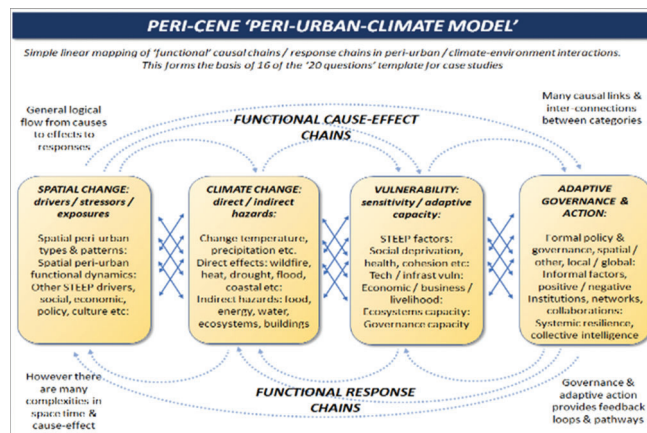
OPTIMISM India team under TaSE multilateral platform is investigating the interactions between urban low-carbon transport interventions with relevant 6 Sustainable Development Goals (at target level) by considering Surat- an industrial metropolis in Gujarat and Udaipur- a tourist city in Rajasthan with different characteristics.

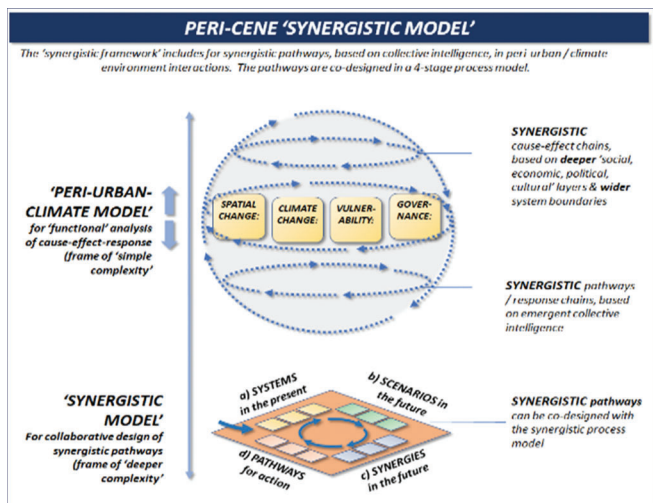
The Opportunities and Trade-offs between SDGs for Food Welfare and Environment in the Deltas project, in collaboration with the UK and Swedish experts, is analysing the challenges and trade-offs between the achievement of

different Sustainable Development Goals in the Indian Sundarbans Delta, West Bengal (with a population of 5 million people).

This project has shown extensive conversion of cropland to rural/urban settlement and aquaculture in the fringe areas of expanding the megacity of Kolkata with a steady reduction of mangrove forest area and health with climate change. While in this direction Govt policies/schemes on livelihood development, improved connectivity, sanitation, water and DRR have a positive impact on the reduction of multidimensional poverty and inequality in the delta.

The Peri-Cene (Peri-Urbanization and Climate environment interaction) project of the department under joint collaborative efforts with TaSE through ongoing work by making “Online Periurban analysis tool kit or (P-CAT) for global Periurban assessment” and “Online Global policy lab showcasing two case studies (Chennai region and Manchester region)” will provide an arena for dialogue and discussion to identify, classify and map the Periurban areas globally. This will provide a first-ever comprehensive assessment of Peri-urbanisation climate impacts, risks and vulnerability benefitting Urban and environmental planners, Climate change specialists, Public policymakers, and in international development studies.





### Peri-cene framework

**Grand Challenges India:** Grand Challenges India (GCI) is the Indian arm of Global Grand Challenges, launched in 2012 and is the flagship program managed by the PMU at BIRAC and is collaboratively funded by the Department of Biotechnology (DBT), Bill & Melinda Gates Foundation (BMGF), USA and The Wellcome Trust, UK. GCI is committed to provide solutions for major public health problems, especially for developing countries. GCI aims to help innovators expand the pipeline of ideas for developing new preventive and curative therapies, piloting new technologies, and exploring new ideas.

Over the years, GCI has grown both as an idea and as a partnership covering varied themes from maternal and child health to agriculture, nutrition, infectious diseases, vaccines, AMR, health systems strengthening, big data, and Medical Technologies (MedTech), etc. to respond to the ever-changing needs of research in public health in India. Till now, GCI has supported Seven open calls and Thirteen specialized programs and has funded 122 projects across India.

**Mission Innovation:** Mission Innovation (MI) is a global initiative of 24 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. MI was announced at COP21 on November 30, 2015, as world leaders came together in Paris to commit to ambitious efforts to combat climate change. The Mission Innovation initiative is making a concerted effort to enhance the pace of innovation and scale of transformation

in support of a clean energy revolution to meet the requirements and goals for India's economic and energy security promptly. This is being achieved by:

- **Increasing International R&D Collaborations:** To encourage and facilitate the leveraging of knowledge, capabilities, and resources among Mission Innovation members and other stakeholders, DBT (via Mission Innovation) via a “**Collaborative**” approach, launched the Funding Opportunity Announcement for Carbon Capture (IC3), Sustainable Biofuels (IC4) and Converting Sunlight (IC5) and 49 collaborative R&D projects supported.
- **Raising awareness of the transformational potential of Energy Innovation:** A wide range of workshops and events were organized to bring together key stakeholders to agree on priorities, promote innovation, opportunities for innovators & investors and explore opportunities for further collaboration. This initiative has helped to highlight the importance of clean energy innovation, address the key gap areas and a strengthening the international platform for collaboration and stepping up the pace of innovation via ambitious research, development and demonstration activities that can help members to unlock clean energy transition pathways measurably and successful transition to MI2.0 via Mission-oriented approach (Stakeholder engagement>2000 stakeholders).



*Winning Solutions from National Energy Product Challenge  
under Clean Energy International Incubation Centre*



- Increased Private Sector Engagement and Investment: CEIIC: DBT-BIRAC-TATA trusts:** DBT and its Public Sector Undertaking, BIRAC has joined hands with Tata Trusts in successfully setting up the Clean Energy International Incubation Centre (CEIIC) to provide end-to-end support to start-ups, ranging from infrastructure, technology, angel funding, access to venture capitalists, mentorship, exposure to national and international organisations, experts. Under Mission Innovation mandate, the Incubation Centre launched a two National Product Energy Challenge which resulted in 25 winning solutions covering different areas of Clean energy.
  - Clean Energy Investment and Technology Innovations:** IEA and the Ministry of Science and Technology, Govt. of India is currently focusing on assessment of R&D investments in clean energy in the country. The Joint partnership is helping to address the Clean Energy Transition in Indian landscape and highlighting the need for exchange of good practices, suggesting a way forward for policy and decision-makers.
  - Avoided Emissions Framework- India-Sweden Collaboration:** India through Clean energy International Incubation Centre (CEIIC) and Sweden through RISE has collaborated under Avoided Emissions Framework (AEF) to accelerate the Clean energy initiatives for a Sustainable Future. Under this partnership, eight companies have been selected to demonstrate an initial 100 million tons of potential CO<sub>2</sub> emission reduction by 2030.
  - Delivering the Mission Innovation Breakthroughs: MI Solutions:** The Mission Innovation Breakthrough Solutions has resulted in Four Clean Energy Success stories in India exemplifying the determination of scientists and engineers in universities and industry across India, to continue to drive the phenomenal progress made to date, and to succeed in delivering a clean growth revolution.
  - Mission Innovations Champions: Scaling the Potential of Clean Energy Innovation: Turning Awareness into Action:** Mission Innovation Champions is a recognition programme to celebrate and support innovative researchers who are accelerating the clean energy revolution. The MI Champions Program 2019 & 2020 has resulted in recognizing exceptional clean energy innovators in India on key innovative clean energy research and technology developments. MI Initiative has resulted in 2 Global MI Champions from India (Prof. SP GonChaudhuri and Dr Purnima Jalihal) scaling up innovations in Clean energy.
  - Information Sharing:** The preparation of reports and related documents highlighting the key gap areas, challenges, success stories and winning solutions in Clean energy has helped in enabling a better and faster understanding of the knowledge and good practices, generating new ideas, team cementing, getting top talent access (nationally and globally) about Clean energy sector.
  - Outreach Activity:** The Mission Innovation India Unit with support from the Department of Biotechnology has launched a dedicated website for Mission Innovation and related activities ([www.mission-innovation-india.net](http://www.mission-innovation-india.net))
  - Engagement with MI Community:** India has been actively participating in the Mission Innovation Ministerial held every year. DBT has successfully engaged >1000 Clean Energy stakeholders including Public-Private partners, Academia, Industry, Investors, Small and Medium Enterprises (SMEs) and Innovators via the successfully organized stakeholders meeting on Public-Private cooperation for Clean energy transition to scale-up innovations.
- DBT-EMBO, EMBC:** The Government of the Republic of India, EMBO and the EMBC signed a Cooperation Agreement to strengthen scientific interaction and collaborative research between India and Europe. As a result, India became an EMBC Associate Member State in January 2016. Consequently, researchers working in India are now eligible to participate in all EMBO Programmes and activities.
- EMBO Young Investigator Programme:** Supports those group leaders who are in the early stages of setting up an independent laboratory in EMBC Member or

Associate Member States. They receive financial and practical support for a period of four years to help them develop skills and connections that will help them during this career stage. One researcher based in India joined the EMBO Young Investigator Programme in 2020.

- *The Global Investigator Network:* was launched in 2019 to support young scientists that have started their independent laboratories in EMBC Associate Member States or countries, and territories covered by a cooperation agreement within the last six years. The first group of Global Investigators began the programme on 1 January 2020. Three researchers based in India joined the EMBO Global Investigator Network in 2020.
- *EMBO Postdoctoral Fellowships:* are awarded for a period of up to two years. In total, five Postdoctoral Fellowships have been awarded to researchers of Indian nationality.
- *India-EMBO Lecture Courses funded by EMBO:* will receive additional support from the India Alliance from 2020. These courses are geared primarily towards PhD students and postdocs and will provide training in cutting-edge topics delivered by experts in their field. These courses should reach a wider audience and help increase EMBO's impact on the Indian Life Science community.

Six EMBO Courses & Workshops have taken place in India in 2020. 55 Indian scientists have attended EMBO Courses & Workshops in 2020. 19 Indian scientists have received travel stipends or Childcare grants to attend EMBO Courses & Workshops in 2020.

- *Funded Lectures:* Organizers of international scientific meetings taking place in India can apply for support of a keynote lecture given by an EMBO Member or EMBO

Young Investigator. Four Lecture Series has taken place in India in 2020.

- *EMBO-India Bioscience Online Seminars:* initiative launched in May 2020 by EMBO in collaboration with India Bioscience to bring the scientific community in India through training webinars to update and practice soft skills, which include communication, grant writing, publishing and scientific integrity.

Under this initiative, India Bioscience organized two webinars, one on the EMBO Fellowship Programme and one on the EMBO Young Investigator Network, which was live-streamed and is now available to potential applicants on YouTube. Gerlind Wallon travelled to the India Bioscience Young Investigator Meeting in February 2020 to give a talk on EMBO and, in particular, the Young Investigator Network, and to meet with Indian partners and members of the EMBO community in India. Two grant writing webinars series have been carried out under the EMBO-India Bioscience Online Seminars scheme, benefiting 400+ scientists in India.

**DBT-HFSP:** The International Human Frontier Science Program Organization (HFSP) funds an international program of research support for frontier research on the complex mechanisms of living organisms through the Human Frontier Science Program (HFSP) and India is one of the members of it. The overall objectives of the programme are to support frontier research on the complex mechanisms of living organisms through innovative, cutting edge high risk means with the promotion of international collaboration in the spirit of science without borders. HFSP support investigators under two categories - Research grant and Long-term fellowship. In 2020, two Indians received HFSP grants support in Research Grant (1) and Long-Term Fellowship (1) for conducting joint collaborative research.



**06**

**DBT RESPONSE TO  
COVID-19 PANDEMIC**



## DBT RESPONSE TO COVID-19 PANDEMIC

The Coronavirus pandemic has caused widespread disruptions and the government has taken several measures to address the challenges posed by the pandemic. The pandemic has brought a new sense of urgency to innovation efforts. The Department of Biotechnology, its autonomous institutions, and its public sector undertaking BIRAC have been at the forefront to address the COVID-19 global health crisis. DBT-BIRAC has been the nodal agency working towards creating a collaborative innovation ecosystem between the government, corporations, academic and research institutions and all these efforts are being leveraged for quicker response to this pandemic.

At the national level, the Department has been identified as the nodal centre by the PMO constituted Task Force, to consolidate efforts for vaccine development in India. Internationally, the Department is involved in key strategic engagements with global public health alliances to further vaccine development activities. The multi-pronged strategy adopted by the Department, coupled with the untiring efforts of the Autonomous Institutions and the Indian Biotechnology enterprises have begun to bear fruit and yield tangible results. DBT has been pro-active in responding to the emerging situation to support the advancement of vaccine candidates and related technologies, by actively partnering with CEPI, through the DBT supported Ind-CEPI Mission. COVID-19 Research Consortium Joint Call issued by the Department along with its Public Sector undertaking BIRAC played a crucial role in attracting some of the best vaccine developers from both public and private institutions and industries. A Network of DBT Autonomous Institutes namely, THSTI (NCR Cluster), NIBMG, CDFD, ILS, RGCB have been at the forefront to co-ordinate and implement various initiatives on sequencing, vaccines, and diagnostics with respect to COVID-19. 5 field sites in a PAN-India manner are being established for rapidly initiating Phase III clinical trials for global and indigenous COVID-19 vaccines. The sites are being prepared for GCP compliance. The sites have been mobilized for conducting COVID sero-epidemiology studies from 1st August 2020, with serial cross-sectional survey of 5000 subjects at each site. 6 Demographic Health System (DHS) sites are being prepared and are currently establishing healthy cohorts with collection

of all background data. Training on GCP compliance for these 6 sites would be initiated shortly.

### A. NATIONAL EFFORTS

#### 1 Immediate scale-up of Biomedical solutions from health-tech start-up companies

DBT-BIRAC identified the Start-ups that had potential solutions to address the challenges and worked with the start-ups to scale up their COVID-19 healthcare prevention and treatment solutions. BIRAC collaborated across the healthcare innovation ecosystem ranging from biotech companies to entrepreneurs coming up with innovations to academic institutions to address the COVID-19 global health care crisis.

The following eight start-ups received support to scale -up products for immediate deployment:

BIRAC also supported two co-funding partners for supporting upto 25 Startups under the BIRAC's mandate to foster market deployment of innovative solutions addressing Covid-19 challenges.

- **Aarna Biomedical Products** scaled-up “Suraksha Full Body Coverage Kit” which would comprise of a full face shield, a face mask, a coverall with fused head coverage, two shoe covers and two hand covers using SPM-Non Woven.
- **Alpha Corpuscless** scaled-up Face Shields that protect the face from pathogen-laden droplets. Face shields offer the advantage of guarding the entire face of healthcare workers from contamination.
- **MicroGo** installed GOassure-an IOT enabled fully automated hand hygiene device which digitalizes the hand hygiene process.
- **Cistron Systems Private Limited** produced PSA Medical oxygen Generators as a solution to produce medical oxygen on-site which can reduce the dependency of supply of oxygen for a hospital from vendors.
- **Ubiqare Health Pvt Ltd created** the platform that enabled care under Home Quarantine/ temporary isolation wards. Specialty mobility healthcare platform with Clinical Intervention support.

- **Ayu Devices Pvt Ltd** scaled up of Bluetooth Enabled Digital Stethoscope for COVID-19 patients monitoring.
- BIRAC through Co-funding with **IKP Knowledge Park** the **IKP COVID Fund** funded, **Parisodhana Technologies Pvt Ltd** for Hybrid multiply face mask; **Turtle**
- **Shell Technologies Pvt. Ltd.** for **Dozee** (health care monitor) and **Monitra Healthcare Pvt Ltd** for **UpBeat** (biosensing platform for remote monitoring).
- Along with **C-CAMP** has also launched an initiative **C-CIDA** in its efforts to scout for innovations that are ready to be deployed immediately or in the near future to curb the COVID-19 outbreak. BIRAC has approved support to CCAMP under the Co-funding partnership. Around 10 start-ups shall be supported under this initiative.

#### Startups supported

## 2 Research & Development



Multiple "Request for Proposal" (RFP) have been published for COVID-19 Research Consortium. The theme of RFP was "Developing Diagnostics, Vaccines, novel Therapeutics and repurposing of drugs for SARS-CoV-2". Nearly 78 projects across all the thematic areas have been shortlisted for financial support.



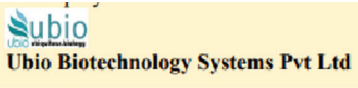


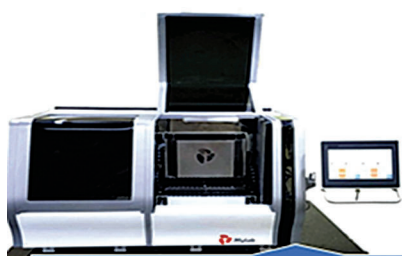
### 2.1 Diagnostics Development

To strengthen indigenous production all types of diagnostics products and their sub-component development and manufacturing was supported for nucleic acid detection kits, Antigen detection kits (Rapid card test, ELISA and other platforms), Antibody detection kits (rapid card tests and ELISA). Some of the early successes are tabulated below:

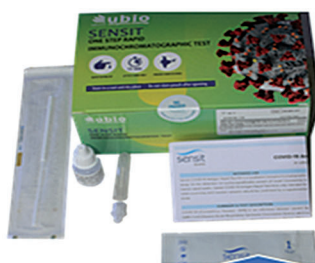
Nucleic Acid Detection	Antibody Detection	Antigen Detection	Miscellaneous: Shared Facility, Components of Diagnostic kits
<ul style="list-style-type: none"> <li>MyLab</li> <li>SHC Shinebiotech</li> <li>Yaathum</li> </ul>	<ul style="list-style-type: none"> <li>Achira Labs</li> <li>Scigenom</li> <li>Xcyton Diagnostics</li> <li>GGSIU</li> </ul>	<ul style="list-style-type: none"> <li>Denovo BioLabs</li> <li>Pathshodh Healthcare</li> <li>Ubio Biotech</li> <li>UDSC</li> </ul>	<ul style="list-style-type: none"> <li>Huwel Life Sciences</li> <li>AMTZ</li> <li>Levram Life Sciences</li> </ul>

## Products Launched:

Grantee	Diagnostic Kit	Market Status	Production Capacity
	RT PCR Antigen Antibody Detection	25,40,000 RT PCR tests manufactured and sold Antigen detection kits : Units Sold: 33,00,000	RT PCR - 4,00,000 test a Antigen test - 2 Lakhs Test
	Reagents which include enzymes for SARS CoV-2 diagnostic kit and RT PCR Kits	Manufactured and sold 4 Lakh units of Molecular Transport Medium (MTM) 11 lakh nucleic acid extraction kits produced	10 lakh vials of MTM per month
	Lateral Flow Diagnostic Platform for detection of viral antigens and antibodies IgG & IgM	1 lakh units sold	



Automated RT-PCR  
machine-MyLab



Antigen detection  
LFA-Ubio



IgG/IgM detection  
LFA-Ubio



Enzymes for RT-PCR kits-  
Huwel

DBT-AMTZ CoMManD (COVID Med Tech Manufacturing & Development Strategy) Consortium, supported under National Biopharma Mission (NBM), enabled rapid scale-up of manufacturing of COVID-19 diagnostic kits, effectively lowering import dependency. Table below gives products

commercialized from AMTZ. Due to the production capacity from multiple companies located at the same place, they have received government orders for 15,000 ventilators. Production of diagnostic kits and related devices has helped reduce import dependency on these devices.

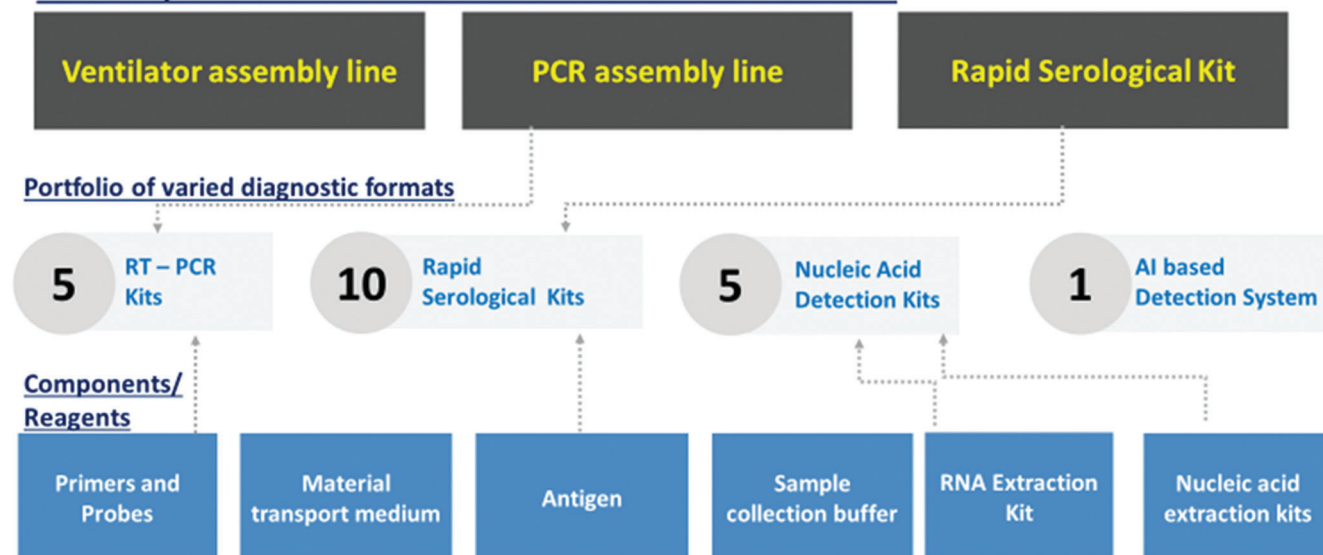




## Diagnostics



### Common/Shared facilities – DBT AMTZ COMMAND Consortia



### Products Commercialized from AMTZ

S No.	Product Brand Name	Product Type	Launched in Market	Units sold
1	Swasit, Swasit +, Numo, LV 100, LV 1000	Critical Care Ventilators	Yes- June 2020	2800 units
2	TrunatCovidsure	RT-PCR	Yes- Trunat April 2020 Yes- Covid Sure - June 2020	Trunat -23 Lakhs Covid Sure-16 Lakhs
3	ERBA LISA - Covid-19IgG	ELISA	Yes Aug-2020	99000 tests
4	Vi-sure	Viral Transport Media	Yes- May 2020	8 Lakhs
5	Asha Plus	IR Thermometer	Yes- Mar 2020	2500
6	iLAB- Rapid Response mobile lab	Mobile Lab	Yes- June 2020	1 & 4 in order stage

I-Lab: Hon'ble Minister of H&FW, S&T and ES, Dr Harsh Vardhan, in the presence of Secretary, DBT, launched India's first I-lab (infectious disease diagnostic lab) to ramp up the COVID-19 testing in rural and inaccessible areas; building of these mobile testing labs is supported through the AMTZ COVID-Command. The first I-Lab is operational and is attached to the THSTI, Faridabad hub. It visited in and around villages and colonies of Faridabad, Ballabhgarh, and Palwal and as on December 3, 2020 has tested 8929 samples in total.



## Main Diagnostic Facilities Per I-Lab

	RT-PCR	ELISA
Capacities	96 TESTS/ DAY	300 TESTS/DAY
Reagents	RT-PCR Kits for performing 2400 tests per month  RNA Extraction Kits for performing 2400 tests per month	ELISA COVID-19 IgG/IgM for COVID-19 Kits for performing 7500 tests per month

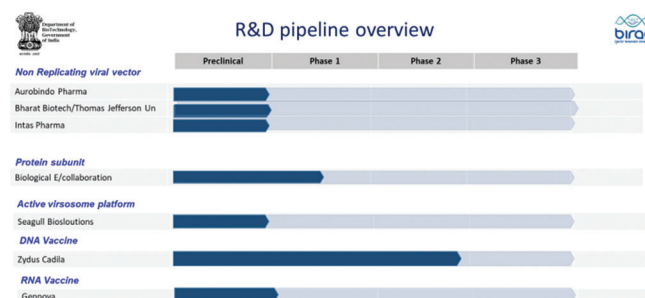
## 2.2 Therapeutics Development:

- **Virchow Biotech: Purification of IgG (convalescent sera from COVID recovered individuals)** at commercial scale and conduct clinical trials using these preparations in CoV positive patients. In parallel, cloning, expression and purification of COVID antigens and immunization of horses with CoV antigens and purification of high titers of equine hyper immune globulin against COVID-19 for the treatment of COVID infected patients.
- **University of Delhi, South Campus and Genova Biopharma Ltd:** To use a phage-display based technology to discover SARS-CoV-2-specific antibodies. Aimed at large scale production and purification of selected antibodies and their evaluation for in vitro/ in vivo neutralization and animal challenge study will be carried out followed by phase 1 and II neutralizing antibodies
- **Bioklone Biotech Pvt Ltd:** To develop an immunotherapeutic for COVID-19 using B cells from convalescent patient blood. (i) Isolation of B cells from COVID-19 convalescent patient blood and development of human monoclonal antibodies (mAb) to SARS-CoV2 proteins (ii) Identification of clones with virus neutralizing potential with high avidity
- **Zydus Cadila:** Repurposing of pegylated Interferon alpha 2 b for COVID-19
- Various academic Institutes have also been supported for :longitudinal study for convalescent plasma therapy (IIT Bombay), development of anti-viral peptide aptamers (Madurai Kamaraj University and ICGB), anti-COVID-19 drug discovery and development program (Central University of Tamil Nadu, IIT Madras)

and evaluating potential role of BCG as a prophylactic agent in hamster model of infection (IISc, Bangalore and ICMR-NICED, Kolkata)

## 2.3 Vaccine Development

DBT's efforts are especially recognized in the area of vaccines whereby, the Department has been identified as the central coordinating agency by the PMO constituted Task force on Vaccines. Both national efforts and international partnerships are being leveraged for vaccine development and manufacturing. Nationally, nearly 30 groups, both academia and industry, are actively involved in development or collaboration or co-development and trials for COVID-19 vaccine in India. Of these, about eight industry-based groups and seven academic groups are being supported by DBT for development of candidate vaccines and associated resources for COVID-19. Various Technology platforms to develop COVID 19 vaccines are being supported. Some major projects being supported include development of mRNA vaccine candidate by Genova Biopharmaceuticals Ltd., inactivated rabies virus vector vaccine candidate by Bharat Biotech, VesiculoVaxplatform based candidate by Aurobindo Pharma, recombinant Adeno Associated Virus vector based candidate by Intas Pharmaceuticals, and virosome based platform by Seagull Biosolutions.

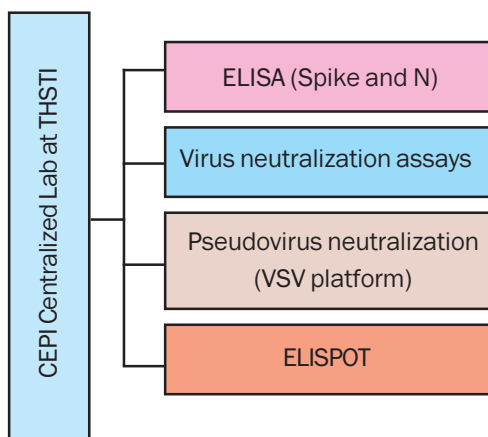


DBT supported DNA vaccine candidate against SARS-CoV-2, being developed by Zydus Cadila, established safety and tolerability in Phase I clinical trials. Phase II Clinical Trials are ongoing and are expected to be completed in December, 2020. Also, the recombinant protein subunit vaccine candidate by Biological E, being supported by DBT, has entered Phase I clinical trials. Furthermore, the self-replicating mRNA vaccine candidate, HGC019 developed by Genova

Biopharma, in partnership with HDT Bio, has been approved by the Drugs Controller General of India (DCGI) for conduct of Phase I/II human clinical trials. DBT-BIRAC has facilitated the establishment of the first-of-its-kind mRNA-based vaccine manufacturing platform in India through provision of seed funding for the development of Gennova's novel self-amplifying mRNA-based vaccine candidate for COVID-19.

Projects encompassing development of bone-marrow chimera mouse model (DBT-NII), development of DNA Electroporation device (Sahajanand Laser Technology Ltd.), development of c-DNA clones (Shiv Nadar University), evaluating immune responses to BCG vaccine (IISc Bangalore), have been initiated. Additionally, to enable comprehensive vaccine development by generating a conducive ecosystem, support is also being extended for development of vaccine associated research resources, establishment of clinical trial sites and notifying enabling regulatory guidelines. The resources include animal challenge models, proteins for performing assays and Pseudovirus for developing neutralization assays.

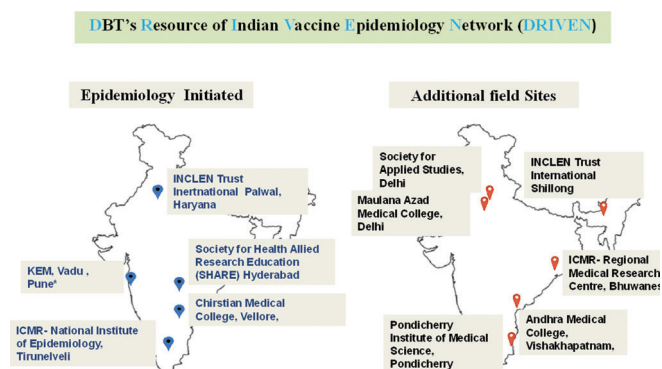
DBT-THSTI, has been recognized by CEPI under their global network of Laboratories for centralized assessment of COVID 19 vaccines. Under the CEPI Global network the Laboratory will use the same reagents and follow a common set of protocols to measure the immune response of multiple vaccine candidates under development and trial which will enable harmonization of the vaccine clinical trial process. This will allow different vaccine candidates to be compared and speed up the selection of the most effective candidate. The mandate of the bioassay laboratory at THSTI is to provide validated assays for vaccine development on par with global standards.



Dr. Reddy's Lab has partnered with Biotechnology Industry Research Assistance Council (BIRAC), for advisory support on clinical trials of Sputnik V vaccine in India

Under DBT's Resource of Indian Vaccine Epidemiology Network (DRIVEN), field sites for facilitation of Phase III clinical trials of global and national vaccine candidates have been prepared. Five GCP compliant clinical trial sites (INCLIN Trust International, Palwal; KEM, Vadu, Pune; Society for Health Allied Research (SHARE), Hyderabad; National Institute of Epidemiology, Chennai and Christian medical College (CMC), Vellore) and six Demographic Health Sites (DHS) spread across the Nation are being prepared. Each site will have access to a cohort of about 50000 - 100000 healthy volunteers, who can be tracked for prolonged periods of time.

#### Field Sites for Clinical Trials



Further, the Government of India (GOI) has launched 'Mission COVID Suraksha- the Indian COVID-19 Vaccine Development Mission', to accelerate the development of at least 5-6 vaccine candidates and ensure that some of these are brought closer to licensure and introduction in the market for consideration of regulatory authorities and for introduction in public health systems. The Mission was announced as part of the third stimulus package with a provision of Rs. 900 Cr. to the Department of Biotechnology (DBT) for research and development of Indian COVID-19 vaccines.

## 2.4 Biomedical Preventive and Treatment solutions

- 1 Develop and deploy contactless, affordable thermopile-based ultrasonic sensors to accurately monitor the temperature of distant moving subjects



2	Indigenous Production of Novel Personal Protective Equipment for Healthcare Personnel
3	Development of a Low-cost Attachment a simple solution that can leverage the AMBU Bag to rapidly convert it to an automatic mechanical ventilator with all basic functionalities desired to manage a pneumonia or ARDS patient
4	Design, develop, and laboratory test a Smart Mechatronic Artificial Respiratory Therapy System (SMARTS), relevant to clinical management of COVID-19
5	Develop an Automated Reprocessing System for hospitals to meet the demand of medical device ventilator expiratory parts, patient circuit, intubation tubes etc. that are necessary in the treatment of patients affected by COVID-19
6	Development and validation of long acting nano material-based coating for inhibiting virus propagation inhibition at various surfaces
7	Design, develop and deploy a digital hand sanitation assurance system. The system comprising of three interconnected
8	A portable protective device to arrest the spread of infection in healthcare and home-care setting
9	Briota'sSpiroPRO for at home monitoring of lung health conditions of high-risk patients (verifying fever, other respiratory symptoms and lung capacity)
10	Development of Screening Technology for testing microbial and viral burden in the environment - Pre/ Post decontamination and monitor Infection Control
11	Development of an Indigenous, High-end, Portable and Invasive Mechanical Ventilator for treating COVID-19 positive patients
12	Affordable Antiviral Coveralls and gowns to provide protection to Healthcare Workers during COVID-19 Pandemic
13	Portable Wireless Infusion monitor and Controller for Gravity Drips

14	A novel interface to improve effectiveness and reduce infection risk of NIV - a lifesaver in COVID scenario
15	Development, Distribution and Evaluation of skin friendly Hand Sanitizer
16	Activated Water Mist AWM based sanitization technology to prevent spread of Covid-19
17	Waist Mounted Hand Sanitizer to combat COVID-19
18	Effective Implementation of Reverse Quarantine Strategy Using Novel M-Health Technology and Community Participation for Control and Prevention of Covid-19 – Pilot Study from Kerala
19	Accessories for affordable mask for preventing endemic outbreak
20	<i>One of the DBT's Biodesign Centre, Healthcare Technology Innovation Centre (HTIC) at IIT Madras and Helyxon, a healthcare startup in IIT Madras Research Park deployed a jointly developed remote patient monitoring solutions for COVID-19. The device is a first-of-its-kind in the market that does clinically accurate continuous monitoring of four critical parameters – Temperature, Oxygen Saturation, Respiratory Rate and Heart Rate. The device is completely self-contained, portable, wireless and can be clipped on to patient's finger and data is streamed to a mobile phone or central monitoring system</i>

## 2.5 Ecosystem for Research and Development

DBT along with BIRAC has also been working to facilitate regulatory support to start-ups through its:

- **FIRST HUB initiative:** Representatives from ICMR, CDSCO, GeM etc. join for special weekly sessions being run every Friday to address the queries of start-ups in wake of the COVID crisis. Regulatory facilitation of 250+ Start-ups were done through FIRST HUB and RIFC (Regulatory Information & Facilitations Centre).
- **Under Biosafety regulation following steps have been taken and guidelines published:**
  - o Rapid Regulatory Response Mechanism

- o Interim Guidance Document on Laboratory Biosafety to Handle COVID-19 Specimens
- o Guidelines for Sharing of Bio-specimen & Data for Research on COVID-19
- o A Rapid Regulatory Pathway for COVID Vaccine developed to facilitate Vaccine Trials
- National Biomedical Resource Indigenization Consortium (NBRIC) was launched to drive indigenous innovation in a Public-Private Partnership with DBT, BIRAC, ABLE and C-CAMP. This Make in India initiative is an important step towards building a self-reliant India. Over 40 companies have till now partnered to develop RT-PCR Kits and its associated reagents and consumables along with serological tests/lateral flow assays and its associated reagents and consumables under NBRIC.

## OTHER INITIATIVES:

*Call launched to mitigate COVID-19 through botanical and traditional medicine:*



*Call launched, soliciting proposals for COVID-19 therapeutics.*



## B INTERNATIONAL EFFORTS

### EU-INDIA COOPERATION

“Department of Biotechnology (DBT) in partnership with European Commission (EC) announced a co-funding call for expression of interest (EoI) on COVID-19 under ‘Horizon 2020’ work programme on **May 30, 2020 with a deadline to submit joint proposals by June 11, 2020**. This initiative aimed to develop innovative and rapid health-related approaches and deliver quick results relevant to society and higher preparedness of health systems to mitigate emergencies like COVID-19. DBT had agreed to participate in 4 call topics focusing on the following: -

- Repurposing of manufacturing for vital medical supplies and equipment
  - Medical technologies, Digital tools and Artificial Intelligence (AI) analytics to improve surveillance and care at high Technology Readiness Levels (TRL)
  - Pan-European COVID-19 cohorts || Research and Innovation Action
  - Networking of existing EU and international cohorts of relevance to COVID-19"
- As an outcome of this co-funding announcement, an ambitious project entitled “*Connecting European Cohorts to Increase Common and Effective Response to SARS-CoV-2 Pandemic*” (ORCHESTRA) has been recommended for further financial support.
- The project is the consortium of 27 institutions belonging to following 15 countries (mainly of EU member states, Horizon 2020 Associate members and LMICs). From India, the project is being coordinated by Prof. Shinjini Bhatnagar, THSTI, Faridabad and by Dr. Dr Uma Chandra MouliNatchu, SJRI, Bangalore.

With a vision to efficiently generate rigorous evidence to improve prevention and treatment of COVID-19 and to rapidly provide a structured platform to test vaccine as soon as available, the said proposal will accomplish the following in **36 months**.

- 1) To establish a new population-based cohort including existing and new large-scale cohorts to rapidly advance

the knowledge on the control of the SARS-CoV-2 infection (short term outcome)

- 2) To define common data standards for data sharing and ensure that all uses of personal data comply with the EU GDPR (short term outcome)
- 3) To assess risk and preventive factors for SARS-CoV-2 infection in order to develop evidence-based recommendations for effective prevention of spreading (short term outcome)
- 4) To investigate human (epi) genetic, immunological, microbial, and viral features with the aim of identifying markers of disease severity (medium/ long term outcome)
- 5) To improve comparability by homogenize bio-sampling protocol for collection, analyses and storage, and data sharing among biobanks (medium-term outcome)
- 6) To establish a large-scale population-based cohort with defined structure and protocols to assess prospectively long-term consequences of COVID-19 (6-12-18-month) and analysis of efficacy of vaccination when vaccines will be available (medium/ long term outcome)
- 7) To estimate the burden of COVID-19 with a multidisciplinary approach accounting by major clinical cofounders, differences in health care systems, geographic factors, and economic and critical social factors (medium-term outcome)

The proposal is likely to provide an innovative approach to learn from the SARS-CoV-2 health crisis and derive recommendations for increasing preparedness for future outbreaks. New pan-European cohort built on existing and, new large-scale population cohorts in European and non-European countries will be established. Data analysis through a federated learning technique supported by advanced modelling capabilities will allow the integration of epidemiological, clinical, microbiological, and genotypic aspects of population-based cohorts with environment and socioeconomic Features.

The ORCHESTRA cohort will include SARS-CoV-2 infected and non-infected individuals of all ages and conditions and thereby enabling a retrospective evaluation of risk factors

for the disease acquisition and progression, and prospective follow-up aimed at exploring long-term consequences and analysis of vaccination response when vaccines will be available. The project will assess also health costs of COVID-19 with special emphasis on delayed health services in the fragile populations. The project will significantly impact on the responsiveness to SARS-CoV-2 and can be used as a model for responsiveness for new public health threats.

**UK-INDIA COOPERATION:** The Department of Biotechnology (DBT), New Delhi in collaboration with UK Research and Innovation (UKRI), through the Medical Research Council (MRC) and Economic and Social Research Council (ESRC), UK launched a “*UK-India Covid-19 Partnership Initiative*” on 27<sup>th</sup> October, 2020. Through this partnership, DBT and UKRI (MRC & ESRC, UK) will support collaborative research focused on understanding the severity of COVID-19 in South Asian populations in India and the UK with the proposal submission deadline of 3<sup>rd</sup> December 2020.

**BRICS STI FRAMEWORK PROGRAMME: Response to COVID-19 pandemic coordinated call for BRICS multilateral projects 2020:** The COVID-19 pandemic caused by SARS-CoV-2 is one of the greatest global challenges, and as such warrants a global response. BRICS countries account for more than 25% of the world territory, more than 40% of the world population and play a vital role in the world economy. In response to the COVID-19 pandemic, the **BRICS STI Framework Programme** launched a call for multilateral basic, applied and innovation research projects facilitating cooperation among the researchers and institutions in the consortia which consist of partners from at least three BRICS countries corresponding to the following thematic areas:

1. Research and development of new technologies/tools for diagnosing COVID-19.
2. Research and development of COVID-19 vaccines and drugs, including repurposing of available drugs.
3. Genomic sequencing of SARS-CoV-2 and studies on the epidemiology and mathematical modelling of the COVID-19 pandemic.
4. AI, ICT and HPC oriented research for COVID-19 drugs design, vaccine development, treatment, clinical trials and public health infrastructures and systems.



5. Epidemiological studies and clinical trials to evaluate the overlap of SARSCoV-2 and co-morbidities, especially tuberculosis.

As a part of the initiative the following research funding organizations from the BRICS countries agreed to jointly establish a scheme for funding multilateral cooperative activities:

- **Brazil:** National Council for Scientific and Technological Development (CNPq)
- **Russia:** Foundation for Assistance to Small Innovative Enterprises (FASIE) Russian Foundation for Basic Research (RFBR)
- **India:** Department of Biotechnology (DBT) Department of Science and Technology (DST)
- **China:** Ministry of Science and Technology (MOST) National Natural Science Foundation of China (NSFC) South Africa:
- **South African Medical Research Council (SAMRC)**



## BRICS STI Framework Programme: Response to COVID-19 pandemic coordinated call for BRICS multilateral projects 2020

### Partnerships for Accelerating Clinical Trials (PACT)

- The Department of Biotechnology, identified as the nodal centre by the PMO constituted Task Force, to consolidate efforts for Indian vaccine development, is working closely with the Ministry of External Affairs, Government of India for supporting COVID-19 vaccine development activities in partnering countries. Accordingly, the Indian PACT (Partnerships for Accelerating Clinical Trials) programme has been

launched for supporting COVID-19 vaccine development activities in partnering countries. The initiative will be implemented by Biotechnology Industry Research Assistance Council (BIRAC) and Clinical Development Services Agency (CDSA) under the aegis of the National Biopharma Mission and Ind-CEPI Mission of DBT. The national partners include Ministry of External Affairs, Ministry of Health and Family Welfare, Indian Council of Medical Research (ICMR), Central Drugs Standard Control Organisation (CDSCO), and the international partners include Coalition for Epidemic Preparedness Innovations (CEPI), World Health Organization (WHO) and National Institute of Health (NIH).

## PACT: A SCIENCE DIPLOMACY INITIATIVE

### Partnerships

Multilateral collaborations and partnerships for making available a safe and effective vaccine for COVID-19

### Centralised Immunoassay

THSTI, Faridabad recognized by CEPI as one of the 6 global network of laboratories for centralized assessment of COVID-19 Vaccines

### Ind-CEPI

'India Centric Epidemic Preparedness through Rapid Vaccine Development: Supporting Indian Vaccine Development'

### LMIC Benefits

Supporting efforts for advancing clinical trial capacity in neighbouring countries and LMICs

The activities being undertaken under the Partnerships for Accelerating Clinical Trials (PACT) programme, include facilitation for Phase III clinical trials of Indian COVID vaccines in neighbouring and friendly countries and Trainings for strengthening clinical trial research capacity in neighbouring countries

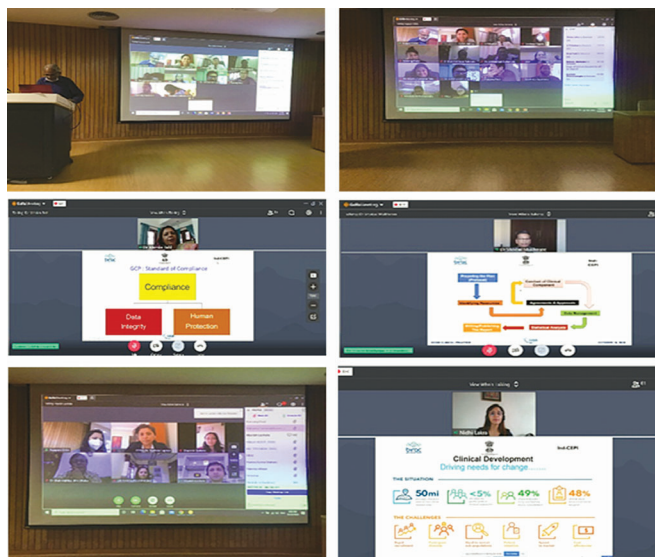
### Phase III Clinical Trials of Indian COVID vaccines in Neighbouring and Friendly Countries

- 1 For Indian companies and researchers, conducting **Clinical trials** of vaccines developed by them in neighbouring and friendly countries
- 2 For LMICs, access to **advisory support** for planning and executing Phase III trials
- 3 For partnering countries, access to the Indian Vaccine development Ecosystem e.g. **Immunogenicity assay testing** of potential vaccine candidates

Building science diplomacy for technological advancement and acceleration of indigenous vaccine development efforts

## Trainings for Strengthening Clinical Research Capacity in Neighboring Countries

Aimed towards skill development, capacity building and development of surveillance frameworks, Ind-CEPI initiated the eCourse Series ***“Strengthening Clinical Trial Research Capacity in Neighbouring Countries”*** in collaboration with CDSA, Faridabad. This training envisages an in-depth coverage of Good Clinical Practice, Ethical considerations in clinical research, Good Clinical Laboratory Practice and Large vaccine field trials. An orientation session to this training program was conducted on 22<sup>nd</sup> Sep 2020 through online platform. Four Sessions on Good Clinical Practice was organized on October 9<sup>th</sup>, 16<sup>th</sup>, 23<sup>rd</sup> and 29<sup>th</sup> with 75, 90, 60 and 88 participants respectively. Two sessions on Ethical Considerations in Clinical Research were organized on 6<sup>th</sup> and 13<sup>th</sup> November, 2020 with 116 and 88 participants respectively. Also, two sessions on Good Clinical Laboratory Practice were organised on 20<sup>th</sup> and 27<sup>th</sup> November, 2020 with 73 and 68 participants respectively. First module for training on Novel vaccine development and immunization policy in a pandemic was held on 4<sup>th</sup> December, 2020 with 69 participants. The second and concluding module of the e-Course training series is scheduled on 11<sup>th</sup> December, 2020. The training modules have been received successfully and have been attended by participants from Afghanistan, Bangladesh, Bhutan, Maldives, Mauritius, Nepal and Sri Lanka



## EFFORTS AND RESPONSE TO COVID-19 PANDEMIC BY DBT AUTONOMOUS INSTITUTIONS

The goal of containing the spread and health impact of SARS-CoV-2, the etiological agent of COVID-19, relies on a comprehensive strategy of rapid testing of the virus in the population, effective treatments, and the development of therapeutics to prevent and control viral infection. In addition to the activities to address these immediate public health needs, it is important to gain scientific advances to understand how SARS-CoV-2 infects humans and affects different organs of the body. The swift deployment of the DBT AIs' world class research infrastructure and highly skilled scientific personnel have resulted in initiation of a broad spectrum of efforts ranging from testing and diagnostics, generating enabling resources to facilitate in-depth understanding of viral infection and progression, and interdisciplinary research programs to find new anti-viral treatment regimes.

**Testing and Diagnostics:** All the DBT AIs have stepped up to the need of the hour and have contributed immensely to COVID testing in their respective states. To scale up testing DBT initiated a hub and spoke model of testing, whereby 21



clusters have been established in a PAN-India manner. Institutes and Laboratories which have the capacity and expertise for both sample collection, handling/processing (BSL-2 facility) and testing (RT-PCR) serve as the hubs and they involve a number of laboratories which have RT PCR machines and the requisite manpower as their extended Testing facilities. Nine DBT Autonomous Institutes (AIs) have been approved as testing centres for COVID-19 diagnosis and are acting as the hubs for their respective City/Regional clusters. Since 15th April, 2020, 20,79,732 samples have been tested by DBT-AI testing hubs. Manpower support for this activity has been funded by the Department of Biotechnology. In addition, all the hubs have been facilitated with the respective state Governments for consumables, equipment and other support as required.

DBT-THSTI's Bioassay Lab (BL) became an ICMR-recognized COVID-19 testing facility, the first one in Faridabad-Palwal region. Bioassay lab has processed more than 55,000 clinical samples for diagnosis from several districts to date. This BL has also been chosen to offer validation services for diagnostic kits by The Foundation for Innovative new Diagnostics (FIND) and Indian Council for Medical Research. THSTI entered into an agreement with the Coalition for Epidemic Preparedness Innovations (CEPI). Under the



agreement, CEPI will a) support provision of access by CEPI Partners (seven labs identified across the world) to COVID-19 testing services and facilities and b) THSTI will have the capacity, equipment and resources to carry out COVID-19 related testing of various biological samples to be provided by CEPI Partners. The Infectious Disease Diagnostic Lab (I-LAB), a mobile lab unit for COVID-19 testing, is being used for COVID-19 testing by THSTI in Faridabad and its adjoining areas.

Similarly, NCCS initiated sample testing early on in April 2020, when very few testing laboratories were available in Maharashtra, the worst-hit state at the time. Centre for DNA Fingerprinting and Diagnostics, Hyderabad initiated RT-PCR based diagnostics for COVID-19 from as early as 17<sup>th</sup> April 2020. Analysis of more than 29,000 samples has been completed till date resulting in the identification of greater than 7500 positive patients which has helped in contact tracing, quarantine and containment efforts of the Telangana government.



DBT-ILS Bhubaneswar has played a significant role in augmenting the testing capacity in Odisha. ILS commenced its testing with effect from 14 April 2020. DBT-ILS has till date carried out RT-PCR based tests for 1,25,000 samples, covering 26 of the 30 districts of Odisha. Also, NIBMG in collaboration with IPGME&R and JNM Hospital, Kalyani have contributed to COVID testing of more than 9000 samples in the state.

Recognizing the need for aggressive testing in India's battle against COVID-19 during early April, inStem and NCBS brought their resources, community and facilities together to set up a testing laboratory. Over 90 volunteers from across inStem and NCBS, enabled the facility to run every day of the week from April 13, 2020. The testing facility, which now operates with dedicated staff, has since tested more than 60,000 samples from Karnataka. ICGBE, New Delhi joined

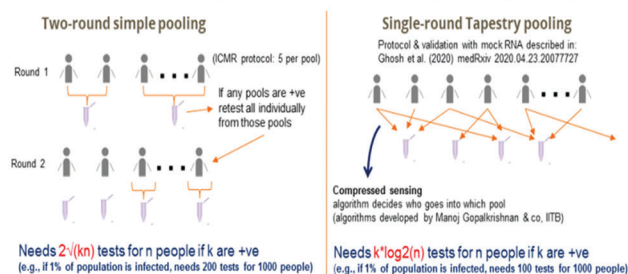


the national effort in controlling the spread of the disease by actively testing hundreds of samples everyday by RT-PCR. On an average 2500 tests are being conducted in a month at the facility. DBT-IBSD-JNIMS Covid-19 testing laboratory at Imphal, Manipur which was accorded approval by ICMR on July 11, 2020, has initiated independent testing and is reporting directly to ICMR. IBSD has supported several north eastern states by providing RT-PCR and other instruments, consumables, and manpower assistance for testing. Also, PPE Kits, Sanitizers etc. were distributed several times among public and in different organizations. Besides, IBSD is independently testing two districts of Manipur- Kangpokpi and Pherzawl district.



Additionally, in partnership with theorists at NCBS and IIT Bombay, DasaradhiPalakodeti of inStem has contributed to the development of a new way to increase and improve testing capacity. The method called Tapestry, is a novel quantitative non-adaptive pooling scheme that can test ~1000 samples at once using the same quantity of reagents that are normally employed for running only 100 samples. More information of this technique can be found at: <https://doi.org/10.1101/2020.04.23.20077727>. As a natural extension of the infrastructure and trained personnel to handle patient samples and to conduct COVID-19 testing efficiently, inStem and NCBS have received designation from the ICMR-NIV to serve as a validation centre for new testing kits developed by academic and biotechnology laboratories. On similar lines, THSTI has also developed Aptamer-based ALISA developed for antigen detection, and, low-cost colorimetric assays for COVID-19 were developed and transferred to industry. Development of aptamer conjugated Citrate Gold

### Simple pooling vs combinatorial Tapestry pooling

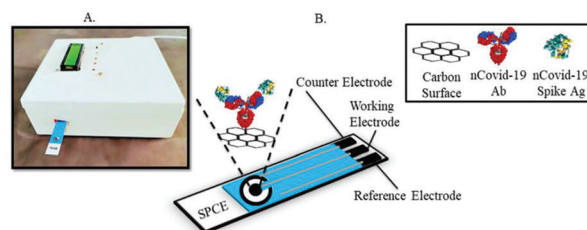


#### Advantages of Tapestry pooling:

1. Fewer tests for large numbers – savings of reagents
2. Single-round – savings of time
3. Can be designed for different use cases, e.g., different expected infection rate

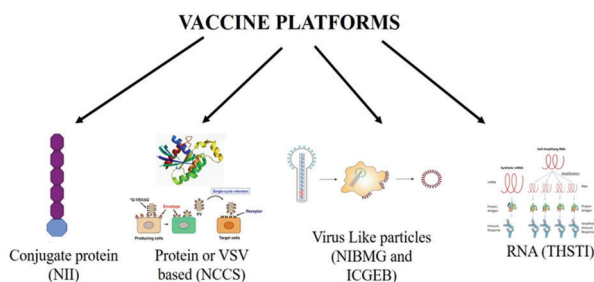
nanoparticles flow strip for testing in actual patient samples is in the final stage at NABI. Furthermore, work by researchers at NABI provides preliminary data that loss in smell sensation for different kind of odorants can be exploited as a quick and affordable screening test to identify infected cases among at risk individuals or localities. The odor test will facilitate targeted mobilization of resources for tracing, testing, and isolation of cases in these areas.

In consultation with ICGEB, J.Mitra & Co. Ltd have also developed a 'COVID-19 MICROLISA' test for the detection of COVID-19 (SARS-CoV-2) IgA, IgM, and IgG antibodies in human serum/plasma. A MoU has also been established between ICGEB and J Mitra & Co Ltd for the development of an antigen test for COVID-19. A sensitive biosensor for detection of novel corona virus surface protein in clinical sample has been developed at DBT-NIAB. This is a potentiostat based sensor to measure change in electrical conductivity by immobilizing the Ab on screen printed carbon electrode (SPCE). The device could detect the surface antigen of SARS CoV2 causing COVID-19, upto fM range. The portable point of care device can be used for rapid detection of coronavirus Ag in human saliva samples.



(A) The fabricated in-house built electrochemical device; (B) Schematic of fabrication process where nCovid-19 Ab was immobilised onto the SPCE followed by addition of nCovid-19 Ag and the transducer detected changes in electrical signal due to Ag-Ab interaction.

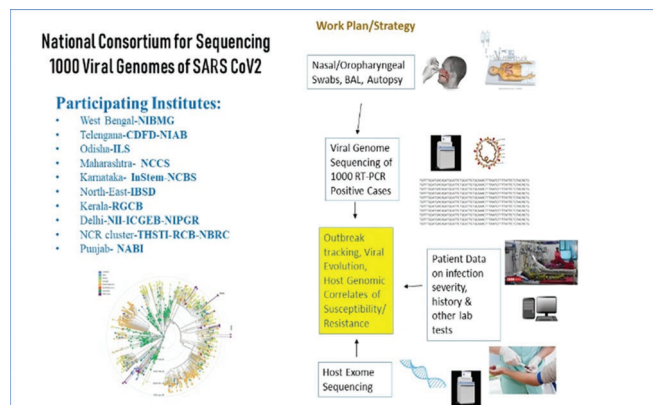
**Vaccine Development:** Different strategies employed by the AIs to develop a vaccine against SARS-CoV-2 are represented in the figure below.



Scientists at NII have developed a novel RBD based candidate vaccine using *E. coli*. The nanoparticle-based formulation elicited high antibody titer. Detailed analysis of the antibody isotypes and Th1 response is in progress. Partnership with Industry to evaluate the immune response in pre-clinical set up is underway. Synthetic antigen-based vaccine for eliciting SARS-CoV-2-specific IgA antibodies to protect lungs / mucosal surfaces are being developed as a potential vaccine candidate at NCCS. They are also working towards production of pseudotyped SARS-CoV-2 using VSV platform for candidate vaccine development and biomedical research use. Scientists at THSTI are working on the development of a self-amplifying mRNA Vaccine candidate against SARS-CoV-2.

Further, THSTI's Bioassay Lab was recognized by CEPI as a centralized laboratory to provide assay services for COVID-19 vaccine development. Under the agreement with THSTI, CEPI will fund development and manufacturing initiatives of vaccines for COVID-19. NIBMG is also involved in generating vaccine based on virus like particles (VLP). The VLP will be constructed using the structural proteins of SARS-CoV-2. RCGB has also initiated work for generating VSV DeltaG –SARS CoV-2 pseudotyped virus. The development of a plant based vaccine is also underway at NIPGR in collaboration with ICGB. The leaf extracts of plants expressing the RBD and purified protein will be tested and used for immunization of mice at different doses to trigger a strong immune response against the virus. As plant-based vaccines provide the ease of administration and monitoring, developing such a vaccine for SARS-CoV-2 would assist in executing mass immunization drives.

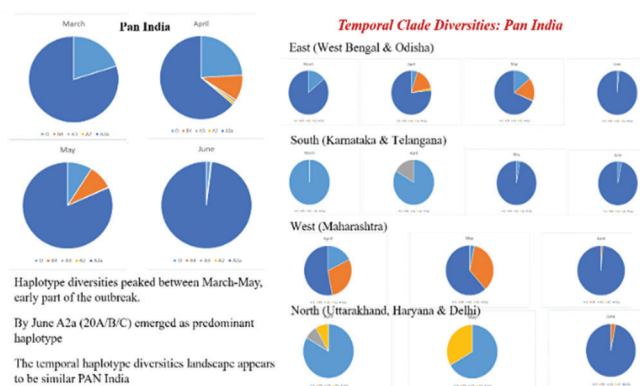
**Genomics:** A PAN-INDIA 1000 SARS-CoV-2 RNA Genome Sequencing Consortium consisting of DBT AIs and collaborating research and clinical organizations were formed under the aegis of the Department of Biotechnology. Institutes across India such as inStem-NCBS, NCCS, CDFD-NIAB, ILS, IBSD, RGC, NII-ICGEB-NIPGR, THSTI-RCB-NBRC and NABI are members of this genomics initiative which is coordinated by NIBMG. The Consortium members has published the initial results on 1058 clinical samples in the form of nasopharyngeal and oropharyngeal swabs collected from individuals testing positive for COVID-19 as per the guidelines of ICMR, isolated and sequenced viral whole genomes. The data is being jointly analyzed along with available epidemiological information on these samples, and all efforts are being undertaken by the Consortium members to disseminate the sequence and related information in GISAID in real-time. It is expected that this large-scale initiative will facilitate informed public health decisions to control the outbreak and provide major thrust in the development of intervention measures.



SARS-CoV-2 RNA sequences generated by the Consortium were distributed in different Indian states. Phylogenetic analyses revealed that the sequences could be classified into 5 different haplotypes, viz., 19A (8%), 19B (5%), 20A (38%), 20B (48%) and 20C (0.5%). The frequency of the viral haplotypes also varied state-wise and region-wise across India. The temporal haplotype diversities scenario in respective regions were largely similar to the pan India landscape, with haplotype diversities peaking between March-May, while by June A2a (20A/B/C) emerged as the predominant one. 19A and 19B haplotypes were genetically close to sequences from other Asian countries, while the 20A, 20B and 20C revealed homology with European and

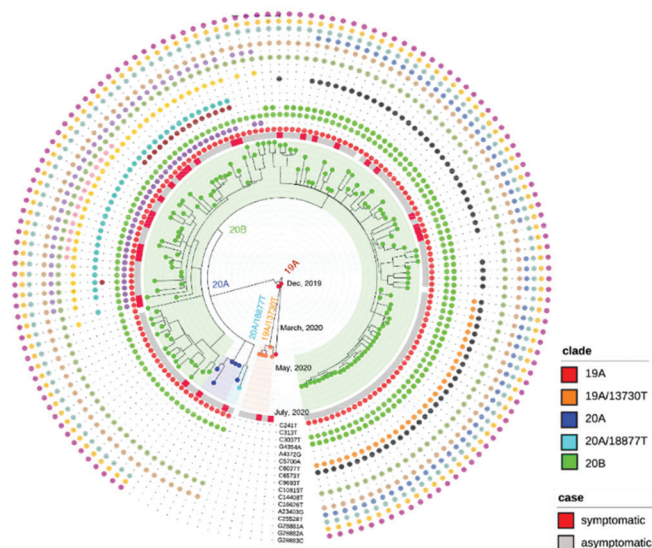
American countries. The country confidence information from phylodynamic time-tree highlighted that haplotype 19A and 19B were mostly introduced from China and 20A, 20B and 20C from the United Kingdom, Italy and Saudi Arabia. Events of multiple introductions of the same haplotype in some geographic regions were also observed.

Temporal and spatial analyses of the various accumulating mutations revealed remarkable clustering-pattern. Some mutations are present at particularly high frequencies in one state as compared to others. Mutation analyses underscored the preponderance of the D614G mutation in structural spike protein, which was observed to be emerging across the whole of the country. D614G in Spike and P323L mutation in RdRP have attained frequencies above 75% in most states to date. Several additional mutations in functionally important regions of SARS-CoV-2 genome with significant geographical clustering have also been observed. The negative estimate Tajimas D ( $D = -2.26817$ ) is consistent with the rapid expansion of SARS-CoV-2 population in India. Detailed mutational analysis across India to understand the gradual emergence of mutants at different regions of the country and its possible implication will help in better disease management.



Analysis of the data indicates that the haplotype diversities pan India and, in each region, continued to increase until May 2020, subsequent to which it reduced drastically with the emergence of the A2a haplotypes which has overtaken other lineages by June 2020. Further data is required to understand whether this observation might also reflect no new introductions of the virus in the country subsequent to May 2020 since India implemented a national lockdown between April to May. Such interpretations might enable improved understanding of such informed public health decisions.

Integrative analyses of SARS-CoV-2 genomes from different geographical locations have been performed at ICGEB which revealed unique features related to host-virus interaction, pathogenesis and clues for novel therapies. Predicted host micro RNAs targeting virus genes, host genes and transcription factors co-regulatory interaction network in cases of infections have also been studied. MD simulations to study the structural and dynamical changes of spike glycoprotein mutations associated with SARS-CoV-2 host receptor binding were performed. The complete genome sequence of >200 SARS-CoV-2 RNA samples was determined with the overarching objective of identifying unique mutations, in addition to determining the dominant viral lineages circulating in the population in the state of Telangana by Scientists at CDFD. The phylodynamic analysis of the sequences revealed a singularly high preponderance of the 20B lineage (also called as G/GR clade). A comprehensive analysis of mutational landscape including high and low frequency variants revealed the presence of frequently mutated regions in the genome.

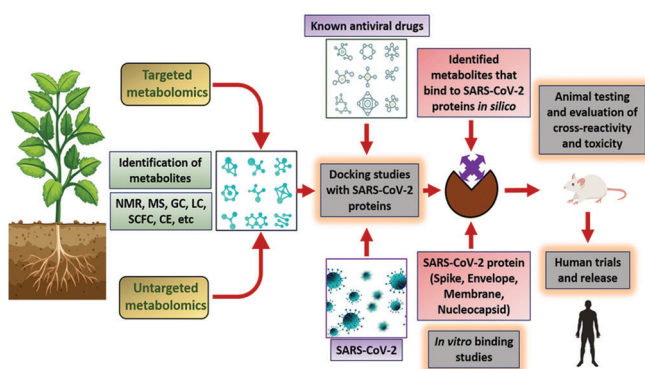


**Therapeutics:** The DBT AIs are collaborating to develop and test a vast variety of therapeutic compounds. NIPGR in collaboration with ICGEB and RCB is screening flavonoids from banana peel for their anti-viral activity. NIPGR in collaboration with RCB is also investigating anti-viral activities of various potent glucosinolates namely, sinigrin (from *B. nigra*), gluconapin (*B. rapa*) and glucomoringin (*Moringa*



*oleifera*). To harness the potential of traditional knowledge based medicinal plants for identifying anti SARS-CoV2 compounds; DBT-ILS is evaluating the potential of 25 medicinal plant extracts in restricting the growth of SARS-CoV-2 in human cells. Taking advantage of its geographical location, DBT-IBSD in collaboration with RCB and ILS is in the process of testing several extracts of NER medicinal plants with anti-viral properties.

Additionally, scientists at RCB have screened the *in vitro* antiviral activity of 15 plant extracts. Extracts from Tulsi, Kalmegh and Kalonji showed maximum antiviral activity. Research at NBRC has found that Triterpene from Yashtimadhu, which is used for inflammatory and respiratory illnesses, inhibits SARS-CoV-2 viral protein induced lung cell death and cytokine storm and is highly effective in inhibiting the replication of SARS-CoV-2 virus without exhibiting any cytotoxicity to the host cells. CIAB in collaboration with RCB is testing the ability of natural garlic essential oil as a potential inhibitor of ACE 2 protein and the main protease PDB6LU7 of SARS-CoV2. Additionally, CIAB is also working towards developing photo-sensitizer nano-formulations for the eradication of SARS-CoV-2 via antiviral photodynamic therapy. Some of these phytopharmaceutical drugs such as AQCH developed by ICGEB as a potential treatment for COVID-19 patients are in Phase-2 trials. ICGEB and THSTI are also collaborating with AYUSH scientists to test selected AYUSH herbal formulations to mitigate SARS-CoV2 and associated pathologies.



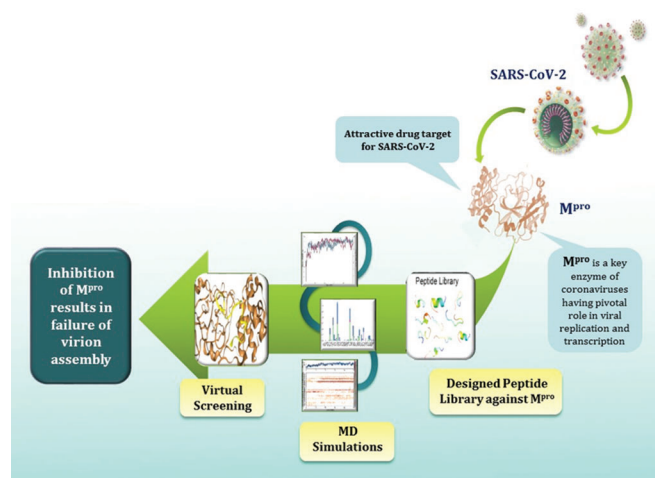
DBT-AYUSH partnership	<ul style="list-style-type: none"> <li>Joint network programme, involving DBT AIs and National Medicinal Plants Board (NMPB) to harness the potential of indigenous medicinal plants for development of plant-based therapeutics to treat COVID-19 ; 50 plants to be screened.</li> </ul>
DCGI approved first Phytopharma drug	<ul style="list-style-type: none"> <li>Phase II clinical trials of AQCH, a phytopharmaceutical drug, developed by DBT-ICGEB along with Sun Pharma initiated. Results expected by October, 2020</li> </ul>
Immunoglobulin based therapeutics	<ul style="list-style-type: none"> <li>Commercial scale purification and clinical trials of immunoglobulin G (IgG) from convalescent individuals</li> <li>Therapeutic human monoclonal antibodies from B-Cells of recovering patients</li> <li>Equine immunoglobulin therapy</li> </ul>
Resources for drug screening	<ul style="list-style-type: none"> <li>Organoid technology <i>in-vitro</i> platform for drug screening and identification of new drug targets</li> </ul>

#### Schematic diagram depicting Highlights of developed effective therapeutics.

The strategy adopted was to develop new diagnostic solutions, studies to understand the pathophysiology of the disease, immediate scale-up of Biomedical solutions developed by Indian start-ups for deployment which was followed by establishing COVID Research Consortia portfolio of Vaccines, Drugs, Diagnostics and other biomedical solutions. In addition facilitation and product development was supported by holding special sessions on COVID-19 regulatory facilitation to start-ups and enhancing the established capacity under its various missions and international partnerships like the National Biopharma Mission, Ind-CEPI, Vaccine Action Program ( NIH-DBT collaboration).

Apart from the phytochemicals, ongoing research is also targeted at developing antibody-based therapy for COVID-19. Monoclonal antibodies generated from single cell sorted memory B cells derived from COVID-19 recovered individuals are being tested by researchers at ICGEB in collaboration with ICMR, and Emory University, USA. Similar virus-neutralizing human monoclonal antibodies are also being developed at NCCS. NII is also in the process of standardizing protocols for enrichment of IgG from human plasma which will have potential for purifying IgG from convalescent plasma. Additionally, NCCS is also involved in peptide-based therapeutics where they have identified four peptides with strong binding affinity against the main protease of SARS-CoV-2 (Mpro), which are being tested in association with the industry. Scientists from inStem and NCBS are working to repurpose FDA-approved drugs to inhibit SARS-CoV-2 entry into cells. The primary screen has identified 38 compounds from a 1280-compound LOPAC library. Of these, 15 compounds have been shortlisted for further analysis based on a series of secondary screens. The establishment of lung

organoids, which can be extended to test SARS-CoV-2 infection assays, will further expand the repertoire and scope of pre-clinical assays. These studies will then be extended to the mouse models of COVID-19 pathogenesis. Academic-industry collaboration between inStem and the R&D unit of Hindustan Unilever in Bangalore is studying the regulation and function of the rich source of antimicrobial peptides (AMPs) in the skin. Building on earlier work the study is assessing whether the AMPs secreted from the skin are capable of targeting the SARS-CoV-2 virus.



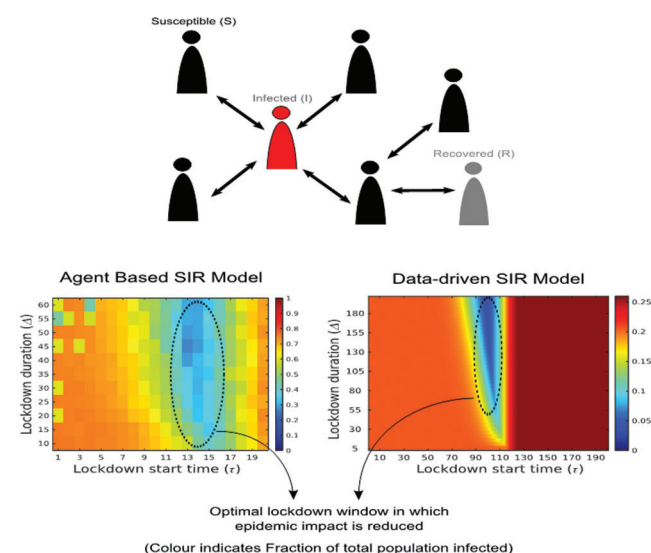
NCCS identified potential therapeutic molecules that target the Mpro protein of the COVID-causing virus using Machine learning.

**Other Interventions:** Scientists at ICGB have developed an Artificial Intelligence based classification method for biomedical imaging related to COVID-19 and major infectious diseases. Publicly available PA chest X-ray images of adult COVID-19 patients were used for the development of AI-based classification models for COVID-19 and Non-COVID-19, Pneumonia, Tuberculosis Patients and Normal. 25 different types of augmentations on the original images were performed to increase the dataset size and develop generalized models. The efficiency and utility of the models are being increased with training with additional data from Indian patient. The latest study led by ICGB has offered a new hope to improve plasma therapy regimen in India. This study finds that nearly half of the COVID-19 recovered individuals examined did not have appreciable levels of neutralizing antibodies despite having SARS-CoV-2 specific IgG. More importantly, this study finds that it was IgG antibodies that bind to the receptor binding domain (RBD) of the SARS-

CoV-2, and not the IgG antibodies that bind to the whole viral protein mix, served as an excellent surrogate measurement to estimate neutralizing antibodies. They report that RBD binding IgG titers of more than 1:3000 indicate neutralizing antibody levels of more 1:320, a titer which is likely to increase chances of success with plasma therapy.

**COVID Research:** Apart from developing interventions, research at various AIs is also aimed at developing a better understanding of the disease. NBRC scientists have been using computational tools to model spread of COVID-19 in Indian population. Computational models help determine whether optimum lockdown windows can be identified such that even modest lockdown durations are sufficient in halting the progression of the disease. This is an important question from social, economic and public health point of view. Scientists have demonstrated timing-based effects of lockdown interventions by modeling the population and spread of disease using graphical networks in *Agent-based Modelling* (ABM). They observed sensitive dependence of lockdown efficacy on lockdown timing, and predict optimal lockdown durations depending upon the human social networks of the region. It was shown that disease severity depends on the kind of social networks in the area, and that the disease recovery rates and network sizes are the key determinants of optimal lockdown windows.

Data-driven Susceptible-Infected-Recovered (SIR) model was used to extend their findings to data on actual COVID-19 spread in India. They used known age-structured contact



matrices to simulate SIR dynamics on data provided by World Health Organization (WHO) for different scenarios such as home, school, workplace etc. Further factors such as the total number of ICU beds in the country were considered. Their results reveal that well-timed lockdowns can significantly alter disease dynamics and prevent the maximum number of active cases from breaching the hospitalization threshold, i.e. the capacity of the available healthcare facilities. Their model suggests lockdown windows for maximal effectiveness for arrest of COVID-19 spread while minimizing strain on the available healthcare infrastructure.

Scientists at ILS examined the immunological profiling of the COVID 19 patients which indicated two major observations i.e. High IgA antibodies in contacts might be protective by neutralizing virus in respiratory tract and Cytokine analysis showed IP-10, MCP-3 as severity indicators whereas MIF, MIP1a, IL-1Ra & IL-2Ra as protective factors. The microbiome studies of the COVID patients at DBT-ILS reported experimental evidence of fecal dissemination of the SARS-CoV-2 genome in COVID-19 patients. This clearly indicated that there is a chance of fecal-oral transmission of this virus, hence optimum sanitary and hygienic measures should be adapted at all levels. THSTI became a member of the global COVID-19 Clinical Research Consortium (CRC) to accelerate clinical research for COVID-19 in resource-limited settings. It has also been instrumental in developing protocols and regulatory approvals for studies for understanding human COVID-19 infection. It has been instrumental in several clinical studies for COVID-19; sero-surveillance studies for COVID-19, use of plasma therapy for COVID-19 treatment (PLACID trial), evaluation of Ulinastatin for COVID-19 treatment. This is being done by CDSA with support provided across trial design, recruitment, data quality monitoring and analysis. The institute supported COVID-19 serosurveillance studies in Mumbai, Pune, Odisha, Haryana, Karnataka.

**Resources for COVID Research:** Various animal models have been developed by the DBT AIs to increase our understanding of the viral life cycle and pathogenesis. A hamster challenge model for SARS-CoV-2 developed by THSTI is being offered as a service to various vaccine developers to evaluate the efficacy in this model.

#### Hamster Infection model based Vaccine and antiviral testing services offered at THSTI

Name of the company	Biotherapeutics
Mynvax	Subunit Vaccine
Zydus Cadila	DNA Vaccine
Zydus Cadila	Antiviral molecules
Vins Bioproducts Ltd	Equine antibody fragment based therapeutics
Cellthion	Bio therapeutics
Themis Medicare Ltd	Antiviral molecules
Biological E Ltd	Subunit Vaccine
Serum Institute	Equine antibody fragment based therapeutics

A Syrian golden hamster and K18-hACE2 transgenic mice is also being developed by ILS for COVID 19 research activities. inStem has generated 3 mouse lines expressing human ACE2 transgene as a model for SARS-CoV-2 infection under the aegis of the DBT funded National Mouse Research Resource effort at the Bangalore Life Science Cluster. The transgenic (K18-hACE2)/Blisc mouse is a humanized model expressing the human ACE2 gene in the lung airways as well as other organs. These mice are available for shipment. More information can be found at: <https://www.ncbs.res.in/research-facilities/acrc>. Furthermore, clinical isolates of SARS-CoV2 have been isolated from patient oropharyngeal swab samples by researchers at ILS. These cultures will help both the academicians and industries for screening, testing and validation of potential anti-SARS-CoV2 drugs and validate neutralizing antibodies. Various other resources such as a new retroviral based pseudovirion assay for SARS CoV2 using p BABE PuromCherry as the fluorescent sensor, panel of ACE-II expressing, SARS Cov-2 permissive cell lines (DLD; HEK293; A549) have been developed by scientists at RCGB. Lentiviral TdTomato-Luciferase stable cells for generating SARS CoV-pseudotypes have been generated. Further, a DynaBead RBD-GFP-Spike S-orange interaction assay has been developed for inhibitor screening.



**Biorepositories:** The Hon'ble Minister launched and dedicated to the Nation the largest national COVID-19 Biorepository Network supported by DBT. Five biorepositories have been supported. So far, 44452 clinical samples and 17 viral isolates have been collected and 10,100 samples shared with around 30 institutions. Also, six Autonomous Institutes of DBT, viz., THSTI, RGCBS, ILS, RCB, IBSD, ICGB have been notified for evaluation of novel investigational products against COVID-19. Additionally, five Autonomous Institutes of DBT, viz., RGCBS, ILS, THSTI, InStem, ICGB have

been identified to provide support as COVID-19 diagnostic kit validation centres. RCB, Faridabad, which harbours a viral repository, has contributed to testing the antiviral effect of nearly 700 compounds so far. Furthermore, RGCBS has addressed 33 requests for antiviral testing and ICGB is processing 24 requests received for antiviral testing. 8 diagnostic kits have been evaluated at THSTI, Faridabad, 10 diagnostic kits have been evaluated at RGCBS, Thiruvananthapuram and 1 is being tested at ILS, Bhubaneswar

Number of unique specimens of each type at various biorepositories

Disease status/ phenotype	Sample type	THSTI-RCB (NCR CLUSTER)	ILS	InSTEM	NCCS	ILBS
RT-PCR confirmed COVID positive	Serum	2974	229	25		400
	Naso-oro-pharyngeal swabs	2854	119	25	5185	11000
10-28 days convalescent samples from RT-PCR confirmed COVID+ patients	Serum	1928	Nil			1905(Sero- surveillance +ve)
6-10 weeks convalescent samples from RT- PCR confirmed COVID+ patients	Plasma, PBMC	959	Nil		31 31	Plasma : 1650
Active samples from RT- PCR confirmed COVID+ patients	Plasma PBMC				94 94	1857(Plasma ) 745 (Buffy coat)
RT-PCR confirmed COVID negative controls	Serum	1084	50			4757(sero- surveillance)
	Naso- oro-pharynge alswabs	1042	Nil		522	30000 Acquired from ICMR- diagnosis lab ILBS
RT-PCR confirmed	Virus isolates COVID positive		17			no
Clinical phenotyping data	Available for all samples	138	RT-PCR Data			Available

The bioassay laboratory at THSTI has also established platforms for rapid evaluation of vaccine candidates during pandemics inclusive of virus neutralization assays (VNT assays) for SARS-CoV-2 infection to support the vaccine and therapeutic development. Most of the vaccine manufacturers from India are now using this facility for validation of their candidates.

COVID-19 VNT assays delivered by THSTI			
Name of the company	Product tested	Assay performed	No. of samples
Zydus Cadila	Serum	SNT	304
INTAS Bio Pharmaceuticals	Plasma-derived samples	SNT and PRNT	9
Mynvax	Serum	SNT	149
Biological E Ltd	Serum	SNT	76
Premas Biotech	Serum	SNT and PRNT	6
AIIMS, New Delhi	Serum	SNT	60
Virchow Biotech	Serum	SNT and PRNT	4
IIT-Delhi	Fabric	SNT and PRNT	4
IISER Pune	Serum	PRNT	200
TIFR Mumbai	Serum	SNT	100
THSTI Cohort	Serum	SNT	200

**Technology Transfer & Services:** Scientists at inStem have developed a germicidal-coated fabric that can be stitched into a facemask and other personal protective equipment (PPE). The germicidal fabric termed *G-fab* is expected to kill viruses and bacteria upon contact. *G-fab* technology has shown a 99.99% kill rate against a wide range of viruses, including COVID-19 causing coronavirus (SARS-CoV-2) and influenza virus (H1N1 flu) and against various harmful bacteria, including gram-negative and gram-positive bacteria. A non-exclusive license to a company called Color Threads, from Tirupur, India will commercialize the *G-fab* technology. The launch of the antiviral face masks (G99+ antiviral) is the first outcome of this technology.



Besides, RGCB in collaboration with an industry partner has developed the following technological solutions for diagnosis of COVID-19:

- (i) **Q-line CoVID-19 RT-PCR kit:** RGCB has developed Q-Line® Molecular nCoV-19 RT-PCR Kit to detect Novel Coronavirus (nCoV-19) based on single tube multiplex real-time RT PCR (rRT-PCR) assays in respiratory and serum specimens. The developed kit was validated and approved by National Institute of Virology-ICMR, Pune with the sensitivity of 98.7% and specificity of 100% for commercial use. As far as now, we have sold more than 1.5M test kits to CoVID-19 screening centers both government organization as well as private hospitals.
- (ii) **Q-line Viral RNA extraction kit:** RGCB has developed Viral RNA extraction method using silica column chemistry for the isolation of highly pure RNA from CoVID-19 patient sample that will be used for downstream processes such as RT-PCR analysis for screening the CoVID-19. The silica column-based RNA extraction system is lysis enzyme proteinase-K free and it can be performed in room temperature that will help and increase the users experience which is not possible in other extraction methods available in the market. Further, RGCB has designed a lysis and working reagents specific to the CoVID-19 viral RNA isolation from the nasal-swab samples and showed better viral RNA quality and quantity as compared to the other available extraction methods. The viral RNA isolation kit was validated and approved by NIV-ICMR with 98% analytical performance for commercial use.

- (iii) **Q-line CoVID-19 antigen rapid Test:** To increase the CoVID-19 screening, RGCB has developed a rapid point-of-care test based on antigen detection. The nCoV antigen test kit is able to detect within 30 minutes at resource limited settings. In this rapid antigen kit, utilized CoVID-19 virus surface spike protein specific antibodies have been utilized to detect the antigen.

**Q-line<sup>®</sup> Molecular** Introducing a Comprehensive **COVID-19** Product Range

**Q-Line Molecular (nCoV-19) RT-PCR Detection Kit (E, RdRp & IPC)**

- Single tube and multiplex kit for screening & confirmation of COVID-19 by targeting E & RdRp gene.
- Kit consist with Human housekeeping gene as Internal Positive Control (IPC) to ensures human sample availability and quality of nucleic acid for the reference of gene expression.
- Sensitivity: 98.7%.
- Specificity: 100%.
- Store at -20°C.

**Q-Line Viral RNA Extraction Kit (Spin Column)**

- Silica-based column are used for purification to get high quality viral RNA free from protein & other organic compound impurities.
- Kit consist with RNA carrier molecule to enhance yield and purity level.
- Yield of the Viral RNA Recovery: >90%.
- Storage at 15-30° C. ( Room Temperature )

**Q-Line Viral RNA Extraction Kit (Magnetic Bead Method)**

- Magnetic bead are used for purification of nucleic acid.
- Fast and high purity RNA.
- One step washing, reduction of nucleic acid loss, increase the extraction rate, more stable test results are obtained.
- Yield of the Viral RNA Recovery: >90%.
- Storage at 15-30° C. ( Room Temperature )

**Q-Line Viral Transport Medium (VTM) Kit**

- Self-standing 10 ml tube with 3 ml filled medium
- Contains antibiotics and anti-fungal to inhibit bacterial as well as fungal growth.
- Individually packed sterile polyester/Nylon swabs with suitable tip & shape with breakpoint as per collection tube.
- Storage at 15-30° C. ( Room Temperature )

R & D: Spengier Biosciences Pvt Ltd Co-developed with: RGCB A joint project of COVID-19 product development with DBT-NCSS & POC Services

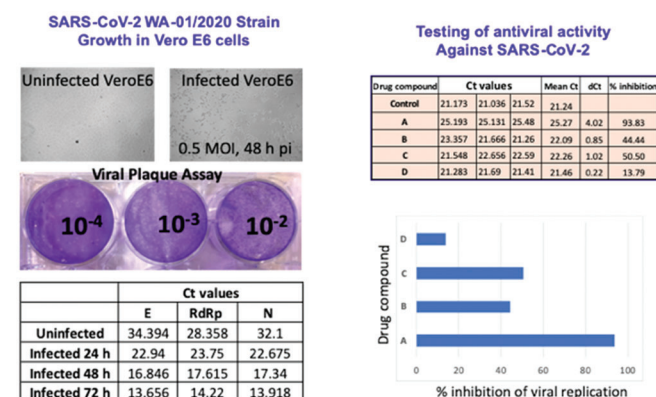
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Monoclonal antibodies (mAb)-secreting clones that showed specific binding to the SARS-CoV2 receptor-binding domain (RBD) were transferred by NCCS, Pune to Bharat Biotech, as a part of the collaborative project funded by CSIR-NMITLI, for further testing and development. Commercial olfactory test is being developed (1000 Nos) for field validation through large scale clinical study at PGIMER. NIAB has signed a MoU and transferred the technology for developing portable electro-chemical device for ultra-sensitive and rapid detection of SARS-CoV-2 to M/s Biogenex Life Sciences Private Limited.

The virus neutralization assay service offered by the Infectious Disease Research Facility of THSTI is being utilized by most of the vaccine and therapeutic developers in India. The national cell repository at DBT-NCCS has facilitating COVID research by supplying cell cultures required for this purpose. 23 cell cultures were supplied to 14 organizations across India (national research organizations, medical college, a University and a private company). To meet the growing need for antiviral assays for new drug candidates, Regional Centre for Biotechnology has set up in its BSL-3 facility an *in vitro* cell culture-based assay to test the antiviral activity against SARS-CoV2. These services have been widely utilized by the academia and industry with 679 samples tested for cytotoxicity, 313 samples tested for antiviral activity and 15 samples for IC50 determination.



**Outreach:** An informative graphic novel which was launched on the COVID-Gyan website recently was created by InStem to create awareness in non-specialist readers, especially children, about the current health crisis caused by COVID-19. The significance of sequencing the viral genome from Indian patients, the outcomes of the studies done through DBT's pan-India 1000 genome sequencing initiative & the findings of the work carried out at NCCS were shared with the public in the local language & English, through news reports, an interview on BBC News Marathi, and a talk delivered online for the Vidnyan Bharati, Pune. The Directors of several DBT AI's have delivered talks on the steps taken for combating Covid-19 in the webinar organized by DBT in association with DBT/Wellcome Trust India Alliance.



**07**

## **SOCIETAL PROGRAMS**

## SOCIETAL PROGRAMS

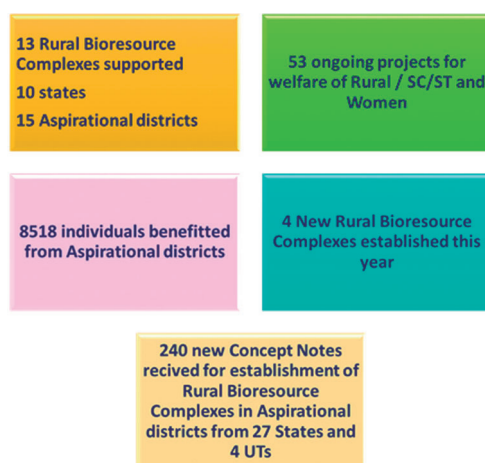
Department has been supporting projects aiming to promote use of biotechnological processes and tools for the benefit of the women, rural and SC/ST population. The programme aims to create platform for self-employment generation among the target population by diffusion of proven and field-tested technologies through demonstration, training and extension activities. The projects are being supported in agriculture and animal husbandry including fish farming, poultry farming, pig production, goat farming, value added products, floriculture, hybrid seed production, integrated farming system, entrepreneurship development, bio-resource utilization, women and child health, hygiene and nutrition. Many rural farmers including youth, SC/STs population and women have been benefited through implementation of the biotechnology based programme for societal development. DBT also has Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) program that empowers farmers, especially women farmers. It aims to understand the problems of water, soil, seed and market faced by the farmers and provide simple solutions to them. 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.

### BIOTECHNOLOGY BASED PROGRAMME FOR SOCIETAL DEVELOPMENT

The Biotechnology based programme for societal development, which is being implemented by the Department since 1990, is a unique program to benefit the vulnerable section of the society particularly the farmers, rural youth, women and SC/ST population. The program emphasizes the diffusion of proven and field tested biotechnological interventions with an aim to reach the unreached through various means like field demonstrations, trainings, education campaigns etc.

NITI Aayog had identified 117 Aspirational districts in 2018 based on 49 indicators across five sectors that include health and nutrition, education, agriculture and water resources, financial inclusion and skill development, and basic infrastructure. Keeping this in mind, the Department has supported establishment of Rural Bioresource Complex (RBC) in Aspirational districts of the country in order to

inculcate and nurture rural bio-entrepreneurship with proven technologies that are available and have a direct impact on society. The Department firmly believes that the benefits of biotechnology-based interventions are all-encompassing and cuts across sectors that have a direct influence on means of daily livelihood. Therefore, the RBCs serve as platforms for self-employment generation among the target population by diffusion of proven and field-tested technologies in a plethora of fields ranging from agriculture, secondary products of agriculture, food processing, animal husbandry and many others. Additionally, the Department envisages that the RBCs shall cater to all sections of the population in these Aspirational districts covering women, rural youth, SC/ST population and other weaker sections in a holistic manner.



This Department has instituted the 'Biotechnology Social Development Awards' since 2015, as a part of its Biotechnology Research Innovation and Technology Excellence (BRITE) awards, to recognize individuals/social organizations (NGOs, trusts etc.) working at the grass-root level for societal development through application of biotechnological interventions, thereby, empowering people in livelihood generation, skill development and entrepreneurship for self-employment. Presently, three awards are conferred under two categories: Individual - two awards & Organization - one award. Each award carries a cash prize along with a citation and a trophy.

### MAJOR INITIATIVES DURING THE YEAR :

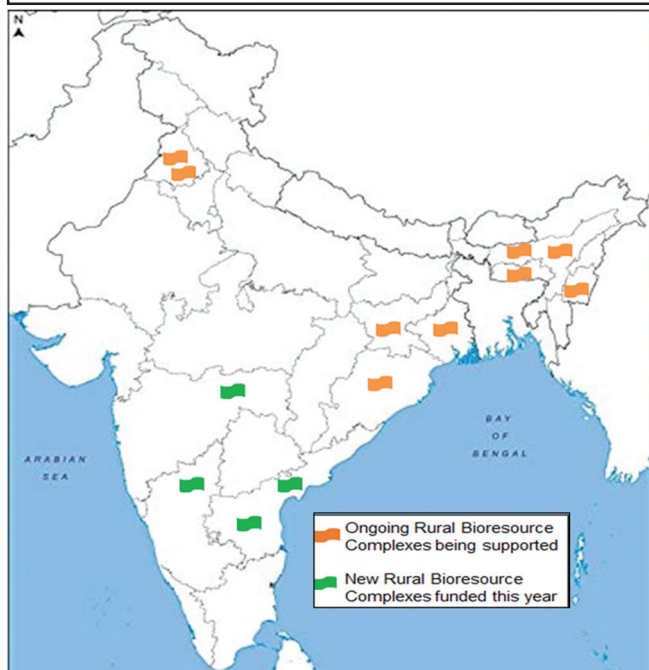
#### RURAL BIORESOURCE COMPLEX / RURAL TECHNOLOGY CLUSTERS

The Department presently supports 11 Rural Bioresource Complex / Rural Technology Clusters across 13 Aspirational



districts in 9 states namely Assam, Manipur, West Bengal, Jharkhand, Odisha, Meghalaya, Punjab, Maharashtra and Andhra Pradesh and aims to establish at least 1 Rural Bioresource Complex / Rural Technology Cluster in each Aspirational district of the country. In order to achieve this challenging objective, despite the restrictions due to the Covid-19 pandemic, the Department had announced a call for submission of Concept Notes for the establishment of Rural Bioresource Complex / Rural Technology Cluster during July 2020. There has been a tremendous response and the Department has received 240 applications from 27 States and 4 Union Territories. Such high number of applications has been recorded for the first time since the initiation of the Aspirational Districts program during 2018-19.

The Department is presently funding 53 projects for benefitting around 20,000 individuals from rural areas, Aspirational districts, womenfolk, youth, SC/ST and socially backward communities. Out of these beneficiaries, 8518 individuals have been supported under projects implemented under the Aspirational districts program. The Department has funded 4 new Rural Bioresource Complex / Rural Technological clusters in Maharashtra, Andhra Pradesh and Karnataka and 4 more Rural Technology Cluster are in final stages of initiation.



### Success story:

- **Creation of Rural bio-entrepreneurship:** The DBT funded project entitled “Bio fortified antioxidant rich coloured wheat cultivation under organic and agronomic supplementation (Fe, Zn, Protein) strategies to increase farm income and improve their health status” was sanctioned during 2019 and was implemented in the Aspirational district of Moga and Ferozepur, Punjab for a duration of 2 years. The Coloured Wheat (Black and Purple) developed at National Agri-Food Biotechnology Institute (NABI), is a rich source of the health promoting antioxidants due to presence of plant pigment anthocyanins. Laboratory research at the institute showed good effect of coloured wheat on the control of blood glucose and body fat in high fat diet induced mouse models. This wheat was grown at the farmers’ field in the Moga and Ferozepur under the DBT funded project for societal development. 29 farmers from 6 villages have directly benefited due to the project.

Farmers were happy as they could get Rs. 2000 to 4000 higher income per acre after the sale of their produce. Further intervention at the farmer’s field has shown increased iron, zinc and protein content of grains that has additional health benefits for the consumer. Farmers are looking at it as an opportunity for higher income generation and possibility of making and selling products at the village level. Industry is looking on it as a new opportunity in the health food sector, as it can be easily stored, consumed daily and cooked easily into wide range of food products like chapatti, biscuit, Dalia, bread, roasted snack etc. NABI has shared its technology with more than 20 companies after signing MOU/NDA with them. Companies are interested in contract farming and marketing different products like atta, dalia, roasted snacks and bakery products. Black wheat is attracting attention of farmers, consumers and industry and it is expected to increase to huge level in the coming years.





*Achievements from the coloured wheat project implemented at the Rural Bioresource Complex, NABI, Mohali*

### CAPACITY BUILDING LEADING TO SELF-EMPLOYMENT GENERATION AMONG RURAL YOUTH

The DBT funded project entitled “Amelioration of infertility in dairy cows through nutritional and biotechnological interventions” was sanctioned during March 2018 for a duration of 2 years. The project was envisaged to diagnose and treat infertility among dairy cattle through nutritional and biotechnological tools; to create awareness among dairy farmers on scientific reproductive management practices to improve fertility and profitability and to train personnel on artificial insemination and veterinary first aid to generate employment. The project was implemented in Chakdah Block of Nadia District of West Bengal. Under the project, Veterinary Health camps were organized once in two weeks and Infertility Camps were organized once in a month in the Dairy Vikas Kendra is located in the Muratipur village, Chakdah Block, Nadia District. Animal health check-ups were also conducted at the farmers’ doorstep. More than 600 farmers have benefited in the veterinary health camps and 1200 animals were provided with veterinary services. More than 120 farmers have benefitted through infertility camps where information on reproductive management for better profitability in dairy farming such as signs of estrus, estrus

detection method, right time of breeding, post-partum cow management, feeding management were deliberated during the camps. Exposure visits to institute dairy farm were arranged to demonstrate scientific dairy cow management.

Six unemployed youths who were trained under the project are now engaged as *Pranibandhus* at the Gram Panchayat level carrying out artificial insemination of cattle and buffalo round the clock and at the right time of insemination at Govt. approved rates besides providing Veterinary first Aid, De-worming, Vaccination of livestock.



*Artificial insemination in cows and animal health checkup camps*

- **Networking, outreach, and dissemination of scientific knowledge to ensure economic empowerment and nutritional security of Tribal Farming Communities in Odisha**

The project entitled “Economic Empowerment of Tribal Farming Communities in one of the Aspirational District of Odisha” being implemented in 2 blocks of Nabarangpur district of Odisha, covering about 10 hamlets by a consortia of 3 premier institutes led by the Institute of Life Sciences, Bhubaneswar. 37 workshops have been conducted prior to March 2020 and the project has reached out to more than 1000 beneficiaries. Seeds for growing vegetables have been distributed and beneficiaries have been mentored on the different organic farming practices. Beneficiaries have also been trained on different aspects of scientific fish and poultry farming. Training and capacity building for women have been carried out on value addition and income generation activities such as mushroom cultivation, Phenyl, Dishwash and wax candle production. The project has now moved to the next level and is currently focused on establishing market linkages for supply of raw material and marketing of finished products leading to self-employment generation. About 500 households in 4 villages of Nabarangpur have been trained, provided with quality seeds and organic fertilizers to establish nutri-kitchen gardens in their backyard. Under this project ICMR-RMRC continuously monitors the baseline health and nutrition status of children, pregnant women and lactating mothers in these villages and promotes the establishment of nutri-kitchen gardens in households for dietary diversification. Both perennial plants like Papaya and Moringa and seasonal vegetables such as Brinjal, Tomato, Lady finger/Okra, Pumpkin, Watermelon, Radish, Cow pea, Chili, Coriander and leafy vegetables have been planted. Nutri-gardens have also been established in 5 residential schools of the district, which has been appreciated by the district administration.



Economic Empowerment of Tribal Farming Communities in Nabarangpur District of Odisha

### BIOTECH-KRISHI INNOVATION SCIENCE APPLICATION NETWORK (BIOTECH-KISAN)

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

Biotech-Krishi Innovation Science Application Network (Biotech-KISAN)	
No. of Ongoing Biotech-KISAN Hubs supported	28
No. of Aspirational Districts covered	105
No. of Demonstrations carried out	300
No. of Interventions carried out	50
No. of frontline demonstrations in the field of farmers'	7000
No. of Farmer beneficiaries under covered under training programmes and workshops	> 50,000

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

Twenty-five beneficiaries were selected in Virudhunagar and Ramanathapuram districts of Tamil Nadu for conducting the baseline survey by Tamil Nadu Agricultural University,



Coimbatore. Training programme on 'Improved fodder varieties and production technologies' was undertaken. The training programme includes lectures, demonstrations and exposure visits. Seed and planting materials were distributed to the selected beneficiaries towards the establishment of nutritional forage cafeteria. Seeds of forage crops viz., Fodder Sorghum, Fodder Maize, *Stylosanthus*, *Desmanthus*, Lucerne, Agathi and Fodder Cowpea. In addition, planting materials viz., Guinea grass, Cenchrus, Cumbu Napier CO (BN) 5 and *Glyricidia* were distributed.

Demonstration of Good Agricultural Practices (GAP) in Basmati rice - wheat - summer moong cropping system was undertaken on 60 ha area in Patiala, Sangrur and Ferozepur districts of Punjab having 25, 24 and 23 farmers by Punjab Agricultural University, Ludhiana. During kharif 2020, the basmati rice was transplanted after green manuring of summer moong. The seed of improved varieties of summer moong and basmati rice were supplied. Consortium biofertilizers for summer moong and basmati rice, and *Trichoderma* for seed and nursery treatment of basmati were made available to farmers. Time to time technical guidance, offline and online, was provided and monitoring of crop was done. As the basmati rice was grown after green manuring with summer moong, the farmers were convinced to use Leaf Colour Chart (LCC) for nitrogen management in basmati rice. Tricho-cards were supplied to the farmers at weekly interval for insect-pest management. Neem based biopesticide was supplied for management of leaf folder. The interventions ensured adoption of green manuring by all the adopted farmers. Majority of the farmers avoided use of any agrochemical and produced 'Zero Agrochemical Use' or 'Zero Pesticide Use' basmati rice.

At the Biotech-KISAN Hub at Krishi Vigyan Kendra, Durgapur, (Badnera) Amravati, about 150 demonstrations have been conducted in the field of 150 farmers beneficiaries of adjacent 33 villages of Hingoli, Akola and Amravati districts with innovative package and practices with major emphasis on intervention of IPM in cotton for pink bollworm management. The techniques viz Pheromone traps, Solar light trap, NSKE, Trichocards have saved the money of farmers on chemical pesticide and due to this intervention and innovative package and practices adopted by farmers they have expected to obtain good yield. An average of 15 qtl/ha yield is obtained. Demonstration plot shows lesser infestation

of pink bollworm as compared to control plot. Under the expansion of activities in two Aspirational Districts (Washim and Gadchiroli), IPM in soybean, linseed, lathyrus and fish culture and pig rearing have been undertaken. Soybean yields on an average 20 qtl/ha were received as compared to control plot 16 qtl/ha.

Good results have been obtained in terms of saving of irrigation water, increased germination percentage in Sugarcane fields due to set treatment with bio-fertilizers, vigorous crop growth with more tillers and crop height at Agricultural Development Trust, Baramati, Pune. Depending on the crop growth parameters, approximate 30 per cent yield increase is expected by the farmers. The farmers have been advised to adopt the decomposting of the trash in the sugarcane field only and make the material available in the nutrient form for the next season crop/ ratoon sugarcane crop. A new decomposting bacteria that has been isolated has been identified to decompose the sugarcane trash and other material in about 40 days only, as compared to about 65-70 days with other bacteria. In Nandurbar District, the awareness programmes on cultivation of Onion and Groundnut were undertaken benefiting 153 farmers. In Osmanabad District, the awareness programmes on cultivation of Soybean and Gram were undertaken benefiting 153 farmers.

A Biotech-KISAN Hub has been recently set up at MSSRF, Chennai with Sub-Hubs in Odisha and Kerala to promote location-specific improved agronomic packages and eco-friendly technologies for cultivation of millets in Odisha, and coffee and pepper in Wayanad, Kerala. This includes improved packages of practices, IPM, INM, post harvesting technology, seed production technology, seed processing, grading, packaging, millet value addition, and marketing. A total of 58 farmers from the three aspirational districts are involved in the demonstration trials with focus on promoting (i) system of millet intensification(SMI) and line transplanting with 22 farmers; (ii) mixed cropping of finger millet+ redgram+blackgram+foxtail millet/little millet/sesame with 16 farmers; (iii) intercropping with finger millet+little millet+red gram among 8 farmers (iv) intercropping with (cashew/mango + fingermillet + littlemillet + niger (boarder)+red gram) with 7 farmers (v) intercropping with cashew/mango+vegetables+pulses among 5 farmers. The harvest data need to be collected. In Sub Hhb-I, 19 field



trainings on improved agronomic practices like seed treatment, preparation of enriched FYM, raised bed nursery preparation, line transplanting, SMI, inter-cropping, use of cycle weeder, pure seed collection etc. was organized for 454 farmers (M:299 and F:155).

At ICAR-NIBSM, Raipur, 32 biotechnological based agricultural interventions have been selected for dissemination in farmers' field with special reference to cultivation of Zinc enriched rice varieties, using biocontrol agents for effective management of pest and disease, establishment of protected horticulture farming with high value crops and scientific goat farming as an alternative livelihood option for small and marginal farmers. In the Kharif season, total 90 acres of land demonstrated with Zinco MS bio-fortified rice variety with complete package of practices.

Biotech-KISAN Project is implemented by FAARD Foundation, Varanasi and ICAR-IIVR, Varanasi in two aspirational districts (Chandauli and Sonbhadra) and two non-aspirational districts (Ghazipur and Varanasi). Further, from each district a cluster of four villages were selected including one for developing as model villages in each district with an objective to strengthen crop diversification, nutritional and livelihood security, and to empower farmers/farm women in different aspects of agriculture enterprises through trainings.

At Biotech-KISAN Hub established at Chitrakoot by ICAR-Indian Agricultural Research Institute, New Delhi engaging 326 farmer beneficiaries, demonstrations of improved varieties of paddy (Pusa Sugandha-5, Pusa Sambha 1850), pigeon pea (Pusa 16), Green gram (Pusa 9531), Sesame (Pragati), Okra (Pusa Sawani), and cowpea (Pusa Komal) were laid out in 205.5 acres; while demonstrations of use of bio-fertilizers and improved varieties of vegetables were laid out in 29 acres and in 9.2 acres, respectively during kharif season. Fifteen (15) trainings and 6 Kisan-Gosthies and 25 field days were organized during kharif season for enhancing the knowledge and skills of the farmers and a total of 333 farmers were benefitted. During the on-going Rabi season, demonstrations of improved varieties of wheat, pulses (chickpea, lentil, pea), and mustard were laid out in 45, 113.75, and 50 acres; respectively and engaged 220 beneficiary farmers. Demonstrations of various bio-fertilizers like rhizobium, azotobacter, liquid bio-fertilizer NPK, micorrhiza, were laid out in 221 acres, while benefiting 253

farmers. Three training programmes on value addition of agricultural produce; Integrated Disease Management and Use of bio-fertilizers were organized in which 47 farmers participated.

The project interventions were made in 7 aspirational districts (Dholpur, Karauli and Baran in Rajasthan, Mewat in Haryana and Shrawasti, Balrampur and Bahraich in Uttar Pradesh). A total of 185 demonstrations of improved varieties of wheat (HD-2932, HD-2967, and HD-3086) and mustard (Giriraj), bio-fertilizers (PSB, VAM, azotobacter, trichoderma, Pusa Sampoon (NPK), ZNSB), and Carrot (Pusa Asita and Pusa Rudhira) were laid out in Dholpur aspirational district of Rajasthan. The demonstrations of improved varieties of wheat (HD-3086 & HD-2967), bio-fertilizers (PSB, Azotobacter and Pusa Sampoon) and vegetables were conducted covering 137 farmers in the Karauli aspirational district of Rajasthan besides providing kitchen garden kits to 100 households for nutritional security and capacity development of 110 farmers in improved crop management practices through training, kisan gosthies and field visits. During the kharif season, demonstrations of Paddy variety Pusa-1121 and BGA bio-fertilizer were conducted in 10 hectares engaging 20 farmers, while 155 farmers were trained in improved cultivation practices and 286 farmers were benefitted through kisan gosthi and field visits in Baran aspirational district of Rajasthan. The orchards of papaya (var. Red Lady) were laid out in 5 hectares engaging 15 farmers. The interventions in Mewat aspirational district of Haryana included demonstrations of improved varieties of paddy (Pusa Basmati 1121, Pusa Basmati 1509 and Pusa Basmati 1718), wheat (HD-3086, HD-2967, and HD-3226), vegetable crops (Carrot-Pusa Vasudha and Radish-Pusa Chetki), bio-fertilizers, and Pusa Decomposer for in-situ crop residue management, engaging 113 farmers. Demonstrations of improved varieties of wheat (HD 3086 and HD 3226), mustard (Pusa Mustard 28), marigold (Pusa Narangi), vegetables and bio-fertilizers were laid out in the fields of 85 farmers in Shrawasti aspirational district of Uttar Pradesh. Nutri-garden kits were provided to 100 farmers for household nutritional security. Orchards of tissue cultured banana (cv. Grand Nain), litchi (cv. Poorvi and China) and guava (cv. L-49 & Allahabad Safeda) were established in the fields of 10, 15, and 7 farmers, respectively. Training on crop diversification with vegetables and flowers; wheat and

mustard cultivation, homestead nutri-garden; management of pest of vegetable crops, use of bio-fertilizers, crop residue management were organized, which benefitted 290 farmers.

In Balrampur aspirational district, demonstrations of improved varieties of paddy (Pusa 44, PNR 381, Pusa 2511, Pusa Samba 1850), bio-fertilizers (PSB, BGA and Azotobacter), improved varieties of vegetable like Lobia (Pusa Dharni), sponge gourd (Pusa Sneha), bottle gourd (Pusa Santusthi), cauliflower (Pusa Ashwini & Pusa Kartik) were organized with 81 farmers. Nutri-garden kits were provided to 25 households. The orchards of mango (cvs. Mallika, Chausa, and Dussehri); Litchi (cvs. China and Shahi), and tissue cultured bananas (cv. Grand Nain) were established in 3 acres. Demonstrations of improved varieties of wheat and mustard as well of bio-fertilizers were laid out in 115 acres in Bahraich aspirational district of Uttar Pradesh, while nutri-garden kits were provided to 25 farmers for household nutritional security. Capacity building programmes were organized in collaboration with KVK, Bahraich to train the farmers in vegetable production technologies for nutrition enhancement, nutria-kitchen gardening, use of bio fertilizers in agriculture, and use of Pusa Decomposer for in-situ crop residue management, which benefitted 144 farmers as well as staff of line departments.

Under Biotech-KISAN Hub at Zandu Foundation for Health Care (ZFHC), Ambach, an area of 51 acre has been covered under medicinal plants cultivation following GAP by involving 65 farmers from districts of Panchmahal, Navsari, Valsad, Vadodara, Anand and Khera in the state of Gujarat. The farmers were made aware about the GAP of targeted species by providing on-site training as well as by distributing pamphlets in regional language. A “Kisan Mela” with the mandate to display and introduce the latest technologies, equipment’s, bio fertilizers etc. organized for the farmers. Farmers training of 5 days duration was also organized by ICAR-DMAPR, Anand in the month of September 2020 in which 45 farmers participated. To facilitate marketing of the cultivated material, ZFHC has initiated the process of forming “Farmers Producers Organisation” (FPO) in the project areas. ZFHC and project partners DMAPR-Anand and KVK-Valsad are making all efforts to give direct access of market to farmers by way of ensuring buy back agreements on mutually agreed prices.

At Biotech-KISAN Hub established at Agri Biotech Foundation, Hyderabad to promote eco-friendly biofertilizers and biopesticides for soil and crop management, field level demonstrations were conducted with 2400 litres of both bio-fertilizers and bio-pesticides covering 325 acres. Under entrepreneurship activity two vegetable seedling nurseries were established with two women entrepreneurs, who generated an income of Rs.4800/- (Reddipalli village) and Rs.2000/- (Narpala village) in three months. Similarly, two on farm *Trichoderma* production units were established with two entrepreneurs. During this period soil fertility assessment for 75 beneficiary farmers was done. Two skill-based trainings were conducted on applications of biofertilizers and biopesticides, vegetable portray technology. Total number of farmer beneficiaries covered during the period is 465.

Biotech-KISAN Hub at SABC, Jodhpur aims to demonstrate the IPM based production system to increase quality production of seed spices in Western Rajasthan. Quality farm inputs have been distributed to 60 farmers for laying out mega demonstrations on priority crops including cumin, Nagauri paan methi and Isabgol in 7 districts of Western Rajasthan in forthcoming Rabi 2020. In order to facilitate the early adoption of IPM based production system, the Biotech-KISAN Hub has prepared easy to understand IPM posters on cumin, paan methi and isabgol based on the recommended POP by NRCSS, State Agriculture University and State Department of Agriculture respectively. The large-scale training programs were organized to educate both identified demonstration farmers and others about the IPM based production system. Experts from ICAR-NRCSS, South Asia Biotechnology Centre (SABC) and the Spices Board of India have participated in all the physical training programs before the onset of Rabi season 2020. Around 575 farmers were directly trained in various programs and messages were reached to hundreds of thousands farmers by involving print, electronic and online media.

A new Biotech-KISAN Hubs has been recently established at Rajendra Prasad Central Agricultural University, Pusa, Bihar along with its three Sub-hubs located at KVKs under Aspirational Districts Muzaffarpur, Sitamarhi and Begusarai. Holistic Aspirational District Agricultural Profiles were developed through Participatory Rural Appraisal (PRA) and baseline survey of Aspirational District Begusarai, Sitamarhi

and Muzaffarpur. Forty marginal farmers' comprising SC/ST/OBC/EWS have been selected from 3 to 4 villages of each Aspiration District for developing their 1-acre plot as demonstration block. The sum total of 120 farmers are undertaking High-Value Horticultural (Fruits/Vegetables/Flowers) Cropping Module following Good Agricultural Practices with special emphasis on soil health and judicious water management. Seeds and planting material of high value vegetables and spices were distributed to all 120 selected farmers. Thirty landless women farmers are in process of selection spanning 3 districts for scientific goat rearing.

At Biotech-KISAN Hub being implemented at ICAR-National Bureau of Agricultural Microorganisms, Mau, the farmers have been sensitized to utilize microbial consortium for rapid bioconversion of agro-waste in three districts namely Mau, Azamgarh and Varanasi. The activities of the project are also being extended to Aspirational districts, Balarampur and Sravasti. To popularize the technologies, 95 HDPE bioconversion units each of 5 bioconversion units (475 bioconversion bags) of capacity 0.8 to 1.0 tons per cycle of compost production within 60 days were established at farmers' field in villages of Mau, Azamgarh and Varanasi districts. Till now 764 farmers have been made aware about the rapid composting technology while establishing the units. On-farm training and live demonstrations on rapid composting technology, microbial bio-inoculant applications were carried out by organizing One Day Farmer's Training and Demonstration programs at Shamshabad (near Karahan) village, Mau for 101 farmers from 20 different villages and village-Mahagaon, Tehsil-Rajatalab, Varanasi for 110 farmers on 13.03.2020 and 02-01-2020, respectively. In all kind of training and awareness programs conducted under project, promotional kits containing *Trichoderma* and compost/vermi-compost packets and other beneficial microbial inoculant-based products from ICAR-NBAIM were also distributed to farmers alongwith literature prepared in the form of technical bulletins and brochures. Twelve scientists mainly from different from KVKs (Azamgarh, Mau, Ghazipur, Jaunpur, Ambedkarnagar, Balrampur) and NDUA & T, Faizabad, ICAR-IISR, Lucknow and ICAR-NBAIM, Mau were trained in a Five Days Scientist Training organized at ICAR-NBAIM Mau in order to make them understand the scientific and practical work w.r.t. composting technology to be disseminated,

demonstrated and facilitated for adoption among farmers.

At Biotech-KISAN Hub established at AAU, Kahikuchi, an area of 50 acres has been successfully brought under the coverage of high curcumin turmeric variety Megha Turmeric 1 in Kamrup district with participation of 413 farmers in which the women farmers figure out to be 345. The beneficiaries of the programme will be further empowered through training and demonstration on innovative Desiccant Dehydration Technology for preparation of dry turmeric for strengthening farm economy which will be the first of its kind in NER. Demonstration on value chain management in turmeric has been successfully done in hills agro-climatic zone of Assam, embracing the critical components like high curcumin variety, GAP including bio- nutrition, IPM and low-cost processing involving mechanized washing, steam cooking and solar conduction drying. This integrated production cum processing technology has been demonstrated to tribal farmers of Jirsong Agro Producers Co. Ltd., Manza, Karbi Anglong, the first Spice based FPC of the state and the approach has been the first of its kind in the Hills agro- climatic zone of Assam.

The demonstration established the production potential of the high curcumin variety Megha Turmeric 1 reflecting 19.30% increase over traditional practice with collateral enhancement of farmers' skill on mechanized processing. The technique of macro-propagation has been demonstrated for generation of quality planting material in high yielding, premium variety of Malbhog banana to selected growers of Goalpara and Kamrup districts of Lower Brahmaputra Valley Agro- Climatic Zone of Assam. The selected group of 35 growers were further supported with QPM for pursuing GAP- based cultivation under an Institution- Village Linkage Model. Till date, 88000 QPM have been disseminated covering an area of 90.81 acres thereby achieving 82.55% progress in horizontal coverage.

Two training programmes in the areas of GAP-based Banana field management were conducted in farmers' field involving 111 farmers. GAP-based production technology of tissue culture Banana cv Grand Naine was demonstrated in Dimapur district of Nagaland. The superiority of technology and production potential of the variety was established through realization of yield up to 25 kg per plant which acted as a great motivational factor for the tribal farmers of interior Nagaland for adoption of technology- driven horticulture for nutritional and income security. Considering the importance



of air breathing fishes in Assam, demonstration on high density rearing of high value fish species in biofloc tank was done in 3 locations in Nalbari district of Assam for technological empowerment of farmers for securing food & nutrition, enhancing farm profitability and generating employment in the rural sector.

At Biotech-KISAN Hub being implemented at ICAR Research Complex for NEH Region, Barapani, a total of 240 Piglets beneficiaries have benefited from this project. Four pigpen houses were constructed at farmer field under the Project. Most important and significant achievements of the centre is to help the migrant workers affected by COVID-19. A total of 11 numbers of migrant workers were identified under this project and to ensure retention of the migrant workers in their villages and to improve their livelihood a total of 22 nos. of piglets and 12 packets of pig feeds were distributed free of cost along with other veterinary aids. WhatsApp has proved to be a useful tool for gathering information and delivering health services to the farmers especially during the imposition of lockdown due to COVID-19. Second round Vaccination against Classical Swine Fever of last year and first round Vaccination against Classical Swine Fever in piglets (65 nos) along with deworming, completed. Demonstration on Sanitization for prevention of African Swine Fever and its application in the field organised on 03.09.2020. Training program organized for beneficiaries under this project for the year 2020-21.

Improved germplasm of pigs (Large White Yorkshire) have been introduced in adopted villages by ICAR-NRC on Pig. The activities of Biotech-KISAN Hub have been expanded in Aspirational Districts of NE Region. A total of 340 numbers of farmers were covered during 2020-21 and 383 numbers of piglets and 51 bags of pig feed (50 kg/bag) were distributed by all partner Institutes along with mineral mixtures, dewormers, and other veterinary aids including vaccination against swine fever free of cost. A total of nine migrant workers were identified under this project and to ensure retention of the migrant workers in their villages and to improve their livelihood a total of 21 nos. of piglets and 9 packets of pig feeds were distributed free of cost along with other veterinary aids. Farmers are presently benefited by getting piglets, pigs feed, and other Veterinary aids from this project, migrant labours are benefited by engaging in pigs rearing and the project is helping to retain the migrant youth in the rural area. This is the first year of the project and beneficiaries are going to be economically benefited by selling the adult pigs, piglets and value-added products in the near future. Besides as per human resource development is concerned, through various training programs, farmers are now expert for scientific rearing of pigs particularly maintenance of hygiene in pigs shed, prevention and control of diseases. Extension leaflets on "Care and Management of Pig" that have been distributed to selected beneficiaries is very much helpful to them.

**08**

**PROMOTING  
BIOTECHNOLOGY IN  
NORTH EASTERN  
REGION**



## PROMOTING BIOTECHNOLOGY IN NORTH EASTERN REGION

The North East Region of India has been identified as one of the biodiversity hotspots of the world. Rich bioresources spread across NER's diverse ecosystems and nurtured by indigenous communities, provide ample opportunities for furthering economic development of the region. In order to give focused attention for the region, the Department has earmarked 10% of its annual budget for promoting and strengthening biotechnology related activities in the region. These region-specific programmes focus on developing local capacities to address regional challenges and harness endemic bioresources for economic development of the region. To effectively manage the programme, NER Biotechnology Management Cell (NER-BPMC) has been set up by DBT-Institute of Life Sciences (DBT-ILS), Bhubaneswar. The NER Biotechnology programmes are being supported under 4 major verticals (i) Research & Development programmes, (ii) Human resource development programmes (iii) Regional Infrastructure development in identified gap areas (iv) Bioresource-based Entrepreneurship programmes in NER to uplift rural income of farmers and small entrepreneurs of the Region.

### New Initiatives in NER

1. Programme on ***"Biotech Interventions in Citrus of North East Region"*** aiming at (i) Germplasm Characterization of NER Citrus, (ii) Mission-mode programme on production of disease-free quality planting material of NER Citrus for supply to NER farmers (iii) Biotic and Abiotic stress tolerance in NER Citrus germplasm (iv) Post-harvest management and value-addition in NER Citrus, and (v) Establishment of Diagnostic Centre in service-mode in NER initiated.
2. ***"Centre of Excellence for Application of Technologies on Child and Maternal Health"*** established at NEIGRIHMS, Shillong and General Hospital, Naharlagun, Arunachal Pradesh in Collaboration with IIT-Bombay. This project is based on applications of monitoring technologies (child malnutrition and pregnancy care) using Child and Maternal Health Monitoring (CMHM) kit, developed

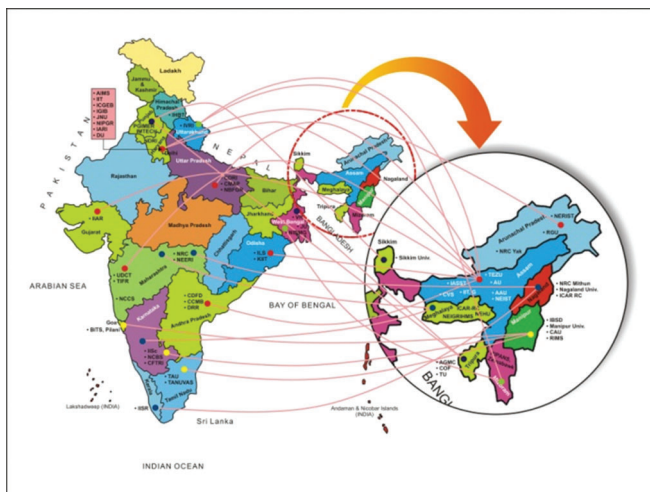
by IIT-Bombay with the goal to generate real time data for child malnutrition so that further interventions can be done to reduce the rate of child malnutrition.

3. With the aim to promote sustainable development and utilization of the unique bioresources of NER and linking it with socio-economic upliftment of the region, the Department announced programme on ***"Development and Utilization of Bioresources of North East Region for Generating Livelihood Security and Entrepreneurship"***. The programme aims to demonstrate and deploy the entrepreneurial outcomes of the already available technologies with proven effectiveness, developed on the priority resources of NER.
4. The Department has announced a programme on ***"Understanding Chemical Ecology of the North East Region"***. The programme aims to bring together researchers in complementary disciplines to explore the role chemical signals plays in shaping the unique ecosystems of the NER by studying interactions at the molecular level using advanced metabolomics tools to answer age old questions by studying how organisms communicate with each other via. chemical signals and discovering novel molecules for improving human life and environment.

### Twinning R & D Programme for NER :

This programme initiated in 2010 has made a huge impact by catalyzing vibrant collaborations between institutions from NER and those from the rest of India, evolving NER-specific projects and their implementation across all eight states of the region. During the year 2020-21, support was continued to 189 Twinning R&D projects in all areas of biotechnology. These included 36 projects under Agriculture Biotechnology 58 in Medical Biotechnology 30 projects in Environment and Environment Biotechnology, 49 in Medicinal & Aromatic Plants and Secondary Agriculture and 16 in Animal, Aquaculture Biotechnology. These projects involve 42 Institutes from NER and over 85 Institutions from outside NER.





Collaborations under Twinning R&D programme

### Major Network/Mission-mode Projects:

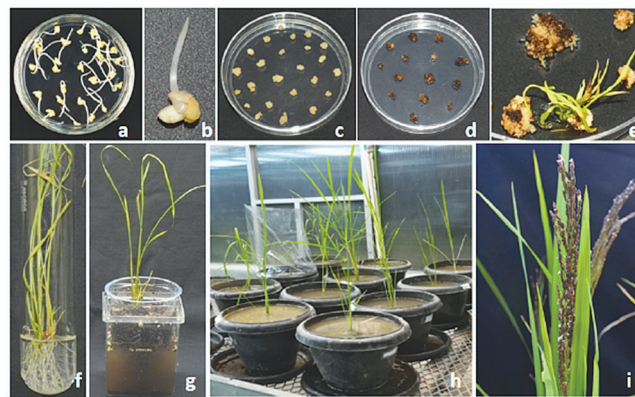
These major network/ mission-mode projects aim at addressing North East specific problems, in all spheres of biotechnology.

#### 1. Agriculture Biotechnology:

In the area of Agriculture Biotechnology, projects were supported for improvement of citrus, Scented and Black rice and Banana varieties endemic to NER through Biotech interventions. The NE region is centre of origin of citrus fruits and harbours a vast reservoir of Citrus diversity in wild and semi-wild form, due to favourable edaphic and climatic conditions. Despite this the productivity of the NER-Citrus is far below the national average. To conserve citrus endemic to NER and to promote sustainable cultivation of the commercially important NER Citrus in the region the Department has launched the programme on “*Biotech Interventions in Citrus of North East Region*” aiming at (i) Germplasm Characterization of NER Citrus, (ii) Mission-mode programme on production of disease-free quality planting material of NER Citrus for supply to NER farmers (iii) Biotic and Abiotic stress tolerance in NER Citrus germplasm (iv) Post-harvest management and value-addition in NER Citrus, and (v) Establishment of Diagnostic Centre in service-mode in NER.

Under DBT's *Scented Rice programme for NER* implemented by 28 Institutes efficient transformation protocol has been developed for Black rice of Manipur. Advanced generation Black rice transgenic lines of overexpressing yield related

gene *OsMPK6*; *ERECTA* gene for enhanced osmotic and heat stress tolerance; *CKX2*-RNAi transgenic lines showing enhanced yield and carrying lines CRISPR-Cas9 genome editing constructs for editing two major rice yield genes namely *CKX2* and *DEP1* have been developed. Advanced generation (BC1F2 / BC2F3) lines were obtained for (a) High yielding non-lodging rice variety Thabiingphou with high anthocyanin content transferred from Chakhao Amubi from a cross Thangiangphou x Chakhao Amubi (b) High yielding non-lodging rice variety Ranjit-sub1 with high anthocyanin content transferred from Chakhao poireiton from a cross Chakhao poireiton x Ranjit sub1 (c) High yielding *Keteki joha* with bacterial blight resistance, (d) High yielding *Chakhao poireiton* with BLB and blast resistance. Bacterial inoculants as individual strains or in consortia mode were developed which increased scented rice grain yield by 23-63% in IASST, Tripura University, Assam university, Silchar and Manipur University. Large scale field trials are underway. An essential oil from *Myristica fragrans* showed pronounced antifungal, antiaflatoxigenic and methylglyoxal suppressing activities and may be recommended as a plant-based food preservative for protection of seeds scented rice of NER.



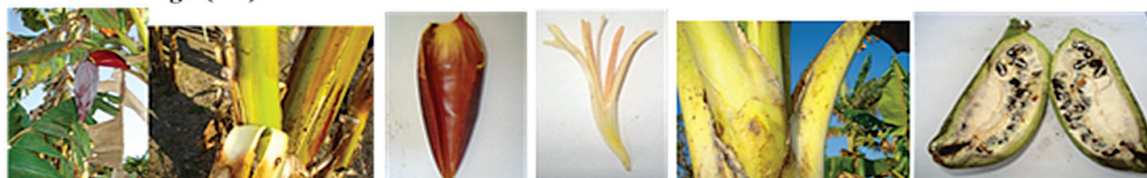
In-vitro regeneration and stable genetic transformation of Kola Joha

Under the *major network programme on NER-Banana* involving 39 institutions, a total of 154 germplasm accessions have been collected for all 8 NE states and characterized morpho taxonomically. Cytological karyotyping has been completed for 32 accessions and molecular characterization for 45 accessions. All the 154 accessions are being maintained in their respective state genebanks. Whole genome has been sequenced for the NER Banana, Bhimkol. Interestingly, some of the accessions from Nagaland

and Arunachal Pradesh are unique belonging to the ABB genome. The projects has led to the collection and characterization of several members of *Rhodochlamys* from

NE states which are the resistant sources to biotic stresses like Sigatoka leaf spot and fusarium wilt and hence could be exploited in the breeding programmes.

**Changbi(BB)**



**Lairawk(AB)**



**Changpawl (AB)**



**Vaibalhla, AAA (one of the commercial variety of Mizoram)**

#### *Genetic Diversity in Banana of NER*

Support was continued to the CoE at AAU Jorhat, North East Centre for Agriculture Biotechnology focuses on (i) Genetic improvement of rice for abiotic and biotic stress tolerance (ii) Genetic improvement of chickpea using gene technology for insect pests resistance (iii) Isolation of novel microbial strains to develop efficient biofertilizers, and bio-pesticides for NER. A core set of 300 ahu rice accessions was created and phenotyped for drought tolerance. Phenotyping of 290 Sali rice accessions has been completed, where submergence tolerant lines have been identified. A total of 7 QTLs for yield and yield attributing traits identified from Banglami x Ranjit. F6 generations were phenotyped. BLB resistance gene has been incorporated into Luit and Dishang varieties. BC2F4 lines are in the field for large-scale trials. The centre has generated 69 transgenic chickpea lines using a construct harbouring two Bt genes Cry1Ac and Cry2Aa genes. Introgressed lines carrying Cry1Ac and Cry2Aa were found to be resistant to pod borers and phenotypically similar to non transgenic counterparts. The CoE has conducted in farmers' field trials of the selected bio-inputs developed during

phase-I. A revenue of 1.82 Lakh was also earned by selling the biofertilizers through existing satellite labs in KVK of Assam under the DBT-NECAB. New satellite labs in the five different states of N E region for onsite production and distribution of Bio-inputs have been established including Nagaland University, Medziphema, Central Agricultural University Imphal, School of PG studies, CAU, Umiam, Meghalaya, College of Agriculture Lembucherra, Tripura, Mizoram University, Mizoram. Seven entrepreneurs were trained on commercial production of Bio-inputs. Eighteen small Tea-Growers trained on organic agriculture. Important bio-agents were isolated for biopesticides production Bioformulations developed included Talc based formulations (*Bio-Time; Biozin-PTB; Bio-Sona; Biolium, Bio-Meta; Bio-Zium; Bio-veer; Biogreen; Biogreen-L*) and Organic based (Biofor-Pf). MoU was signed for transferring Bio-input (Biopesticide production technology) Technology to the three companies: VRS Agritech, Guwahati, School of Livelihood & Rural Development (SLRD), Shillong, M/s Orgaman R&D Division, Jorhat.

## 2. Animal and Aquaculture Biotechnology

At the CoE on Fisheries and Agriculture Biotechnology, at College of Fisheries, Tripura, a package of mass seed production of pengba and pabda have been established. Seeds of pengba (2 million spawn) and pabda (20 thousand fingerlings) have been provided to farmers in Tripura for propagation in the field. On Farm Training (OFT) of pengba in polyculture with Indian major carps is being undertaken with three farmers in collaboration with KVK, Khowai, Tripura. OFT of practical grow-out feed produced at College utilizing locally available ingredients is under progress in collaboration with KVK, Sephailila, Tripura. Twenty-five (25) farmers have been trained in culture and utilization of wolffia as local feed resources.

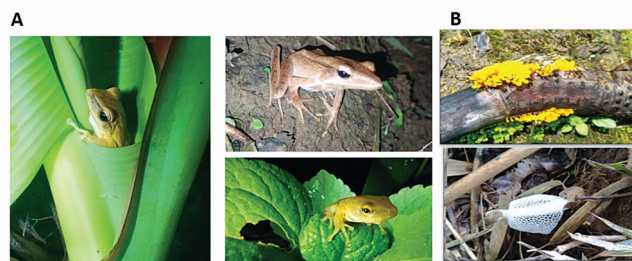
## 3. Bioresource and Environmental Biotechnology:

With the aim to promote sustainable development and utilization of the unique bioresources of NER and linking it with socio-economic upliftment of the region, the Department announced programme on *“Development and Utilization of Bioresources of North East Region for Generating Livelihood Security and Entrepreneurship”*. The programme aims to demonstrate and deploy the entrepreneurial outcomes of the already available technologies with proven effectiveness, developed on the priority resources of NER.

The Department has announced a programme on *“Understanding Chemical Ecology of the North East Region”*. The programme aims to bring together researchers in complementary disciplines to explore the role chemical signals plays in shaping the unique ecosystems of the NER by studying interactions at the molecular level using advanced metabolomics tools to answer age old questions by studying how organisms communicate with each other via. chemical signals and discovering novel molecules for improving human life and environment.

Under the project supported to Mizoram University for setting up of *“Mizoram Natural History Museum”*, unique for the NER, specimens from the study sites (Pualreng and Tokalo Wildlife Sanctuary) were collected and preserved. Morphological identification of upto the lowest possible taxon

was carried out for a total of 926 individual specimens have been collected from the field work from mushrooms (30), Moth (45), Amphibians (102), Beetles (749) unique to Mizoram. Barcoding work has been initiated for all the collected samples.



a) Study of the diversity of Amphibians in selected sites of Mizoram; b) Mushrooms collected from Phualreng Wildlife Sanctuary and Tokalo Wildlife Sanctuary.

## 4. Medical Biotechnology:

A multicentric project titled *“Centre of Excellence for Application of Technologies on Child and Maternal Health”* is being supported by IIT Bombay with two NEIGRIHMS, Shillong and General Hospital, Naharlagun, Arunachal Pradesh. This project is based on applications of monitoring technologies (child malnutrition and pregnancy care) using Child and Maternal Health Monitoring (CMHM) kit, developed by IIT-Bombay with the goal to generate real time data for child malnutrition so that further interventions can be done to reduce the rate of child malnutrition (0-5 years). The data will be collected with the help of rural health care workers, Aanganwadi workers in selected sites in Maharashtra (Mumbai) and North East States viz. Meghalaya and Arunachal Pradesh by tracking 5.00 lakh children.

Multi Drug Resistant-TB has very high prevalence in NER, being the highest rated being in Sikkim. The department has initiated a major network programme on *“MDR-TB in North East India: a genomic driven approach”* involving 22 NER institutes from 8 states and 14 other Institutes, to address various scientific and societal issues of MDR-TB which is highly prevalent in NER. Ethnic diversity in NER and absence of an inclusive database among different tribes of NER has blunted efforts to target appropriate TB chemotherapy and therefore skews transmission, virulence and drug resistance patterns of M.tb strains in NER. A comprehensive programme with a large, multi-institutional, consortium based has been



launched in NER with particular emphasis to understand clinical presentation of multi-drug resistant tuberculosis patients of diverse ethnicity in NER. The goal is to map hot-spots of TB and MDR/XDR-TB in NER using genome sequencing approach and carry population genetic studies to delineate predisposing factors, in ethnic populations of Tripura, Nagaland, Sikkim, Manipur and Arunachal Pradesh.

The project lead by Mizoram University, project aims for Genomic landscaping of drug resistant pathogen strains and infected hosts in NER, to understand host-pathogen interactions in relation to susceptibility and to discover pathogen diversity; functional genomics to uncover mechanisms of susceptibility; drug sensitivity and pharmacokinetic analyses for novel interventions and Formation of a strain-repository in Mizoram, with plan for expansion to other NER States. Another project aims to perform whole genome sequencing and associations studies on Mtb from sputum samples and BM-MSCs to discover novel mutations in Mtb strains prevalent in the region as well as to explore stem cell niche for MDR Mtb. The study will provide novel therapeutic insights for MDR-Mtb in NE and the role of BM-MSCs in MDR evolution and ways to target it.

Consortium programmes have also been initiated towards development/validation of new tools for diagnosis of TB & MDR-TB and, Paragonimiasis, non-tuberculosis mycobacterium (NTM) and initiating awareness programme. Paragonimiasis, with manifestation similar to Tuberculosis is very common in the Nagaland population due to consumption of raw crab meat. Often due to lack of awareness of paragonimiasis and correct information with respect to diagnostic tools for this disease cases are wrongly diagnosed as smear negative tuberculosis. This leads to a higher incidence of treatment failures recorded in tuberculosis. The project at Kohima Hospital, Nagaland aims to increase the awareness about the existence of the disease along with its diagnosis and treatment to help provide accurate assessment of TB failure rates in regions endemic for both diseases. This would also decrease undue exposure of the patient to costly and toxic anti-tubercular drugs. Increasing prevalence and geographical variability of non-tuberculous mycobacterium (NTM) in NER has prompted development of a rapid and sensitive diagnostic method for diagnosing NTM and monitoring drug resistance. This project aims to develop quick identification methods, by reducing time for

diagnosis, could expedite institution of specific treatment thereby increasing chances of success.

### Demonstration and scale-up programmes for Societal upliftment in NER

Under the project on *pilot-scale demonstration of cultivation of Strawberry with improved Agrotechnology in Farmers field in Meghalaya* cultivation of tissue cultured Strawberry varieties viz., Camorosa, Sweet Charlie and Chandler using bio-technology intervened Agro-technologies were demonstrated in open field over an area of 15.15 acres in 50 demonstrative units in farmers' fields in the sites selected from East Khasi Hills, West Khasi Hills, Garo Hills and Jayanti Hills of Meghalaya. About 150 farmers were trained during the year. The produce i.e. strawberries was sold by farmers at an average of Rs.200/kg in local market, while some also converted their produce into value-added products like jam, jellies, wines etc.



*Strawberry plants in flowering in beneficiary farmers field in West Khasi Hills of Meghalaya*

Under the *demonstration project on the tissue-cultured cut flower orchid production*, a network of 50 end to end production cum demonstration units of dendrobium plants at village level in Assam and Meghalaya have been identified and awareness programme conducted at IHT, Mandira, Assam. Each beneficiary was provided with a unit of 80 m<sup>2</sup> protected area with cladding material and orchid benches for growing orchid dendrobium hybrid cut flower along with the inputs like growing blocks, fertilizers, and necessary pesticides. Capacity building of farmers and youth in Assam and Meghalaya was carried out. About 1000 farmers were trained in Dendrobium cut flower production systems at homesteads in Assam and Meghalaya, Transfer of technology for standard spikes of Dendrobium of high quality for trade, in domestic and export market, Post-harvest storage, management and value addition of the produce for high end

trade, and Market intelligence/marketing skills and collection of produce.



Awareness programme for farmers of Assam in IHT, Mandira, Assam

*Technology Incubation Centre for entrepreneurship development for mushroom culture and farming at Bodoland University, Kokrajhar, Assam* aims at developing rural entrepreneurship in NER by promoting local Mushroom cultivation among the local youth. Using the local Bioresources (crop residues), mushroom cultivation of different species (basic, advance and super) has been standardised. Value addition of the mushroom has been done through lyophilized powder in to various food products like fortified Mushroom. FSSAI and ISO on food products has also been registered. Good quality Mushroom Spawn has been distributed to farmers across NE States (71 quintals) eCommerce platform for Mushroom has been developed through ePortal (AxomBazar.com) and Android based app (TIC DBT Bodoland University) has also been made. Rural mushroom making infrastructure like low cost hut (24 Nos) has been have been set up and integrated with Vermicompost Unit, Methane Gas and Solar Unit to have Zero Waste Output. Mushroom Helpline no 9101952358 has also been established About 2700 rural youths have been trained through 115 trainings, and 48 entrepreneurs, 25 SHGs, NGOs, GOs have been helped for mushroom cultivation.



Farmer of Kokrajhar cultivating paddy straw mushroom after getting training at Bodoland University

## Major outcome under the NER programmes

### Personals Trained in NER

- 678 students trained as JRF/SRF, 68 Post Doctoral fellows
- 33 PhD students were awarded PhD degrees under Chemical Ecology Programme and CoE-NECAB at AAU, Jorhat
- 35 NER researchers trained at NECAB at IIT-Guwahati in Healthcare Engineering

### Publications

- 46 publications in peer-reviewed journals

### Patents filed/Granted

- Eight patent applications filed before the Indian Patent Office
- Two patents granted (one International and one national)

### Technologies transferred

Bioformulations developed at CoE AAU Jorhat – NECAB include Talc based formulations (*Bio-Time; Biozin-PTB; Bio-Sona; Biollium, Bio-Meta; Bio-Zium; Bio-veer; Biogreen; Biogreen-L*) and Organic based (Biofor-Pf). MoU was signed for transferring Bio-input (Biopesticide production technology) Technology to the three companies: VRS Agritech, Guwahati, School of Livelihood & Rural Development (SLRD), Shillong, M/s Orgaman R&D Division, Jorhat.

### Entrepreneurship Development

- Technology Incubation Centre for Entrepreneurship Development on Mushroom Culture & Farming developed at Bodoland University, Kokrajhar, Assam. A total of 2700 farmers and 48 small scale entrepreneurs have been trained in mushroom cultivation in Bodoland District of Assam
- 150 farmers trained in cultivation of Strawberry with improved Agro-technology in Farmers field in Meghalaya
- 1000 farmers trained in Dendrobium cut flower production systems in Assam and Meghalaya

### Capacity Building Programmes for NER

To boost research in biological sciences and health engineering in North East Region, an advanced research facility called *North East Centre for Biological Sciences and Healthcare Engineering (NECBH)*, has been established at IIT-Guwahati. The major objectives of the project are: establishing research facility for biological sciences and healthcare engineering, addressing key research in identified areas, conducting trainings/workshops under outreach program and funding the small twinning projects for northeast institutes. The facilities under the project are anticipated to be fully functional soon. To facilitate the use of this facility by researchers across the NER, an online portal for instrument

booking was developed. The interactive website developed for the project can be accessed through the link <http://www.iitg.ac.in/necbh>. As part of the outreach programme, 2 workshops were conducted this year: one in IIT-Guwahati and one in Manipur University. A total of around 131 participants from the 25 different institutes of NER attended these events. With regard to the Outreach Twinning programme, 32 micro-projects covering the field of Biological Sciences and Health care engineering were funded, with researchers from across NER being mentored by IIT-Guwahati researchers. Considerable outputs in the form of 24 publications were published and 2 patents are filed during the year. Ninety-eight human resources were trained as part of this initiative in the 2<sup>nd</sup> year under various micro-grants.



Infrastructure Facility at North East Centre for Biological Sciences and Healthcare Engineering (NECBH) at IIT-Guwahati

The *Chemical Ecology programme between NER and Bangalore Institutes*, was designed to train and equip young scientists from the Northeast regions of India and produce quality research outcome by providing tailored interdisciplinary training to PhD students and chemical ecology postdoctoral fellows, recruited under collaborative projects in the field of chemical ecology offered by the participating PIs. Some significant outcomes of these NER students driven projects include (i) First record of pollinating and non-pollinating fig wasps (Hymenoptera: Chalcidoidea) from *Ficus elastica*, the living root bridge tree of Meghalaya in North-east India, (ii) Understanding the case for chemical dialects in the communication between figs and figs wasps in India across

large geographical areas, (iii) Thyroid hormone analyses in free-ranging Asian elephants exposed to a gradient of human disturbance, (iv) Venom Gland characterization from evolutionary related predatory species water Bugs and water Scorpions, (v) understanding Morphological and transcriptomic differences of bumblebee workers collected at different elevations in the Eastern Himalayas, (vi) Analysis of the volatile organic compounds in *Artemisia vulgaris* L. from Manipur using Headspace Solid-Phase Microextraction GC/MS. Under the project joint PhD degree has been awarded to 25 NER students. In addition, 5 Post-doctoral fellows were trained in the Chemical Ecology, an important area of research for NER owing to its rich biodiversity.



**09**

**DBT AUTONOMOUS  
INSTITUTIONS AND  
PUBLIC SECTOR  
UNDERTAKINGS**

## DBT AUTONOMOUS INSTITUTIONS AND PUBLIC SECTOR UNDERTAKINGS

For improving the knowledge base in Modern Biology and Biotechnology and to translate such knowledge in addressing societal goals, it is necessary to have dedicated theme-based institutions which can achieve these objectives. To this end, the Department has set up 15 theme based Autonomous Institutions and supporting one International Centre. These institutions facilitate flow of knowledge from Basic Science to Translational Research in Health, Agriculture, Bioresource and Basic & Emerging Biotechnologies. The institutions offer open day and interact with school students and public to create interest and inclination towards biotechnology and biological sciences. These institutes are also playing an important role in Capacity Building, Training and Skilling of Young Scientists, Students and Researchers. During the year, the research outcome of DBT Autonomous Institutions has resulted in about 650 Publications and filing of 50 Patent Applications. Apart from Autonomous Institutions, the DBT also has three Public Sector Undertakings (PSUs) under its administrative control. Various activities carried out during the year by these institutions are as follows. Apart from the R&D activities in various areas of Biotechnology and Modern Biology, the autonomous institutions and PSUs have taken R&D initiatives to address the challenges due to COVID-19 pandemic including efforts related to understanding the pathophysiology and epidemiology of the disease, and development of diagnostics, vaccine and therapeutics. These initiatives pertaining to the COVID-19 pandemic have been mentioned in a special chapter. The other R&D activities carried out during the year by these institutions are as follows.

### NATIONAL INSTITUTE OF IMMUNOLOGY (NII), NEW DELHI

The National Institute of Immunology (NII) was created in 1981 and was mandated to carry out research on immunological defense mechanisms, as well as to facilitate the development of innovative prophylactic, diagnostic and therapeutic measures. The Institute aims to create an internationally-competitive intellectual base as a sustainable source of research and discovery, addressing healthcare issues such as vaccines against COVID, pneumonia, malaria, tuberculosis and other infectious agents; institutional interests also extend to the detection and diagnosis of different types of cancer which afflict a vast population worldwide.

While continuing explorative thrusts in basic research, NII also lays stress upon the development of new products and the establishment of novel processes, with the objective of creating a more immediate impact on the human condition. NII's ever-expanding interactions with Industry are aimed at quick and effective translation of research leads into novel products and processes.

The Institute is primarily involved in basic and applied research in the following broad areas:

- Biophysics and Molecular Design
- Cancer Biology and Chronic Diseases
- Cell and Molecular Biology
- Immunology and Vaccines
- Infectious Diseases

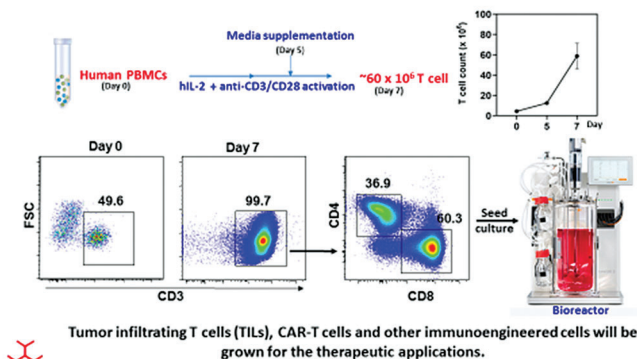
### Major Initiatives

#### Immuno-Engineering as a Flagship Programme

As our understanding of immunology broadens, we increasingly imbibe the tools and techniques of physical and engineering science. In order to fully exploit the potential of such cross-fertilization, NII has recently initiated a Flagship Programme on ImmunoEngineering. This umbrella project encompasses research on novel adjuvants and vaccines (for infectious diseases and cancer), immunotherapeutic strategies and artificial antigen presenting cells, scaffolds and drug delivery devices, and on new methods and protocols for regenerative medicine. To begin with, NII has initiated process development for the large-scale culture of human T cells (including CAR-T cells) for therapeutic applications. It also aims to set up an advanced cell culture/fermentation facility to grow other human cells/tissues/organs.

#### Immunoengineering : Cell Therapy Platforms at NII

**Objective: To grow immune cells ( T, NK and DC ) in large numbers in bioreactor for immunotherapeutic applications**

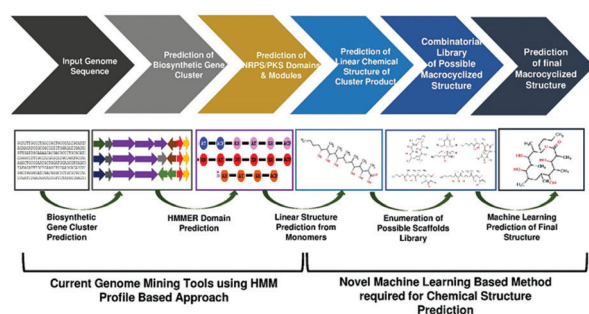




## Major Scientific Achievements

The Institute has published more than seventy-three research papers in international journal of repute (in the core areas of immunology, infectious disease biology, structural biology, and cancer biology), along with a dozen book chapters; ten patents have also been filed/granted. Some salient discoveries are described here:

- A. Computational approaches to ascertain biomolecular structure and to determine enzyme substrate specificity are being developed at NII to explore their applicability in the identification of novel biosynthetic pathways and regulatory networks. Ribosomally-synthesized, post-translationally modified peptides (RiPPs) constitute a large class of natural bacterial products of diverse structure and bioactivity. RiPPMiner, developed earlier, used a machine learning approach to predict RiPP class, leader cleavage sites and cross-linked chemical structures of RiPPs, utilizing only the sequence of the precursor peptide as input. RiPPMiner-Genome, a significantly updated version of RiPPMiner, takes genomic sequences as input and identifies RiPP biosynthetic gene clusters and modifying enzymes, significantly enhancing the accuracy of RiPP chemical structure prediction. This genome-mining approach helps to discover novel candidate drugs against many pathogens. (Agrawal P, Mohanty D, Bioinformatics. DOI: 10.1093/bioinformatics/btaa851, 2020)



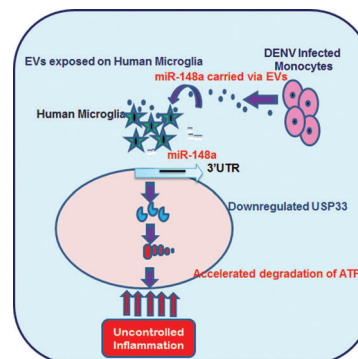
Pictorial depiction of different tasks involved in automated *in silico* prediction of chemical structures of polyketides and nonribosomal peptides starting from sequences of bacterial genomes. Currently available genome mining tools use HMM profile based methods to depict organization of modules and catalytic domains in a BGC and based on substrate specificity of catalytic domains, they can only predict the chemical structure of the linear precursor. Novel machine learning based computational methods are required for predicting the final macrocyclized structure of PKs/NRPs by *in silico* genome mining.

- B. Understanding signalling at cellular and molecular level has been a long interest of NII in the context of infectious diseases and immunology. Crosstalk of non-canonical NF- $\kappa$ B signaling pathway with the canonical NF- $\kappa$ B signalling pathway, and with the IRF3-type 1 interferon

axis, is being elucidated to understand signalling pathways in immunomodulation. The canonical RelA NF- $\kappa$ B pathway was found to exert a pro-viral role during infection, arising from the ability of RelA to suppress cell death. Further, whether non-canonical NF- $\kappa$ B signalling influenced TNF-induced gene expression was assessed, employing microarray analysis on specific NF- $\kappa$ B component-deficient mouse embryonic fibroblasts. Data suggests that the p100 subunit modified transcriptional responses to TNF via both RelA- as well as RelB-dependent mechanism (Chawla M, Roy P, Basak S. Curr Opin Immunol. 68:21-27, 2020).

- C. Learning how viral genes exploit cellular processes to promote viral replication has been a long-standing interest of NII in the context of HIV. The Tat protein from HIV subtype B was shown to exhibit significantly higher RNAi-silencing suppressor activity than the Tat protein from HIV subtype C. The E3 ligase CHIP was shown to modulate the stability of Tat, and transfection of CHIP significantly reduced HIV-1 replication. In other work, novel frame-shift mutations in the gene for CCR5 were detected in HIV sero-negative individuals from North India. This provides interesting observations about the replication cycle of HIV.

Besides, recent findings suggest a potential role of circulating host microRNA-148a which has been found to travel in exosomes, gets internalized by human brain cells such as microglia and triggers the neuroinflammatory cascade in Dengue virus-infected persons. As a post-viral dynamic, the data provides novel insight on how neurological anomalies can emerge in recovered patients (Mishra R, Lahon A, Banerjee AC. J Immunol. 205:1787-1798, 2020).



Role of circulatory host microRNA-148a in the neuroinflammatory cascade in Dengue-infected persons



- D. In another study, signaling cascades which work to promote survival of *Mycobacterium tuberculosis* are being delineated. Infection of macrophages with *H37Rv* resulted in higher levels of double-stranded breaks in host DNA than did infection with *H37Ra*; damage to host DNA was also observed in *Mycobacterium tuberculosis*-infected mice. Treatment of infected mice with a combination of isoniazid and an ATM inhibitor resulted in a synergistic reduction in bacterial load indicating that reversing pro-survival signals may therefore result in therapeutic benefit (Lochab S, Singh Y, Sengupta S, Nandicoori VK. eLife, DOI: 10.7554/eLife.51466, 2020).

### Major Collaborative Research

The Institute continuously strives to enhance collaboration with different research and academic organizations, both nationally and internationally. Notable recent joint programmes are mentioned here:

- An MOU with IIT Delhi has been signed to carry out collaborative research and to share infrastructure.
- A collaborative project has been initiated with INMAS (Delhi, DRDO) for research in non-human primates.
- NII is the coordinating Institute on an INDO-EU project for developing candidate flu vaccines.
- NII is collaborating with ICMR for the development of a liver stage and transmission blocking candidate malaria vaccine.
- NII has continued its MOU with Cadila Pharma (Ahmedabad) to explore possibilities of using *Mycobacterium indicus pranii* as an immunomodulator to control a variety of infections.
- NII has also initiated collaborative research with ILBS, New Delhi, on cell therapy-based platform as well as on antibody therapy.

### Societal Impact

The Institute is actively engaged in the running “Science Setu” Programme which has a great societal impact. MoUs have been signed with several undergraduate colleges of Delhi University, as well as with Manav Rachna International University, Faridabad.

Webinars were conducted on COVID-19 to disseminate information on the pandemic. In addition, in order to scale-up the country’s testing capacity for the SARS-CoV-2 virus, the Institute arranged hands-on training of medical lab technologists, with the support of Gates Foundation. This initiative was coordinated by TIFR through the Office of the Principal Scientific Advisor, Government of India.

### NATIONAL CENTRE FOR CELL SCIENCE (NCCS), PUNE

NCCS is involved in cutting-edge research in several areas of cell biology relevant to human health, including the biology of diseases like cancer, malaria, tuberculosis, metabolic disorders like diabetes and obesity, as also neurobiology, stem cell biology, immunology and microbiology. It contributes immensely to the capacity building of the nation through high-quality human resource development in cell biology research. The National Centre for Cell Science (NCCS) was established at Pune with a mandate of three main functions:

- To carry out research in cell biology
- To serve as a national cell repository
- Human Resource Development.

**Major Initiatives:** NCCS initiated discussions with TechEx. In to explore possibilities for the transfer and licensing of its IP and technologies. TechEx. In is one of the Technology Transfer Offices supported by the National Biopharma Mission to enhance academia-industry inter-linkages, hosted by Venture Center in Pune. The Indian Human Microbiome project was also initiated by NCCS.

### Salient achievements

- Contributions of the National Cell Repository:** Facilitated cell biology research across India by providing 23 cell cultures to 14 organizations.
- Research Achievements:** Research in cell biology at NCCS led to several meaningful outcomes, including the development of human iPSCs from a liver cirrhosis patient of Indian origin, which could serve as a valuable resource for Indian population-specific biomedical investigations. Research at NCCS has also illuminated

important aspects of the molecular processes in the translation regulation of glucose-induced insulin production, which could help understand diabetes better. Using cutting-edge proteomics and bioinformatics tools, NCCS identified some promising proteins that could serve as biomarkers and therapeutic targets for multiple myeloma, the second most prevalent blood cancer at the global level. Studies on the Indian human microbiome have revealed changes in the proportions of some specific groups of gut bacteria in non-diabetic, pre-diabetic and the diabetic conditions, which may help in developing microbiome-based interventions for diabetes. Further, the gut, mouth and skin microbiomes from the healthy Indian population were found to undergo very specific age-related changes, which could serve as a baseline reference for further microbiome studies focused on individuals with a disease like diabetes and obesity.

## Research Highlights

NCCS research published in *Nature Structural and Molecular Biology* was among the top 5% of all research outputs scored by Altmetric. It was also selected as one of the most exciting subjects investigated at the European Synchrotron Radiation Facility (ESRF) in recent times, and will be featured in their annual publication, ESRF Highlights 2020.

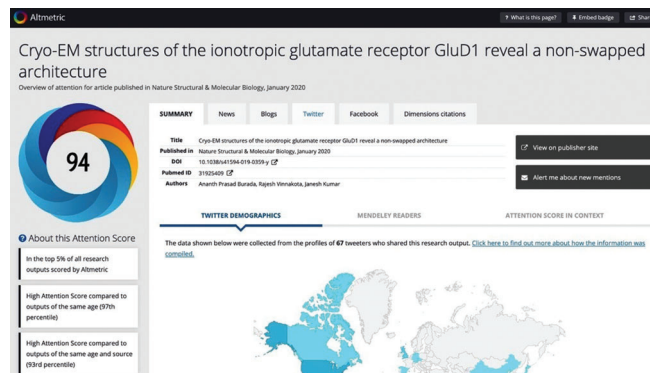
## Salient Achievements

### a) The National Cell Repository facilitated COVID-research -

(i)	Cell cultures supplied:	23
(ii)	Organizations that the cell cultures were supplied to:	14
(iii)	Samples preserved at the COVID biorepository:	127

### b) Research Achievements -

(i)	Patents & Technologies filed:	05
(ii)	Number of Publications in Peer Reviewed Journals :	76



NCCS research published in *Nature Structural and Molecular Biology* is among the top 5% of all research outputs scored by Altmetric.

### c) Awards & Honours:

During this year, the scientists from NCCS, Pune were decorated with several awards like J.C. Bose National Fellowship, Fellow of the Indian National Science Academy (INSA), MiltenyiBiotec MACS® Grants 2020, India EMBO Lecture Course Awards 2021. The Scientists were also elected/ nominated as the members of some of the esteemed committees like the Executive Board of the International Committee on Systematics of Prokaryotes, Guha Research Conference', Subcommittee on Methanoarchaea, of the International Committee on Systematics of Prokaryotes (ICSP)

## Societal Impact:

### a) Capacity Building

Beneficiaries of the NCCS Academic Programmes (01 April - 10 Nov, 2020)		
1	Research Fellows who received a Ph.D.	5
2	Registered Ph.D. students (as on 10 Nov, 2020)	125
3	Project trainees	35
4	Postdoctoral Fellows / Early career scientists	15
5	Participants (including faculty) from NIT, Warangal, who received online training in Bioinformatics (MD simulations)	75

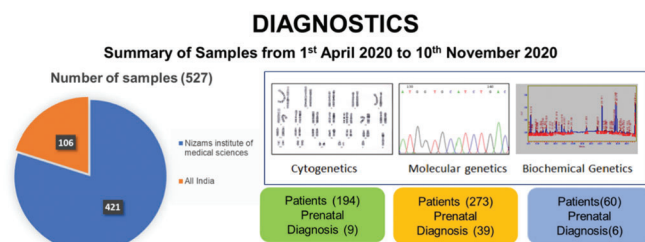
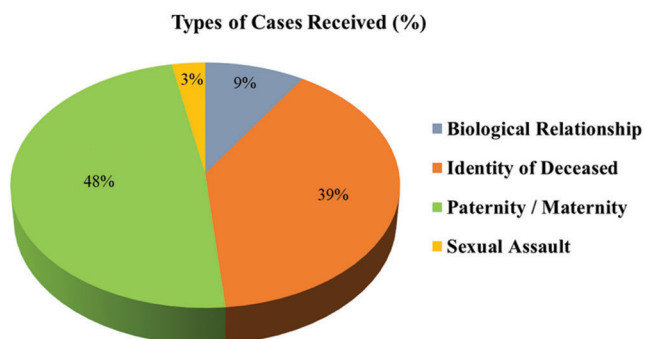
**b) Promoting science through outreach activities & invited talks:**

- Scientists from NCCS participated in the Vaishvik Bhartiya Vaigyanik (VAIBHAV) Summit as panelists and speakers, to support the Government's efforts to promote science.
- During the tenure, several popular science and scientific lectures were delivered, and popular science articles were published in Hindi, Marathi and English by the faculty, postdoctoral Fellows and students of NCCS, Pune. These included diverse topics, such as the sudden change in colour of the Lonar lake water to pink, stem cells, the 'Indian Human Microbiome' project, Foldscope, Antimicrobial resistance, and the world's largest collection of microorganisms.

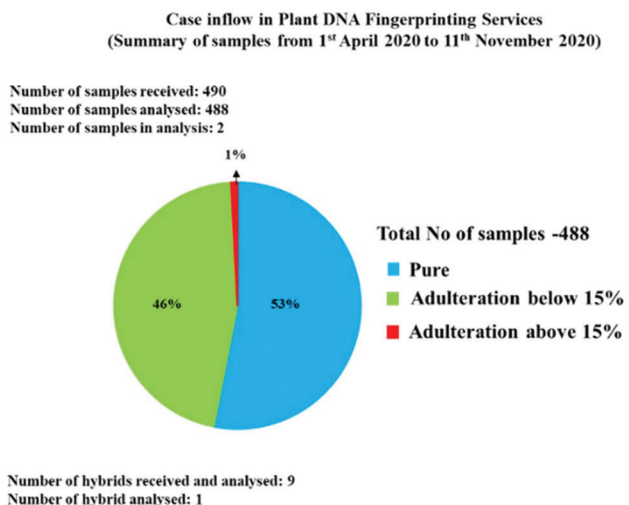
**CENTRE FOR DNA FINGERPRINTING AND DIAGNOSTICS (CDFD), HYDERABAD, TELANGANA**

The Centre for DNA Fingerprinting and Diagnostics (CDFD) was established as an autonomous institute of the Department of Biotechnology (DBT), Ministry of Science & Technology, Govt. of India, in the year 1996. CDFD is the first institute in the country to incorporate a "hybrid model" amalgamating services and research, with both components enriching each other. The mission of the CDFD is to carry out scientific research, services and training; to achieve global excellence in fundamental and applied research; and simultaneously endeavour to transfer the benefits of modern biology to every section of society. The main objectives of CDFD are: to provide DNA fingerprinting services to the judiciary and to law enforcing agencies, to establish DNA diagnostics methods for detecting genetic disorders, to use DNA fingerprinting techniques for authentication of plant species (e.g. basmati rice), and to undertake basic, applied and developmental R&D work. Another important mandate of CDFD is to provide highly trained and skilled manpower in the domains of modern biology through its PhD and various other training programmes.

**HUMAN DNA FINGERPRINTING SERVICES**



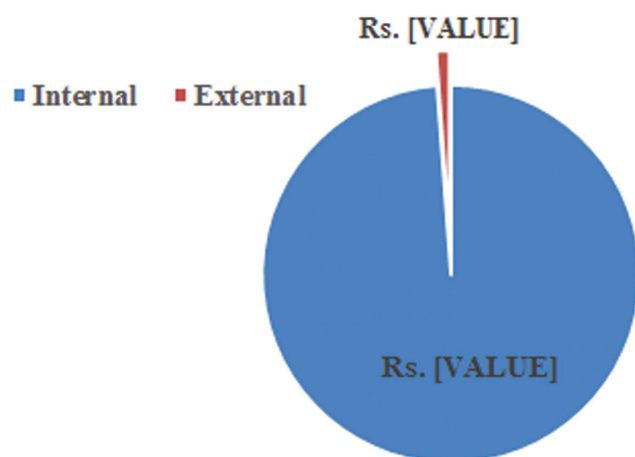
**PLANT DNA FINGERPRINTING SERVICES**



**SOPHISTICATED EQUIPMENT FACILITY:** CDFD offers a wide range of instrumentation and analytical services of modern molecular and cell biology using state-of-the-art, high precision, supreme quality, sophisticated scientific instruments. This matchless facility is being made accessible to all interested scholars, academicians and scientists from Universities, R&D institutes, and industry along with teachers and students from colleges and schools, at a notional cost.



### Revenue Generated from SEF in Rupees (from 1<sup>st</sup> April 2020 to 11<sup>th</sup> November 2020)



Grand Total = ₹ 12,82,939

SEF usage	
Number of Users	1545
Number of Samples	7137

### Salient Achievements:

- In the year 2020-21, CDFD has provided a) High quality forensic DNA fingerprinting services in 33 cases to the various courts of law, law enforcement and investigative agencies of the country; b) Genetic diagnostic services, prenatal diagnosis, and clinical genetic counselling services to more than 500 people, c) Plant DNA fingerprinting services for 490 samples.
- During the reporting period 33 research papers have been published by various scientific groups at CDFD and 1 patent was filed by CDFD during the period. Besides, Dr. Subhadeep Chatterjee received Shanti Swarup Bhatnagar Prize in Biological Sciences by the Council of Scientific and Industrial Research (CSIR) and has been elected as fellow of the Indian National Science Academy (INSA).

### NATIONAL INSTITUTE OF PLANT GENOME RESEARCH (NIPGR), NEW DELHI

The National Institute of Plant Genome Research (NIPGR), an autonomous institute of Department of Biotechnology (DBT) starting from its inception in 1998, has focused

scientific program both in basic science and translational work with a mission to undertake research of high caliber in plant molecular biology and to seek applications of the same. The Institute is actively engaged in research on topics ranging from genome analysis and molecular breeding, plant development and architecture, adaptation to abiotic stresses, molecular mechanisms of host-pathogen interactions, plant immunity, computational & structural biology, nutritional genomics and emerging areas covering cutting-edge research. Overall, the Institute has made significant progress in its research activities, which are reflected in high-quality publications and some promising technology leads. Now, it is poised to steadily march forward in contributing to plant science and thereby the nation building. Today NIPGR's vision is to be recognized as a centre of excellence not only in the Asia-Pacific region, but also among top plant science institute in the world. To fulfil the vision, the mission is to continue to call for research and innovation to has transformative impact on society.

### Vision and Mission

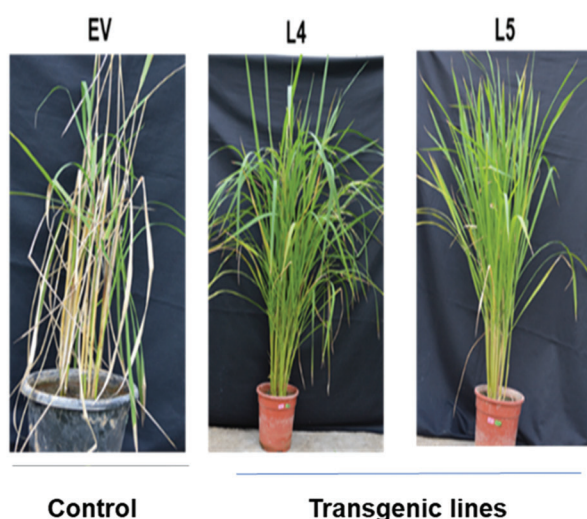
The Vision of the Institute is to generate new knowledge in the area of plant genomics, assimilate it with current knowledge, and translate the same for genetic enhancement of plants for social benefits. The Mission is to undertake, aid, promote, guide and coordinate research of high caliber in basic and applied plant molecular biology.

### Major Initiatives

- Institute is continuously upgrading its research infrastructure in order to effectively pursue the twin goals of conducting high-quality basic research and seeking its application towards product development. Towards this, a Gene Functional Analysis platform, Metabolomics facility and Advanced Proteomics facility had been established and currently fully functional.
- The National Genomics and Genotyping Facility (NGGF) has been established and would be providing service to the scientific community very soon.
- The Institute has prepared to launch mega-projects in nationally important areas. One such program on "Protein nutrition" has been developed in collaboration with different ICAR and ICMR institutes and currently under consideration by DBT.

- d) Another program under Multi-institutional National Mission Mode on “Characterization of Chickpea Germplasm Resource to Accelerate Genomics-assisted Crop Improvement” has been developed in partnership with ICAR, ICRISAT and SAUs and currently under consideration by DBT.

**NIPGR flagship program:** Imparting sheath blight disease tolerance in rice focused at developing newer ways of managing sheath blight disease using a multi-pronged approach. The institutional participants in this program are: National Agri-food Biotechnology Institute (NABI); Indian Agricultural Research Institute (IARI); Indian Institute of Rice Research (IIRR); International Rice Research Institute (IRRI) and the National Institute of Immunology (NII). Under this program, the rice lines overexpressing Bg\_9562 (that encode an antifungal protein) have been generated. The transgenic lines provided ~95% protection against sheath blight disease under controlled condition. Further studies are in progress.



The transgenic rice line overexpressing the Bg\_9562 protein under pathogen inducible promoter exhibits sheath blight disease tolerance. The disease symptoms of *R. solani* infected control (empty vector, EV) and transgenic lines (L4 and L5) are reflected.

## Salient Achievements

**Development of high yielding high protein chickpea variety:** 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 characteristic has been transferred into a commercially important desi chickpea variety, JG11 (ICCV 93954). The Improved JG1 variety has a 15-20% increase in yield over the parent. This line has passed the multi-locational field trial (AVT 1) conducted under “ICAR-AICRP (All India Coordinated Research Projects) in collaboration with IARI and ICRISAT (Figure 1). Currently, the variety is undergoing the Advanced Varietal Trial-2 (AVT-2) at 16 different rainfed areas of India. If the performance of Improved JG-1 is also satisfactory in AVT-2, it can be considered for release as a variety for commercial cultivation.

### Development of high yielding chickpea using ABC Transporter *CaABCC3*

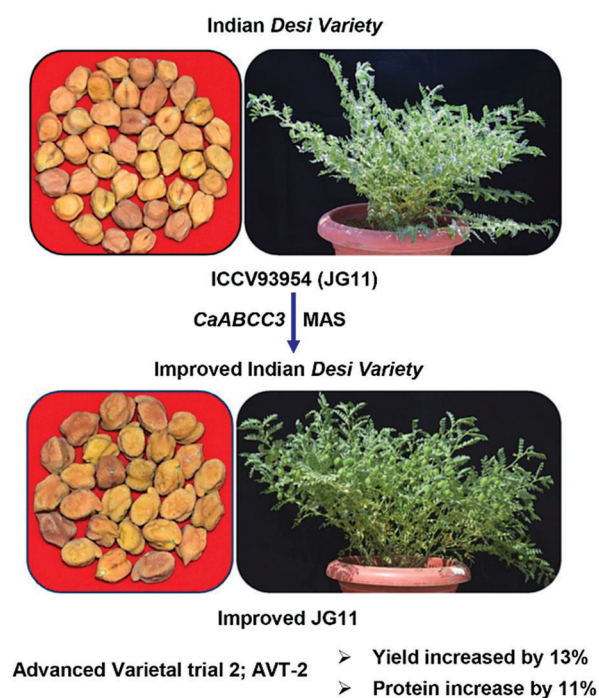
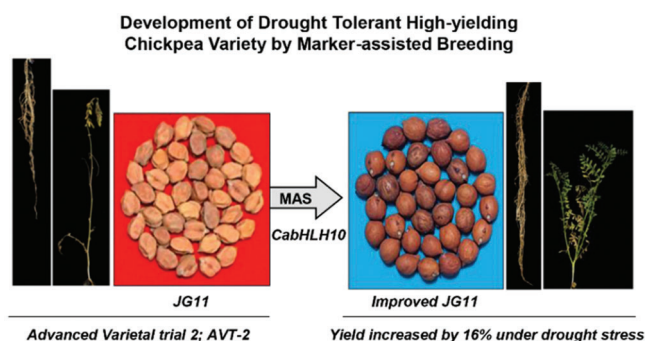


Figure 1

**Development of drought tolerant high yielding chickpea variety:** Very recently, an informative molecular marker tightly linked to superior natural haplotypes of a *CabHLH10* gene has been identified for drought tolerance in chickpea. This marker has been used to transfer drought tolerance characteristic from an Indian landrace/variety (ICC 4958 and Pusa 362) of chickpea into a commercially

important Indian variety (ICCV 93954, popularly called as JG 11) that has drought sensitivity. The newly developed chickpea lines exhibited overall 16% enhancement of yield/productivity under drought stress as compared to the parent line ICCV 93954 (JG 11) and evaluated in “ICAR-AICRP (All India Coordinated Research Projects) on Chickpea” Advanced Varietal Trial 1 (AVT1) (Figure 2). Currently, in the Rabi season (2020-21) the AVT2 trial is underway at different rainfed areas of India prior to possible release as a variety.



**Event selection trial of nutritionally improved low glucosinolate mustard:** Low glucosinolate transgenic mustard BjMYB28-RNAi lines developed at the Institute has undergone event selection trial in collaboration with University of Delhi South Campus under BIRAC funding, which established the stability of the trait in the open field condition (Figure 3). Further, biochemical and yield parameters also were found to be comparable to the check cultivar, Varuna. This paves the way for development of nutritionally improved Canola quality lines in Indian oilseed mustard cultivars.

**Event Selection Trial of low glucosinolate transgenic mustard conducted in collaboration with UDSC**



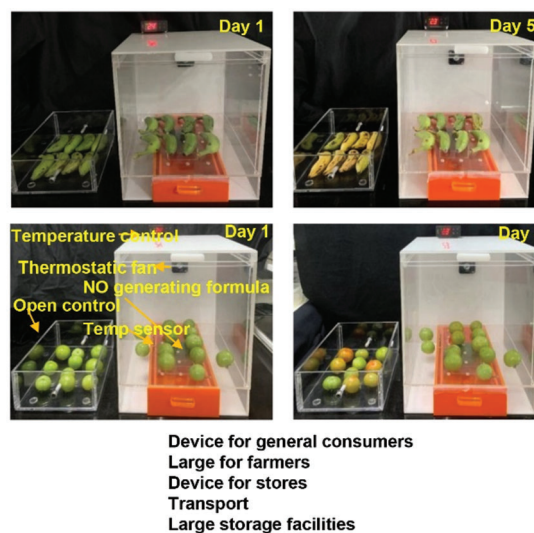
- Low glucosinolate transgenic mustard lines were stable under open field condition
- Agronomic performance for 12 yield traits was comparable to Varuna, the national check

**Figure 3**

**Development of an engineered device for increasing shelf-life of fruits and vegetables using hypoxia induced nitric oxide:**

In another area towards exploring the role of nitric oxide (NO) in hypoxia and fruit quality, furthering the molecular lead from the basic studies, under a BIRAC BIG grant a prototype of an engineered device has been developed for increasing shelf-life of fruits and vegetables using hypoxia induced nitric oxide (Figure 4).

**Development of an engineered device for increasing shelf-life of fruits and vegetables using hypoxia induced nitric oxide**



**Societal Impact:**

**Science Outreach Activities:** With a view to popularize science and showcase the various facets of research and development to young innovators, students, teachers, and individuals interested in the field of plant sciences, the Institute organized several events such as: Brainstorming discussion meeting in diverse areas of Technologies in Agriculture (April 04, 2019); DBT NCR Cluster Seminar Series', seminar on 'Genomic tools and applications in modern biology' (April 12, 2019); Training Programme for School teachers (September 6, 2019); Open Day/Public Outreach Day (October 23, 2019); International Symposium on "Recent trends in Bioinformatics and Big data analysis" (November 8, 2019); Public lectures on "Biodiversity of National capital Region (NCR)" to celebrate the National Science day (February 28, 2020); to celebrate PoshanMaah International webinar on "Food, Nutrition and Health", inaugurated by



Secretary, DBT (September 21, 2020). Further, a few hundred students from thirteen different Universities/Colleges/School(s) visited NIPGR to familiarize themselves with the frontier research being carried out at NIPGR and interacted with the faculty.

### NATIONAL BRAIN RESEARCH CENTRE (NBRC), MANESAR, HARYANA

The National Brain Research Centre is engaged in understanding brain functions in health and disease through basic and clinically oriented research. NBRC has been recognised as an 'Institution of Excellence' by the Government of India. The mandate of NBRC is to pursue research to understand brain function in health and disease, generate trained human resources to carry out interdisciplinary research in neuroscience, and promote neuroscience in India through networking among institutions across the country. NBRC is a Deemed to be University and runs M.Sc. and Ph.D. programs besides other post-graduate and post-doctoral training programs to generate trained human resources with the knowledge and skills required to conduct interdisciplinary research in advanced neurosciences. The broader vision of NBRC is to discover underlying mechanisms and develop diagnostic markers and cures for various diseases affecting the brain and mental health through innovative approaches in basic and translational research. The Centre aims to contribute towards reducing the burden of neurological disorders in the population through its cutting edge basic and clinically relevant research.

**Major Initiatives:** During the year, NBRC continued its *Flagship Programme 'Comparative mapping of common mental disorders (CMD) over the lifespan'*. This program aims to understand how information processing networks in the brain are affected in common mental disorders viz. anxiety, depression, obsessive-compulsive disorder and post-traumatic stress disorder. The goal is to understand underlying brain network mechanisms that differentiate between these disorders, and if these networks are affected in the same manner in patients of different age groups. The information will help establish age-specific diagnostic markers for these disorders. We will expand the program into a multicentric nationwide programme in the next phase and carry out genetic investigations.

The second major initiative of NBRC is the Dementia Science Program, which is a national level program. Dementia in elderly is ballooning into a major health problem with rapidly aging population of the country, and the changing social structure towards nuclear families. Goal of this program is to determine incidence and prevalence of dementia in the country, and to determine the factor such as lifestyle, genetics and previous medical history that result in a subset of people progressing from Mild Cognitive Impairment (MCI) to dementia, so that possible intervention could be developed. The Programme involves three community-based sites in the north (Palwal), south (Bengaluru) and east (Mawphalang) India, where rural, urban and tribal cohorts are being setup for long-term follow up. In addition, there are four hospital-based sites at AIIMS New Delhi, NIMHANS Bengaluru, SCTIMST Thiruvananthapuram and BIN Kolkata. Harmonised protocols for data collection have been finalized and pilot runs have been done. Investigators will start patient recruitment phase as soon as the COVID19 outbreak subsides.

The third major initiative started this year was to understand the basic biology of SARS-CoV-2 and search for possible ways to reduce the pathology of the virus. In this direction, research has been started on human brain cells and lung carcinoma cell lines, and a natural compound has been identified that has strong antiviral activity and reduces Cytokine storm.

### Salient Achievements:

Infectious diseases group at NBRC is interested in understanding the molecular mechanisms of viral diseases of the nervous system. Current research is focused on identifying the role of microglia and neural stem/progenitor cells in the healthy and diseased central nervous system. A set of experiments initiated this year are to understand the role of long noncoding (lnc) RNA in regulating neuroinflammation, and how astrocytes regulate immune metabolism following neurotropic viral infection. The findings from this work showed that Japanese Encephalitis virus (JEV) infection induces classical activation (M1) of microglia that drive the production of pro-inflammatory cytokines, while suppressing alternative activation (M2) that could serve to dampen the inflammatory response, thereby inducing inflammatory response, microglial activation, and neuronal apoptosis.

Synapse-specific mechanisms of memory storage also involve long non-coding RNAs and miRNAs. One laboratory has identified a subset of synapse-enriched long non-coding RNAs and miRNAs that regulates structure and functions of synapses by modulating *de novo* protein synthesis. The laboratory has shown that sleep loss, a pathological condition during aging and Alzheimer's disease, led to impairment of translation at synapses associated with memory storage. To take this further, a tri-institutional collaborative research programme with Iowa Neuroscience Institute USA, National Institute of Mental Health & Neuroscience Bangalore and National Brain Research Centre, Manesar has been established. This research programme is funded by University of Iowa to investigate age-related molecular changes at the synapse that impacts memory storage in human brains with distinct ethnicity.

In a multi-trial task, long-term memory formation depends on the pattern of learning. If learning is distributed over multiple sessions with a time interval between them (spaced training), better long-term memory is formed. But, if the entire learning is crammed into one session or into multiple sessions with very little time interval between them (massed training), none or very poor long-term memory is formed. NBRC scientists are investigating the mechanisms that are involved in differential memory formation by massed and spaced patterns of training. Long-term potentiation is a kind of synaptic plasticity in which long-lasting enhancement in synaptic strength is induced by experience. Similar to memory formation, spaced pattern of presynaptic stimulation induces higher potentiation of synapses than massed pattern of stimulation. Previous studies at NBRC showed that long-term memory and synaptic potentiation induced by massed patterns can be facilitated if the level of a specific protein modification is increased in the cells. Researchers are now investigating the effects of other compounds which may facilitate memory formation by massed pattern of training. These studies are likely to inform us regarding the mechanisms involved in differential memory formation by massed and spaced patterns of training and help in discovering possible therapeutic agents for diseases leading to loss of memory.

Researchers at the Centre are studying changes in the cortical neural circuitry involved in hearing and vocalizations during development as well as reward pathways in the brain using

post-mortem human brain samples and a model system of songbirds. Understanding such changes is important for planning timely interventions such as cochlear implants for deaf children, and to understand the neural basis for the ability to learn multiple languages. The auditory cortex is also known to be affected in schizophrenia, which is known to have a neurodevelopmental origin. Studies are ongoing on developmental changes in inhibitory connections and interneurons in normal adults and compare this with patients suffering from schizophrenia or bipolar disorder. Working on songbirds including house crows and zebra finches, wherein the organization of neural circuits for hearing, speech and reward are remarkably similar to those in humans, it was found that the opioid system affects the motivation to sing as well as the acoustic properties of the birdsong, besides adult neurogenesis. Recent results have demonstrated that even small alterations in opioid modulation during development can lead to changes in the songs that juvenile male birds produce as adults. Further studies are planned to understand the role of the opioid system in vocal learning and vocalization.

Working on *C. elegans*, a powerful nematode model system for neuroscience research, scientists have demonstrated that Kinesin-13 family microtubule catastrophe factor is a critical determinant of neuronal microtubule dynamics and polarity. This work provides a mechanistic link between Wnt-signaling and Kinesin-13 in establishing neuronal polarity. Furthermore, the group established an exercise paradigm involving swimming in worm and showed this exercise regimen promotes both axon regrowth as well as post-regrowth functional recovery. This work provides molecular evidence that the activity of the metabolic energy sensor AMPK/AKK-2 in muscle as well as injured neuron is important in exercise induced improvement in axon regeneration phenomenon. This study sets up a paradigm in *C. elegans* model to address how other tissues communicate with the injured nervous system for the functional rewiring process.

Working on understanding neurobiological mechanisms of multisensory integration and basic sensory function, NBRC scientists have found using Graph theoretical measures, segregation (modularity, clustering coefficient and local efficiency) and integration (global efficiency and characteristic path length) in the network information processing in healthy and diseased brains. These factors were found to be related

to optimal GABA and glutamate concentrations and pathological values reported in epilepsy and schizophrenia respectively.

### Societal impact

In addition to the productive research outcomes, NBRC fulfils its societal responsibility through various ways. With an aim to reduce the burden of neurological disorders amongst the in general population, NBRC offers neurological outpatient services at Civil Hospital, Gurgaon to patients from the city as well as neighbouring districts. Patients with epilepsy continue to come to NBRC for sophisticated investigations using the Magnetoencephalography (MEG) facility set up in collaboration with AIIMS, New Delhi. 'DALI' a tool in Indian languages for dyslexia assessment in children developed at NBRC remains in high demand and is being increasingly adopted countrywide.

NBRC scientists have developed specialized tools named BRAHMA and ANSH for integrating inputs from neuroimaging data and the clinical information to help in diagnosis of various brain diseases such as Alzheimer's and Parkinson's. The tool is standardized on a robust Indian brain template that is representative of the Indian population-specific brain anatomy. NBRC usually organizes open days for children from local schools, and other citizens to visit the campus and interact with researchers. Despite the COVID19 outbreak, we continued the outreach program but in an online mode. NBRC faculty members also delivered popular science webinars for Schools and Colleges across the country.

### INSTITUTE OF BIORESOURCES AND SUSTAINABLE DEVELOPMENT (IBSD), IMPHAL, MANIPUR

North East (NE) region of India has unique bioresources, which needs to be explored through evidence-based scientific validation. The ethnic people of NE region traditionally practice medicinal plants for therapeutical uses, however there is a lack of scientific validation. There are reports on bioresources (plants, edible insects, fermented foods etc.) of NE India having immune-boosting properties. Considering the significance of the rich Biodiversity and the unique Bioresources of the region, the Department of Biotechnology established the Institute of Bio-resources and Sustainable Development (IBSD) to carry out research and development

activities in the areas of plant resources, microorganisms, traditional foods, and animal resources for various applications in phytopharma drug development, nutraceuticals.

**Major Initiatives:** To strengthen the research activities of IBSD, collaboration with several reputed International and national research Institutes for collaborative research programmes is being initiated. This encourages the scientists and students of IBSD to exchange knowledge helping in achieving major goals with collective efforts. All these works through different research verticals will help in developing a platform for knowledge sharing, promotion, and development of natural resources of North East Region (NER).

**Significant Achievements:** During the current year, IBSD has made significant contributions in plant, animal and microbial resources. IBSD started undertaking relevant research and development efforts in the much-needed areas categorized in different verticals for research including; Phytopharmaceutical Mission, Ethnobotany, Ethnopharmacology & Drug Discovery, Microbial Resources, Fermented Food and Value Addition, Plant Resources, Animal Resources, Eco-Restoration, and Bioenergy and Biofuel. In addition to it, Bioinformatics is applied in all the verticals for advanced data analytics, visualization, documentation, and storage to strengthen the objectives. The unique bioresources, ethnic and traditional practices, indigenous traditional knowledge, etc. of this region are explored through evidence-based scientific validation.



Phytopharmaceutical Mission is a major initiative taken up by IBSD which will highlight on development of translational research components of NER for development of phytopharmaceuticals from bioresources of NER.



Collaborative research programme between IBSD and Jadavpur University (JU), Botanical Survey of India (BSI), Kolkata, MISTIC, Govt. of Mizoram, and with several other organizations are initiated under the mission. Several works on *Withania somnifera*, *Andrographis paniculata*, *Ficus semicordata*, *Gaultheria fragrantissima*, and Bamboo biosilica (Vanshlochan) has been started. Evaluation of nutraceutical properties of selected edible insect species of NER is carried out and research on development of potential natural insect repellents and anti-viral agents from traditional aromatic and medicinal plants from NER are being carried out. From *Artemisia vulgaris* a unique phytomarker is isolated and characterized and named as Iso-seco-tanaphthalide which is found to be toxic to various insect pests. Biosilica accumulation is analyzed in eight different bamboo species of Mizoram and out of them *D. longispathus* species of bamboo shoots recorded with a high biosilica accumulation in the young edible sprouts.

A hydro distillation unit for mass scale extraction of essential oils from aromatic plants is installed at National Bioresources Park, Haraorou, Manipur. Compendium of 71 medicinal plants from NER with antiviral properties has been created. Aphyto marker compound is isolated from the aerial parts of *Tithonia diversifolia* named as Dihydro-p-coumaric acid, which is toxic to stored grain insect pests and can help in development of biopesticides. Zerumbone showed inhibitory action against IL-10 release in the suppression of cervical cancer cell proliferation in a dose dependent manner. On proteomics analysis, several differentially induced enzymes were identified from digestive fluid of un-opened and opened pitchers of *Nepenthes khasiana*. In Bioenergy programme, biological pre-treatment studies showed eco-friendly process for the pre-treatment of biomass for producing sugars for biofuels and high value products compared with chemical process.

In the plant resource programme, 11 *Prunus* species, 7 *Rattan* species and 48 Orchid species has been collected. Nucleotide sequence of ITS region for 9 (Nine) *Prunus* samples of Manipur were deposited at NCBI GenBank. *Calanthe hancockii* Rolfe., a rare and endangered Orchid was reported for the first time from North East India. Detection of incidence of 'Candidatus Liberibacter asiaticus' causing HLB or Citrus greening disease in Manipur was carried out using molecular

techniques and its occurrence varied with elevation. IBSD is focusing in creating awareness of HLB among the citrus growers to reduce the spread of HLB and preserve the citrus cultivation in this biodiversity hotspot region. In animal resource programme, *Tipula* species and *Darthula* species are recorded as edible insects for the first time from Mao, Manipur. Corm-Borer (*Aplosomyx* sp.) from *Colocasia* sp. was first reported as edible insect by the Kuki community from Manipur. The n-hexane extract of *Ageratina adenophora* has shown antifeedant activity against cabbage pests.

In the microbial resource programme, microbial repository deposits have increased to more than 72,000 cultures including bacteria, fungi, actinomycetes and yeasts. Whole genome analysis of *Bacillus subtilis* KN2B, *B. licheniformis* KN1G, *B. amyloliquefaciens* KN2G, and *B. subtilis* KN2M is done and as the species are selected as starter culture for *kinema* production and compared their functional properties. Peptides from peptidome of soybean based fermented foods of Sikkim were screened *in-silico* against two major proteins identified as key receptors including SARS-CoV-2 Spike Glycoprotein (S1) Receptor Binding Domain (RBD) and the main protease. Further, fungal endophytes (*Thielaviasterrestris* PSRF52 and *Lambertellacornimaris* PSRF53) isolated from *Panax sokpayensis* were found to produce Ginsenoside Compound K in *in-vitro* condition as detected by LC-ESI-MS.

**Societal Impact:** IBSD has been organizing an international webinar series "Reimagine Ethnopharmacology" jointly with Society for Ethnopharmacology (SFE)-India and International Society for Ethnopharmacology (ISE), Switzerland, since May 2020 on Saturdays.

## INSTITUTE OF LIFE SCIENCES, BHUBANESWAR, ODISHA

Institute of Life Sciences (ILS) is pursuing the defined mandate "Betterment of Human Health and Welfare" through its highly energetic and experienced faculty members in the area of life science research, education and outreach. The efforts are being intensified and consolidated through sustained support from the Department of Biotechnology, Govt. of India since 2003. There are four major groups working in the fields of Cancer biology, infectious disease biology, genetic and autoimmune diseases, and plant and microbial biotechnology. It aims at deciphering the cellular and molecular components

regulating growth, differentiation, and development processes using cutting edge technology and employ translational approaches for developing technologies and products for the betterment of society.

### Major Initiatives:

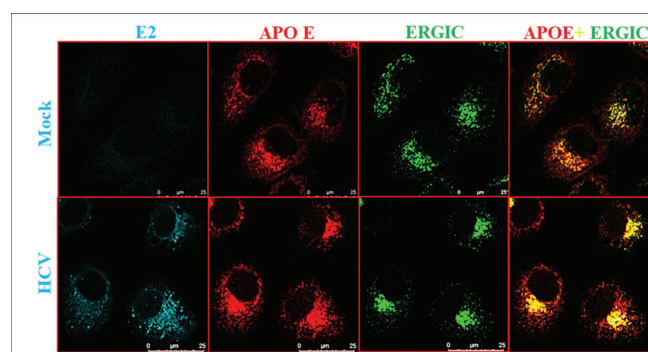
ILS, in partnership with ICMR-Regional Medical Research Centre and Kalinga Institute of Social Sciences University, is undertaking project activities aimed at ecological and economic improvement of tribal and rural farming communities in one of the aspirational districts of Odisha (Nabarangapur). The programme focuses on enhancing agricultural production and farm income, imparting nutritional literacy, and promoting establishment of nutrition garden for ensuring dietary diversification, as well as developing value-added and promotional entrepreneurial activities involving more than 500 farm-families in the district.

### Salient Achievements

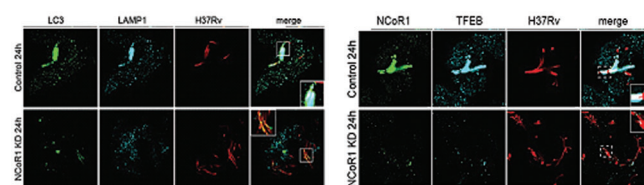
**Tribal Health and Nutrition:** The flagship program of ILS on “Tribal Health and Nutrition” has an overall goal of contributing towards providing a comprehensive outcome on human nutrition and diseases through an integrated approach of understanding genomic diversity and differentiation, linking immune-metabolic variations to prevalent diseases and understanding gut microbiome diversity in ethnically distinct, well-differentiated and geographically distributed tribal populations of the state of Odisha. During the last year, tribal samples were collected from two places in the Sundergarh district of Odisha; Telijore, which lies in Balisankara block (latitude 22p 21<sup>146.8</sup>° N longitude 84p 0<sup>12.6</sup>°E) and another from Nuagaon (latitude 22p 18<sup>110.3</sup>° N longitude 85p 0<sup>122</sup>°E) Teterkela block. Urban/control samples were collected from the Chandrasekharapur area in Bhubaneswar, Odisha. Blood and Stool samples along with their anthropometric data were collected from Sundergarh district. A total of 145 tribal and 51 urban/control samples were collected from two villages of Sundergarh district and Bhubaneswar respectively. Detailed genomic, metabolic, immune profile and microbiome analysis were carried out using the collected samples.

**Infectious Diseases Biology:** The research studies conducted by the infectious disease group focus on identifying the molecular mechanisms underlying disease pathogenesis.

Studies carried out at ILS has shown that human IRGM is a master suppressor of interferon-signaling and targeting IRGM induces a broad antiviral response which can be further developed for anti-viral therapeutics. In another significant work, it has been shown that Chikungunya virus nsP2 protein interacts with the checkpoint kinase 2 and exploits its activity for Chikungunya virus replication. Significance of nuclear receptor corepressor 1 (NCoR1) in fine-tuning the type 1 IFN response in cDC1 dendritic cells were established in regulating *Mycobacterium tuberculosis* infection by regulating the autophagic flux. The role of COP-II vesicle size regulation in Hepatitis C virus (HCV) secretion has been studied.



Redistribution of ERGIC (ER-Golgi Intermediate Compartment) and ER exit sites in HCV infected cells



Expression of autophagy marker genes LC3, LAMP1 and TFEB in NCoR1 depleted THP1 cells 24h after *Mycobacterium tuberculosis* infection

**Cancer biology:** Numerous studies have been undertaken on host gene expression and regulation associated with cancer group at ILS. The different phytochemical loaded nanoparticles developed at ILS could be a potential therapeutic strategy for eradicating cancer through the elimination of cancer stem cells. The investigations in oral cancer revealed that ketorolac salt restores drug induced cell death in cisplatin resistant OSCC cells. Using bioinformatics analysis, the miRNAs that can differentiate between early and late stage of HNSCC have been identified. MIF expressed by CAFs in pancreatic cancer has a functional role in regulating pathophysiological properties of these cells. In the breast cancer studies it was established that the ectopic

expression of ERR $\alpha$  can checkmate cancer proliferation and migration.

**Genetic & Autoimmune Disorders:** The T-cell group have investigated on T cell mediated pathology in Rheumatoid arthritis and diabetes. It is reported that T cell mediated pathology come in different shades depending on the pathology for e.g. Th17 mediated inflammation in RA is Th17 and IL-17 mediated while T cell mediated inflammation in diabetes is sourced from TNF- $\alpha$ , from both Th1 and Th17 cells. The human genetics group working on otosclerosis reported that the increased methylation and IHC expression of OPG in patients with otosclerosis is higher than that of normal individuals. It indicates that the methylation of OPG can promote the occurrence and development of otosclerosis.

**Plant and Microbial Biotechnology:** During the last year, ILS has been recognised as a coordinating centre (project Management Unit) for the network project on minor pulses and is involved in genomics and transcriptomic studies in moth bean and black gram. ILS groups are also working on microbial ecology and genomics. In this regard, several novel Archaeal genome have been identified from thermal springs following metagenomic approach. This archaeal genome represents the phylum *Bathyarchaeota* and *Thaumarchaeota*, this is the first observation in *Bathyarchaeota* from tropical hot spring. The group has identified 97 WRKY proteins and analyzed the expression of identified PgWRKYs under dehydration and salinity stress. They have also explored the biochemical and physiological involvement of *Arabidopsis Flowering Locus T (AtFT)* in plant growth and development.

#### Other activities/achievements:

The Institute of Life Sciences has transferred a technology for production of curcumin sponge for wound healing for commercialization. DBT-ILS BIOINCUBATOR established with support from DBT, Govt of Odisha and BIONEST, aims to nucleate and nurture technology and knowledge-based enterprises in the areas of biotechnology (biopharma, agribiotech, industrial biotech), biomedical engineering/ devices/ diagnostics, bioinformatics, bio/medical services and related disciplines.

A number of faculty and research students participated in many national and international conferences and has been

recognized with best presentation/ poster awards for their scientific work. Dr. Soma Chattopadhyay received the “DBT-Biotech Product, Process Development and Commercialization Awards 2019” and Dr. Santosh Chauhan was awarded S Ramachandran-National Bioscience Award for Career Development, and was the runner up for the “Merck young Scientist Award-2019”.

#### Societal Impact:

Demonstration and adoption of relevant technologies for societal benefit is being undertaken for improving lives and livelihoods of rural and tribal communities. During the year, in partnership with NASI, ILS has initiated several activities including cultivation of medicinal and aromatic plants in Tigiria block of Cuttack district. In the Aspirational district of Nabarangapur, ILS has established integrated farming systems, backyard nutri-kitchen gardens in tribal village households and residential schools, fish culture in small ponds and backyard poultry farms for resource poor farm families.

#### RAJIV GANDHI CENTRE FOR BIOTECHNOLOGY (RGCB), THIRUVANANTHAPURAM, KERALA

Rajiv Gandhi Centre for Biotechnology (RGCB) has the mandate of studying disease biology and works from basic to translational research focusing local, regional, national, and global problems. RGCB has shown its capabilities in vaccine trails, drug trials, and biomarker applications in disease or diagnostic development with commendable translational value. Discovery and translation research programs of Rajiv Gandhi Centre for Biotechnology are spread over Cancer Research, Pathogen Biology, Chemical Biology, Cardiovascular & Diabetes Biology, Neurobiology, Reproduction Biology and Plant Disease Biology. The primary focus of the institute's cancer research is drug discovery and clinical studies on common cancers of India including oral cancer, cervical, colon and breast cancers. RGCB has established a nationwide investigator network for research on Head and Neck Cancer (HNC) and established one of the best HNC Biorepository in our country. Similarly, the central cell and tissue repository continue to generate large number of model cancer cell resources and patient derived xenografts to enable drug discovery and genomics analysis of specific tumors. RGCB has an established pathogen biology group



working on host factors of broad-spectrum antivirals and disease pathogenesis modifiers associated with Chikungunya, dengue, identification and early-stage development of antimicrobial agents, antimicrobial drug resistance, population studies on distribution and transmission of infectious agents, infection biology and response to vaccines. Cardiovascular research program has as its mission, the study of molecular mechanisms involved in human cardiovascular diseases and diabetes and translation of bench findings to new bedside strategies for diagnosis and therapy. RGCB is also working on identification of factors responsible for increased risk for vascular disease in patients with type II diabetes mellitus with the aim of discovering diagnostic biomarkers and possibly develop diagnostic tools as well as strategies to reduce the risk. The chemical biology division of RGCB has been working on specialized bacterial nanopore CymA of sophisticated architecture and elucidate the molecular mechanism of carbohydrate polymer translocation and bioactive peptides.

### Major initiatives:

RGCB has initiated a center for excellence programme in technology interventions for tribal heritage resilience of Kerala supported by DST, Govt. of India. A dedicated life-time imaging facility is being established at Akkulam campus to support training in lifetime imaging and development of cell line resources of molecular sensors for life-time imaging. Besides, RGCB is serving as one of the key centres in the Department's GenomIndia study.

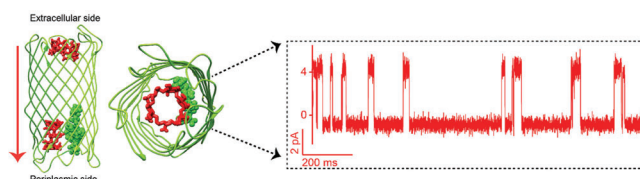
### Salient Achievements:

RGCB has published more than 65 research articles in the year 2020 in peer-reviewed scientific journals. Some of the key findings have been published in journals like: *Federation of American Societies for Experimental Biology Journal*, *American Chemical Society Nano*, *Cancer Research*, *Bioresource Technology*, *Frontiers in Cell and Developmental Biology*, *Antimicrobial Agents and Chemotherapy*. Four patents have been filed during the year.

The Research & Development efforts of the institute have resulted in the following discoveries:

#### 1. Nanopore Passport Control for Substrate Specific Translocation

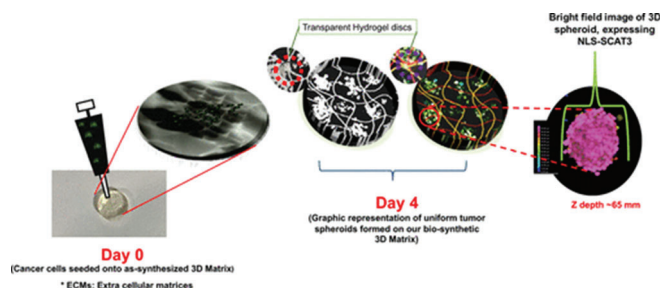
Cells and compartments within cells, are bounded by membranes, which are barriers in the form of oily films. The research work carried out at RGCB demonstrates an innovative, naturally evolved mechanism for regulating the selective uptake of the nutrients effectively through membrane pores. The group described specialized substrate selective bacterial nanopore CymA, which has the 15-residue segment inside the pore barrel, restricting its diameter, generating a sophisticated architecture. This substrate-specific nanopore with unusual geometry will be useful for nanobiotechnology applications, including stochastic sensing and biopolymer characterization. This work has been published in *ACS Nano* (Nanopore Passport Control for Substrate Specific Translocation. *ACS Nano*. 2020.14(2):2285-2295).



**Structural and electrical properties of CymA.** The structure of CymA with cyclic sugar interaction (side view and top view). Single-channel electrical recordings of single CymA in the presence of cationic cyclic sugar.

#### 2. Water-Templated, Polysaccharide-rich Bioartificial 3D Microarchitectures as Extra-Cellular Matrix Bioautomatons.

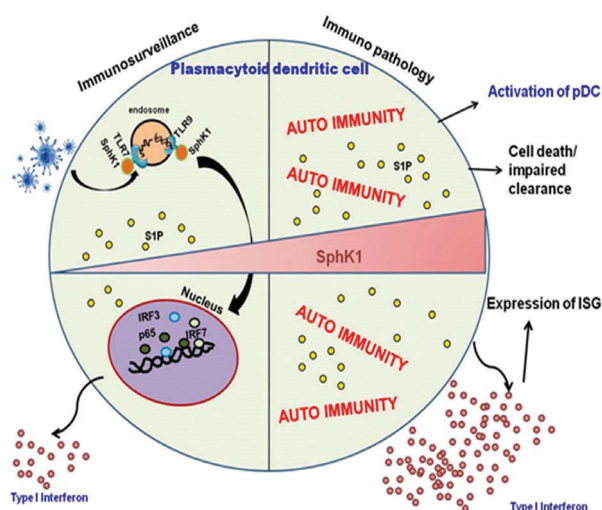
A joint research work involving teams from RGCB and other collaborators has led to the development of a true extracellular matrix exploiting the “quasi-spherical” shape of water molecules. The bio-artificial hybrid, polysaccharide-hydrogel composites prepared with varying feed ratios of alloe-polysaccharide proved as a good matrix system for tumor modelling and also for drug screening. Their capacity for anticancer drug screening was examined using limited cancer drugs. Moreover, their potential for real-time, high-content, phenotypic precision oncology was affirmed by the exceptional transparency of the synthesized composite. Since this 3D microarchitecture typifies ECM bioautomaton, this matrix can also be wielded for precision oncology. This work has been published in *ACS Appl. Mater. Interfaces*, 2020, 6;12(18):20912-20921



The graphic representation of uniform of tumor spheroids formed on our bio synthetic matrix and z depth image of a tumor.

### 3. A lipid kinase regulate type I interferon response and autoimmunity

A team of investigators at RGC B has reported that a lipid kinase namely Sphingosine kinase 1 (SphK1) is important mediator of immune response. Using a pharmacological inhibitor and knockout models of mice they have shown that SphK1 regulate the functions of plasmacytoid dendritic cells (pDC) the major producer of type I interferons in response to viral attack. The study indicates a pivotal regulatory role for the SphK1/S1P axis in maintaining the balance between immunosurveillance and immunopathology. Given the efficacy demonstrated by SK1-I in a preclinical animal model, and the elevation of SphK1 and serum S1P in murine models of SLE and in human patients, the data suggests that SK1-I may warrant clinical evaluation as a potential treatment for SLE. This work has been published in the FASEB journal (*The FASEB Journal*. 34(3):4329-4347).



*A model illustrating the role of SphK1 in type I interferon-dependent innate and autoimmune activation. Plasmacytoid dendritic cells (pDCs) are the integral innate immune cells that sense and respond to a viral invasion. Inhibition of SphK1 by pharmacological intervention or genetic ablation in pDCs decreases uptake of TLR7/9 ligands and subsequent production of type I interferons. In systemic lupus erythematosus, overt Interferon production and a characteristic interferon signature correlated with up regulation of SphK1 and increased S1P.*

The Research & Development efforts of the institute have resulted in the development of the following technologies/ products:

- (i) Annexin V FITC Kit: Bacterial and Mammalian expressed recombinant Annexin V were developed employing a low-cost expression and purification approach. The recombinant Annexin V FITC –PE kit developed using this approach has been validated for microscopy and flow cytometry application. It is commercially available from Layog Life Sciences.
- (ii) Annexin V C3 –DAPI Kit: A new apoptosis necrosis kit that can be employed with GFP or FITC multiplexing has been developed using the recombinant Annexin V Cy3 –DAPI. The kit has been validated for microscopy and flow cytometry application and is available from Layog Life Sciences.

### Societal Impact:

Laboratory Medicine & Molecular Diagnostics (LMMD), the diagnostic service division of RGC B is supporting over 65 viral diagnostics, all bacterial, fungal, and parasitic infection diagnosis using molecular diagnostic methods. RGC B is one of the DBT and ICMR approved centres to perform test kit validation for viral transport medium, RNA isolation kits, PCR kits, LAMP assay kits, Rapid antigen, and Rapid antibody test kits. RGC B's DNA fingerprinting service has been continuously supporting all DNA fingerprinting requirements of state government agencies and Academic institutions.

### REGIONAL CENTRE FOR BIOTECHNOLOGY, FARIDABAD, HARYANA

Regional Centre for Biotechnology (RCB) is an Institution of

National Importance established by the Department of Biotechnology (DBT), Govt. of India, under the aegis of UNESCO with a mandate to impart education and training, and conduct research in the frontier areas of biotechnology. The vision of RCB is to produce human resources tailored to drive innovation in biotechnology, particularly in areas of new opportunities and also to fill the talent gap in deficient areas. The mandate of the Centre is to provide a platform for biotechnology education, training, and research at the interface of multiple disciplines.

### Salient Achievements:

- i. **Academic Programs:** RCB offers structured degree programs as well as short-term training programs in highly specialized areas of biotechnology and life sciences. More than 100 students are pursuing doctoral degree programs in Biotechnology, Bioinformatics, and Biostatistics in different RCB laboratories. RCB also has an integrated MSc-PhD degree program where students with bachelor's degrees are admitted. A total of 25 students are currently registered for this programme. The RCB Act 2016 empowers the Centre to recognize higher learning institutions for their various academic programs. In this direction, after the due diligence, RCB has granted recognition to the MSc, MSc-PhD (integrated), or PhD programs at ten such centers. These include the Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad; National Institute of Animal Biotechnology (NIAB), Hyderabad; National Agri-Biotechnology Institute (NABI), Mohali; Centre for Innovative and Applied Biotechnology (CIAB), Mohali; Institute of Life Sciences (ILS), Bhubaneswar; Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram; Translational Health Science and Technology Institute (THSTI), Faridabad; National Institute of Biomedical Genomics (NIBMG), Kalyani; Christian Medical College (CMC), Vellore and National Centre for Cell Science (NCCS), Pune. A total of 219 students from these recognized centers are registered for their degrees with RCB.
- ii. **Scientific Programs:** RCB's scientific achievements in terms of quality of publications and the ability of our faculty to attract extramural grants have shown

consistent growth. RCB continued to conduct cutting-edge scientific research in the broad areas of Structural Biology, Infectious Disease Biology, Molecular Medicine, Cancer and Cell Biology, Agricultural Biotechnology, and Systems and Synthetic Biology. The Agri biotech group developed insights into potential resistance and susceptibility mechanisms employed by the forage legume *Medicago truncatula* against the pea powdery mildew pathogen during an early infection event. Key virulence proteins from the pea powdery mildew pathogen representing attractive molecular targets for engineering RNA interference-based disease resistance in legumes were also identified. The Cancer & Cell Biology group developed a natural bile acid peptide conjugate to eradicate the biofilms formed by fungus and gram-positive bacteria. Another group of scientists developed the first animal model for Freeman Sheldon Syndrome, a genetic disease that affects the muscle in humans. Using this model, the group explored the molecular basis of muscle defects in this disease, which should lead to new strategies to treat patients born with this disorder. The structural biology group produced and crystallized a recombinant pilus adhesin from an early colonizer *Streptococcus oralis* of dental plaque for its structure determination towards understanding and targeting pili-mediated interaction in combating infections. Recombinant sortases and basal pilin were also produced and crystallized from probiotic *Lactobacillus rhamnosus* GG for understanding the mechanism of pilus biogenesis and basal pilin incorporation. The structure of a transcription factor that regulates biofilm formation from *Pseudomonas aeruginosa* has also been determined. It was demonstrated that the moderate activity of the protein is essential for rapid motility to biofilm transition. The RCB Flagship Research Program on the development of antivirals has been initiated harnessing the expertise of the in-house structural biologists and virologists. During 2020, RCB scientists published around 60 research articles in various reputed journals and one Indian patent application was filed.

**Human Resource Development:** Towards human resource development in the advanced areas of life sciences



and biotech sciences, RCB conducted several training programs. Notable among these was a 6-days' long workshop on molecular neurobiology. A variety of topics relating to the neurobiology of smell and taste, Autism, Epilepsy, and Parkinson's and Alzheimer's disease were discussed. RCB hosted an international conference on calcium signaling, which held sessions on calcium homeostasis, organellar calcium dynamics, and the role of calcium microdynamics in physiology and disease. A workshop on high content imaging trained researchers in advanced techniques for drug screening. Another workshop on Science Communication and Careers was organized in collaboration with WT/DBT-IA, where students were trained to improve their writing skills, to communicate their discoveries in an effective way and communicate different Career options in Science. Besides, RCB continues to provide the Indian researchers access to the ESRF synchrotron radiation facility. This program has provided tremendous support to the Indian structural biologists and has benefited a large number of young research students. Besides, The BIRAC-funded Bio-Incubator attracted more than a dozen start-ups during the reporting period. Bio-Incubator has also conducted several entrepreneurial development activities including IDEA, EMPOWER, IDEATHON, LEARN etc. Besides, RCB continued to nurture the young investigators through the various funding mechanisms such as RCB Young Investigator Award, INSPIRE Faculty Award, and National Post-doctoral Fellowships etc. Besides, RCB has also carried out national and international collaborations with various institutions and industries.



*Workshop on Science Communication and Careers*



*Workshop on Molecular Neurobiology*

### Societal Impact:

RCB has contributed significantly to human resource development by training students and young researchers for their skill enhancement and academic degree programs. RCB has been catalyzing the entrepreneurial activities in the National Capital Region through its Bio-Incubator which is supporting several start-ups in the area of life sciences. RCB Flagship program aims to develop prophylactics and therapeutics against viral diseases highly prevalent in the Indian population.

### TRANSLATIONAL HEALTH SCIENCE AND TECHNOLOGY INSTITUTE (THSTI), FARIDABAD, HARYANA

The Translational Health Science and Technology Institute (THSTI), in the NCR Biotech Science Cluster in Faridabad aims to facilitate development, optimization and evaluation of technologies to provide innovative solutions for challenges in public health in India. THSTI collaborates widely in India and internationally for leadership in innovative translational research and entrepreneurship. THSTI has four strategically prioritized thematic programs complemented by four core facilities under the Translational Research Program (TRP) funded by DBT. The institute complements discovery, design, and development of interventions by building rigorous research capacity through high-quality training. The institute is addressing issues of national priority through theme-based research programs on infectious diseases, maternal and child health, metabolic diseases and diagnostics (for infectious diseases).

**Major Initiatives:**

- THSTI entered the Multi-Omics for Mothers and Infants (MOMI) consortium agreement to carry out extensive epidemiological analysis and omics assays (genetics, metabolome, proteome etc.) on samples collected in different studies across low and middle-income countries.
- Establishing the following national facilities to support vaccine development:
  - o Bioassay laboratory was approved by NABL for accreditation under ISO 17025:2017 standard
  - o Biorepository with over 10 lakh biological samples stored
  - o Upgradation and expansion of small animal facility
  - o Construction of ferret facility
  - o Biosafety level 3 facility at the NCR-Biotech cluster
  - o Repository of dengue isolates from India
- Functional characterization of vaginal microbiome to develop interventions for preterm birth
- Multi-omics approach for identification of predictive biomarkers for preterm birth
- Env-pseudotyped viruses of HIV clade C to identify broadly neutralizing antibodies
- CRISPR/Cas-based approach has been utilized to identify essential genes for *Mycobacterium tuberculosis* persistence and survival
- Aptamer-based interventions have been developed against snake venom

**Salient Achievements:**

- The institute has published 28 papers, filed 8 patent applications, one copyright application, one trademark application, 4 technology developed, 4 technologies transferred, and 1 technology has been commercialized during the year. Some of the most significant achievements of the institute are given in the boxes below.

**INFECTION AND IMMUNOLOGY PROGRAM**

- Bioassay laboratory has created a dengue virus repository of 40 isolates that are being characterized and will help in vaccine development
- Established Dengue structural E protein platform to support antibody-based therapeutic discovery and development and AG129 mouse breeding and colony to facilitate dengue research
- A structurally occluded conserved region in influenza virus been identified among pandemic and circulating strains in India for testing as a universal vaccine candidate
- Identified a novel HIV-1 Indian clade C native like trimer antigen that has demonstrated favourable immunogenicity in rabbit model
- Solved the crystal structure of vapB12 antitoxin and generated a hetero-octameric model of vapBC12 toxin-antitoxin complex
- Simultaneous action of ClpX and ClpC1 on a substrate protein was established for the first time in mycobacteria. An *in vitro* model of persistence was established in Mtb H37Rv
- Identified Thiophene as small molecule inhibitor that possesses intracellular activity against *M. tuberculosis* and generated a number of attenuated strains that offer better protection than BCG in animal models.
- Different Lactobacillus species isolated from the reproductive tract of Indian women could be potential indigenous probiotic strains.

**NON-COMMUNICABLE DISEASES**

- Establishment of in vitro (protein and cell based) and animal models of non-alcoholic fatty liver disease (NAFLD)/non-alcoholic steatohepatitis (NASH)
- New drug discovery (small synthetic molecule and natural product) for the treatment of NAFLD/NASH, which has no FDA approved therapy so far.
- Identification of stage specific biomarkers for NAFLD/NASH, so as to distinguish NASH from no-NASH, using lipidomics, metabolomics and proteomics approaches

## MATERNAL AND CHILD HEALTH PROGRAM

- First national reference for fetal growth & gestational weight gain was generated from the data obtained from GARBH-Ini: Pregnancy cohort.
- Candidate protein biomarkers predictive of preterm birth and 40 biological pathways and 8 unique metabolites modulated in preterm birth have been identified
- Significant reduction in neonatal death (24%), risk of hypothermia (35%) & sepsis (18%) with iKMC was observed in a study to evaluate the impact of immediate kangaroo mother care in very low birth weight babies
- Efficacy of antenatal corticosteroids administered in impending preterm labour for improving outcomes in late preterm newborns is being evaluated
- THSTI biorepository was registered with International Society for Biologicals & Environmental Repositories (ISBER)

## Meetings/conferences/webinars/symposia:

- COVID-19 Ask the Experts series co-hosted with DBT/ Wellcome Trust India Alliance, IAVI and Nature India. Eight webinars were hosted with several experts on virology, epidemiology, public health, mental health, health security and ethics on the panels. DBT-THSTI has partnered with Panellists answer questions about COVID-19, scientific underpinnings, public health questions and role of communication. The webinar series is primarily targeted for journalists writing health and science stories in the regional media.
- Prof. Gagandeep Kang, Executive Director (THSTI) and also Vice-Chair, Coalition of Epidemic Preparedness Innovations (CEPI), spoke at the webinar titled “Science, Business, and Vaccine Development to Combat the Pandemic” where *the speakers reflected upon the geopolitics of how vaccines are developed, the funding and distribution methods that are critical to the effort, and the global alliances that facilitate this in the world today.*
- Prof. Gagandeep Kang was a co-panelist in a discussion on Research and Development ecosystem in India in the STIP 2020: Across the table, organized by DST, India, Science Policy Forum, and Gubbi Labs.

- CDSA completed its Online Good Clinical Practice (GCP) Course (Series I) successfully. This five-week module ended with an online, auto-proctored exit assessment. The course was inaugurated by Dr. Renu Swarup, Secretary, DBT on Aug 07, 2020. The course was conducted from Aug 07-Sept 04, 2020.
- THSTI and RCB co-organized a session of the VAIBHAV summit 2020 of the Government of India, themed antimicrobial resistance on 17th October with experts from India and overseas. The session titled “Insights into the emergence and spread of clinically relevant antimicrobial-resistant bacterial pathogens in India” had discussions on the prevalence of AMR pathogens, their evolution, mode of dissemination, and a potential strategy to overcome the crisis.



### Insights into the emergence and spread of clinically relevant antimicrobial resistant bacterial pathogens in India

- THSTI and RCB co-organized the First Prof. M. K. Bhan Memorial Lecture delivered by Prof. V. K. Paul, Member, NITI Aayog.

**Societal Impact:** Two major research programs funded to THSTI namely the Translational Research Program and the IndCEPI mission have created a national resource at THSTI in the form of an accredited bioassay laboratory that would engage actively with vaccine developers. This is the only NABL-accredited lab under DBT umbrella and is the only lab in India to be part of CEPI-centralized network lab which is one of the seven labs in the world. The biorepository and the bioassay lab together have had a huge impact on India's response to COVID-19 and will also be a hallmark of India's capacity to create enabling platforms as a national resource for societal impact for other major illnesses like TB, HIV and Influenza.



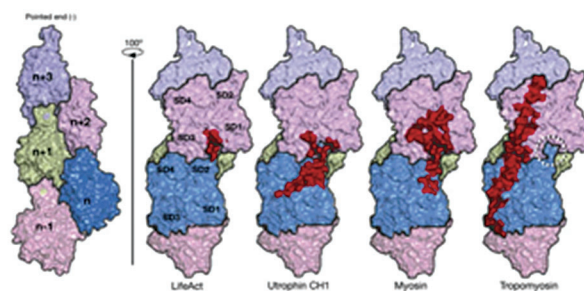
## INSTITUTE FOR STEM CELL SCIENCE & REGENERATIVE MEDICINE (inStem), BENGALURU, KARNATAKA

The Department established the Institute for Stem Cell Science and Regenerative Medicine (inStem) at Bangalore, as India's first stem cell institute committed to accelerating advances in stem cell biology & regeneration to understanding disease. inStem's mandate is to address complex problems in areas of directed differentiation and tissue regeneration with disease relevance through collaborative research programs involving interdisciplinary teams with translation emphasis. Efforts have focused on building core strengths in stem cell biology and manipulations, in areas such as repair from injury or wounding, disorders of the brain and heart disease. The institute also has developed an elaborate 'Gene therapy program' at Center for Stem Cell Research (CSCR) which is its translational unit, located at CMC, Vellore.

**Salient Achievements:** During the year, inStem has developed and transferred one new technology, published more than 30 research articles, had students recognized by awards and 5 students submitted their thesis for the award of PhD degree.

### Structural insights into filament recognition by cellular actin markers: Kumari et al., EMBO Journal, 2020.

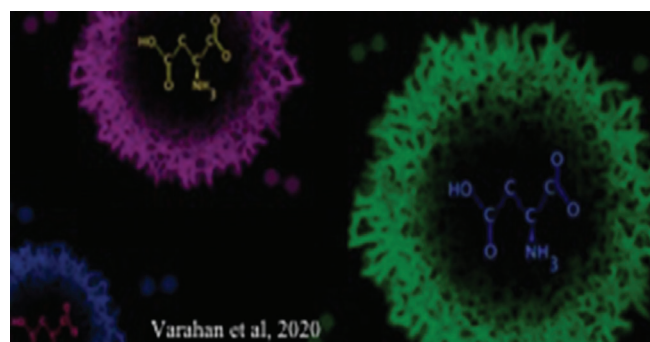
Minhaj Sirajuddin and his group at the Centre for Cardiovascular Disorders (CCBD) at inStem used cryo-EM (Cryogenic Electron Microscopy) to determine the structures of actin filament bound to commonly used actin markers. These research findings were recently published as 'Structural insights into filament recognition by cellular actin markers.' The research findings will enable researchers in choosing and designing improvements to probes that can be used to label and understand the many roles of cellular actin in future. The study, is a collaboration with Dr Vinothkumar Kutti Ragunath (NCBS), has built a pipeline to explore cryo-EM structure determination methods in studying actin.



Surface representation of F-actin with five monomers as marked. Footprint (in red) of actin monomers and respective residues interacting with lifeAct, utrophin CH1, myosin, and tropomyosin as indicated and the D-loop is shown circled. The myosin and tropomyosin footprints were derived from PDB IDs, 6C1D, and 5JLF, respectively. Minhaj Sirajuddin, 2020

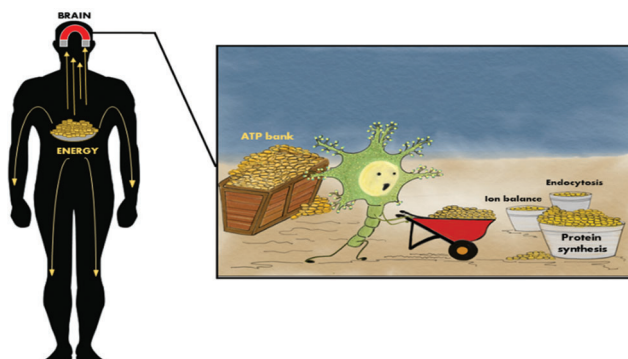
### Resource plasticity-driven carbon-nitrogen budgeting enables specialization and division of labor in a clonal community: Varahan et al., Elife 2020.

In this study, the researchers investigated as to how genetically identical cells growing in similar environments show different properties. Using yeast cells (*Saccharomyces cerevisiae*) as the model organism in their research, the study shows that this occurs through the self-organization of biochemical networks through which cells can utilize/produce molecules that change cellular properties. Some resources are plentifully available for cells (in this case the amino acid aspartate), and the way this is used can drive heterogeneity. This is achieved through differential 'budgeting' of the resource, for creating new molecules with other functions, or for more traditional tasks. This makes groups of cells specialize in function, with each group performing very different metabolic tasks. Thus, groups of cells, may support each other through 'cross-feeding' systems and give the community as a whole advantages for survival and growth. The work advances our basic understanding of cell behavior in systems such as microbial communities and possibly, tumour and stem cell microenvironments.



## Energy Budgeting in the Brain

A group of investigators in the Centre for Neurodevelopmental Synaptopathies (CNS) at inStem explored cellular and molecular processes underpinning the metabolic energy supply to the brain. Their work shows that more than its electrical activity, the brain needs energy for protein synthesis. Identifying a crucial link between activity-induced protein synthesis and energy metabolism in neurons is an important outcome of this work.



*Casting a Long Shadow: The Consequences of Adverse Childhood Experiences*

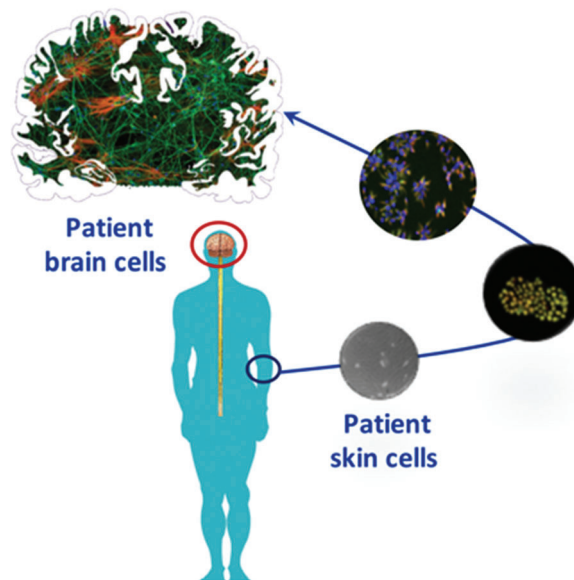
Adverse Childhood Experiences (ACEs) are distressing experiences that occur during early life, and result in altering adulthood with serious mental illnesses. As part of the project under The Accelerator Program for the Discovery in Brain Disorders using Stem cells (ADBS), Biju Viswanath and Jayant Mahadevan from NIMHANS with their groups studied individuals from families, enrolled in this program, where at least two individuals suffer from a major psychiatric illness like schizophrenia, bipolar disorder, obsessive compulsive disorder (OCD), substance use disorder (SUD) or Alzheimer's dementia.



## Modelling Autism in a dish

Autism Spectrum Disorders and Intellectual Disabilities (ASD/IDs) represent a major and growing public health challenge. Supported by The Department of Biotechnology (DBT), the Centre for Neurodevelopmental Synaptopathies (CNS) is a partnership between inStem and NCBS in Bangalore and the University of Edinburgh, UK that studies the pathophysiology of ASD/IDs. A major effort at the CNS has been on accelerating the discovery of effective therapeutics for these debilitating brain disorders. Exploiting human stem cell and gene editing technologies offer an unprecedented opportunity for the creation of in vitro human based systems that model aspects of ASDs. Hence, CNS has established human induced pluripotent stem cell (iPSC) based in vitro assays for discovering cellular mechanisms underlying ASDs.

### "Autism in a dish"



The current work provides new insights into neural defects caused by Fragile X Syndrome (FXS) – the leading genetic cause of ASD/IDs. FXS is estimated to affect 1 in 5,000 men and 1 in 4,00-6,000 women worldwide. Rates of FXS have been calculated to be similar in India. The work also put light on the aberrant electrical activity patterns in human cortical neurons caused by FXS. Further, this work identifies specific molecular mechanisms underlying these abnormalities, which can be reversed using pharmacological manipulations. Together, these observations offer new potential therapeutic targets that can be assessed in pre-clinical platforms and eventually lead to more efficient translation to the clinic.

## Awards and Recognition

- inStem's Recognition in **Nature Index 2020** based on Research Publications in June 2020. inStem ranked in the top 50 among Indian institutions in the Nature Index 2020, ratings, based on its research publications. inStem is ranked 7th in the Life Sciences in India.

## inStem Science Outreach

- The translational unit of inStem i.e., Centre for Stem Cell Research (CSCR) hosted the 5th edition of the **Cell & Gene Therapy Symposium at CMC Vellore** <http://www.cscr.in/symposium/> on September 3 & 4, 2020. Adapting deftly to the changed requirements of the post-corona world, the symposium was organised in a virtual format. The meeting schedule was modified to include live talks (all but one) from multiple time zones, from all across the globe. The increasing impact of this annual meeting - a relatively fledgling area in India - was apparent in the large number of registered participants from across 8 countries that by and large remained in attendance for the entire duration of the meeting. In its eight sessions the symposium covered topics ranging from technical advances, research to clinical practices in the area.
- A bi-weekly public lecture series of talks on **"The Human Body: InsideOUT"**. This lecture series is curated for high school students and undergraduates and includes textbook basics to the latest research in the subject. These talks are electronic and have attracted wide participation.

## NATIONAL INSTITUTE OF BIOMEDICAL GENOMICS (NIBMG), KALYANI, WEST BENGAL

The National Institute of Biomedical Genomics (NIBMG) is the first institution in India explicitly devoted to research, training, translation & service and capacity-building in Biomedical Genomics. The research focus of the institute is to understand the molecular basis of disease using genomics and integrative biology, as well as functionalization of genomic leads. Such knowledge is translated for enhanced prediction, prevention and cure and also provides us with the insight into mechanism of disease development and progression.

NIBMG laboratories are equipped with high end instruments and state of art facilities.

## Major Initiatives:

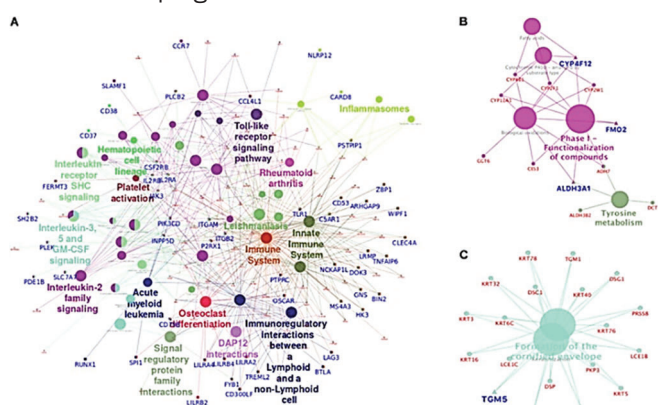
- The ICGC – India Project team of NIBMG participated in the Pan Cancer Analysis of Whole Genomes, a large scale international collaborative initiative of ICGC and TCGA which undertook integrative analysis of 2,658 whole-cancer genomes and their matching normal tissues across 38 tumour types from the Pan-Cancer Analysis of Whole Genomes (PCAWG) Consortium of the International Cancer Genome Consortium (ICGC) and The Cancer Genome Atlas (TCGA).
- NIBMG coordinated the whole genome sequencing of SARS-CoV-2 as part of DBT's PAN-INDIA 1000 SARS-CoV-2 RNA genome sequencing consortium. More than thousand SARS-CoV-2 genomes from oropharyngeal and nasopharyngeal swabs of COVID-19 positive individuals from across India were sequenced.
- NIBMG undertook a collaborative study on epigenomic and genomic correlates of preterm birth and a lateral study on genomic marker of maternal stress which are associated with preterm birth outcome.
- The Systems Medicine Cluster undertook major initiatives on oral and cervical cancer, specific research projects on genomics of gastric, breast and pancreatic cancer, tuberculosis, NAFLD, glaucoma, motor neurone diseases and microbiome of atopic dermatitis.
- NIBMG is also a part of the Genome India initiative which aims to collect 10,000 genetic samples from citizens across India, to build a reference genome.

## Salient Achievements:

1. **Driver mutations in Cancer and their functional implications:** A study by the International Cancer Genomics Consortium reported various driver mutations in cancer and their potential functional implications. In another collaborative study, we reported that the habit of using RAN/tobacco and GSTP1 AA-genotype together play a significant role in predisposition to oral cancer risk.



2. **Single cell transcriptomic analysis of oral cancer:** NIBMG undertook single cell transcriptomic analysis of oral cancer (gingivobuccal and tongue). The initial data is the first of its kind generated on these cancer subtypes. Further identification of gene expression programs and cell diversity is ongoing. In a collaborative program with NEHU and NEIGRIHMS in Meghalaya, investigators from NIBMG whole genome DNA methylation and gene expression profiling of oropharyngeal cancer patients in North-Eastern India and identified epigenetically altered gene expression changes which can be used to develop biomarkers of disease progress.



Results from the oropharyngeal cancer study conducted in the North-Eastern India reveals functionally grouped network of epigenetically upregulated and downregulated genes.

3. **p.A138V somatic variant in TP53 as a prognostic marker to classify Indian Pancreatic ductal adenocarcinoma patients:** p.A138V somatic variant in TP53 might also have a role in determining treatment regimes.
4. An analysis of the entire mitochondrial genome from blood samples of tuberculosis patients revealed 28 non-synonymous variants in the mtDNA which suggested detailed analysis of mtDNA. were found.
5. A study using the Transcriptome-based systems biology approach segregated cancer into two groups, Sepsis Like Cancer (SLC) and Cancer Alone, based on similarity with Septic shock (SS). It was found that host response to infection plays a key role in pathogenesis of SS and SLC. However, we hypothesize that some component of the host response is protective in both SS and SLC.

6. A meta-analysis that NIBMG was a part of validated the SNP rs641738C>T near **MBOAT7** as a risk factor for the presence and severity of NAFLD in individuals of European descent. Next, the WES findings have led us to identify reported as well as novel variants for the first time in Indian Congenital Muscular Dystrophy and Congenital Myopathy patients. Transferring these WES findings to clinical practice will help guided clinical care of the affected patients and informed genetic counselling.

### Societal Impact:

NIBMG is a part of many multi-institutional programmes. The ICGC has been launched to coordinate large scale studies to generate high resolution catalogues of genomic alterations in tumors of 50 different cancer types/subtypes that have clinical and societal importance across the globe. The Pre-term birth project is a major national programme to identify the correlates, causes and predictive biomarkers of preterm birth which will contribute significantly towards reduction in infant and maternal mortality rates. Through the Kalyani Cohort study NIBMG is arranging for quality diagnosis of diseases for persons and families enrolled in this study, that is also fostering linkages among the local population, NIBMG and hospitals in Kalyani and Kolkata. Genome India aims at cataloguing all the variations in the Indian populations. In addition, NIBMG actively conducts outreach activities to promote the spread of knowledge on biomedical genomics.

### NATIONAL AGRI-FOOD BIOTECHNOLOGY INSTITUTE (NABI), MOHALI, PUNJAB

National Agri-Food Biotechnology Institute (NABI) is the first Agri-Food Biotechnology Institute, established in India. NABI is a unique institute that has undertaken various overlapping research activities encompassing the areas of Agriculture, Food and Nutrition biology. The main research focus of NABI is to harness biotechnological tools in the area of Agriculture Biotechnology, Food Science and Technology and Nutritional Science so as to provide sustainable and novel solutions towards quality food and nutrition. Activities undertaken at NABI could be classified into five major areas that includes, a) Improving Cereals for nutrition and processing quality; b) Improving fruits for post-harvest quality and nutrition; c) Basic Biology for crop improvement; d) Functional food for better health and e) Genomics and Computational biology for marker

and gene discovery. Besides, these activities NABI has an important mandate for the development of skilled human resource in the above-mentioned areas, through doctoral, post-doctoral programmes, training and workshops.

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 discover.

### Major initiatives:

- Flagship program dealing with the broader areas of nutritional biofortification to enhance the traits such as micronutrient, protein etc along with six other co-partners in wheat crop.

### Salient Achievements:

- Improving nutritional and processing properties in hexaploid wheat:**

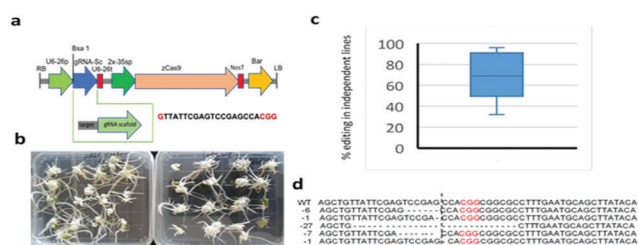
One of the important germplasm generated by the Institute is the amylose rich wheat which is currently at RIL (recombinant in-bred lines) population (F6) comprising 200 progenies with amylose variation ranging from 6 to 80%. A few high amylose lines 'TAC 35' show potential low glycemic wheat line when tested using cell-lines based assays. During the last one year, special emphasis has also been given for development of coloured wheat derived products or dissemination of the seeds through MoUs with seed companies so that the benefits can reach society. In this direction as many as 8 MoUs have been signed. Further, studies show that anthocyanin biofortified wheat might have potential to stimulate the growth of the beneficial bacteria residing in the gut. To understand the molecular basis of micronutrient accumulation in hexaploid wheat, a transcriptome based resource was generated and multiple gene families have been characterized to short list the candidate transporter/regulators to enhance the

nutrient uptake, long distance transport and loading in grains. Genome editing tools are also being employed for functional characterization of wheat lines. Similarly, tissue and cell-type specific RNAseq was performed on developing rice grains to identify the role of subsets of genes in loading of micronutrients in different tissues.

- Employing genome editing tools to improve crop traits:**

In the area of Banana biofortification, the gene encoding for LCY $\alpha$  was edited and analysis suggested that lutein and  $\alpha$ -carotene content was reduced up to ~69% and ~98% with 6-fold enhanced  $\beta$ -carotene ( $23.80 \pm 1.26$   $\mu\text{g/g}$ ) content was observed as compared to the pulp of fruits of unedited controls. Additionally, a patent has been filed for the process that deals with the DXS over-expression in Banana for enhancing carotenoid level in the pulp. A proof of concept for adapting genome editing tools for hardy crops such as *Lathyrus* has been demonstrated. Multiple edited lines by means of hairy root transformation was done and the transformation protocol in *Lathyrus* spp. has been now established. Efforts are now focused on targeting the pathway genes and regulators to achieve low ODAP in seeds by using genome editing approaches. Work has also been initiated to develop the mutant population of *Lathyrus* to achieve different traits. Work initiated earlier to metabolically engineer triacylglycerol (TAG) biosynthetic pathway in rice shows that genes encoding for lipase and LOX are highly expressed during the onset of lipid mobilization and *ole2* gene was identified for enhanced protection of TAG molecules from lipase enzymes.

### Genome Editing in *Lathyrus*



Editing OCS in hairy roots in *Lathyrus*. a) gRNA construct b) Hairy roots from cotyledons c) Percentage of editing estimated in individual roots by amplicon sequencing d) Indels in edited hairy root lines

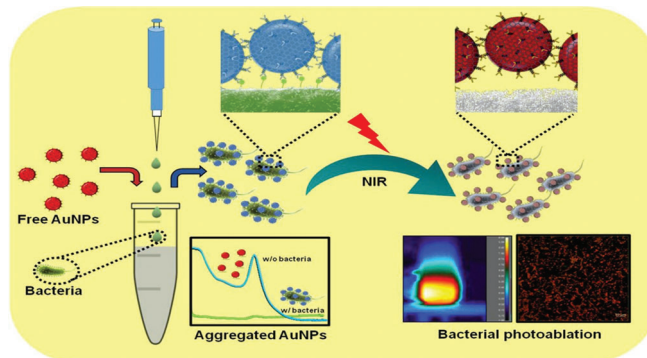
- **Exploring Functional foods and nutraceutical for better health:**

In the area of Food and Nutritional biotechnology, research work has shown that gut bacteria could provide beneficial modulation for mitigating metabolic disorders and have developed a novel anti-inflammatory synbiotic formulation which in pre-clinical studies is useful for preventing ulcerative colitis. In the area of development of novel probiotic formulations for metabolic disorders, our scientists have shown that Allicin rich garlic extract modulates TRPA1 and rectifies gut hormone dysregulation under diet induced obesity and associated comorbidities suggesting TRPA1 agonism may be exploited as a nutraceuticals/functional food for the prevention of over-nutrition related complications.

- **Employing nanotechnological based approaches:**

Using nanotechnology-based approach, two types of bacterial specific antibody conjugated gold nanoparticles were synthesized with simple steps for rapid visible detection of food borne bacteria within 5 minutes. Colorimetric and different microscopic techniques showed specific binding of antibody conjugated gold nanoparticles on bacterial cell surface. By graphene oxide coating, the sensitivity of the antibody conjugated gold nanoparticles has been increased by 10 times. Hybrid material based colorimetric detection and ablation platform was built in a unique manner to kill and detect food borne bacteria simultaneously. Similarly, multifunctional nanomaterial-based biosensor was developed to detect food borne bacteria. A handy nanodevices based on carbohydrate, antibody and aptamer based nanoprobe with high sensitivity and selectivity for detection of food borne bacteria was developed. In the area of development of ultrasensitive, portable, and rapid biosensor for the detection of pesticides and food contaminants using functional hybrid nanostructures, our scientists have developed polyaniline and gold nanoparticles composites for biosensing metal ions and pesticides using a green chemical route.

#### Biosensor based detection of bacterial contaminants



*Antibody Assisted Graphene Oxide Coated Gold Nanoparticles for Rapid Bacterial Detection and Near Infrared Light Enhanced Antibacterial Activity*

#### Biosensor based detection of metals



*Examples of colour-based sensing of toxic metal ions using capped gold nanoparticles. On the basis of capping of gold nanoparticle, gold nanoparticles displayed colour change in presence of lead/iron (left) and cobalt (right).*

#### Societal impact:

- During the year, NABI recruited 42 numbers of trainees from various institutes and universities. The selected students were exposed to different research tools to provide them expertise in the specialized niche areas of Agri-biotechnology and Food-Nutritional Biotechnology.
- NABI has developed anthocyanin rich wheat lines. These lines were tested for their strong antioxidant activity. Development of different products from these wheat lines will prevent the consumers with various disease and disorders.

**NATIONAL INSTITUTE OF ANIMAL BIOTECHNOLOGY (NIAB), HYDERABAD, TELANGANA**

NIAB aims to take up research in the cutting-edge area for improving animal health and productivity by integrating novel



and emerging biotechnological interventions. Institute research activities are mainly focussed on animal genomics and genetics, transgenic technology, reproductive biotechnology, animal diseases, bioinformatics and nutrition enrichment. Institute has special thrust on basic research having potential to develop novel vaccines, diagnostics and improved therapeutics for farm animals.

**Vision:** To demonstrate excellence in promoting and commercializing leads in biotechnology and to produce globally competitive livestock products, pharmaceuticals and biologicals for animal health care.

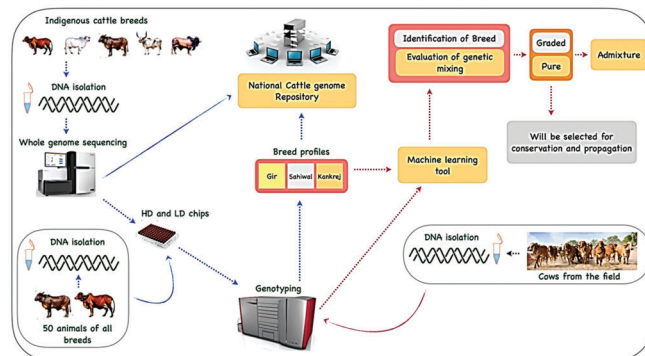
**Mission:** Development of sustainable and globally competitive livestock industry through innovative technology.

**Major Initiatives:** The whole genome sequencing of Indian cattle breeds are underway as part of the major project on genomic selection for conservation of indigenous cattle breeds. In addition, the institute is working on improvement of fertility of cattle through development assays or platforms for estrous detection. Also, research projects in areas of infectious diseases such as brucellosis, leptospirosis, staphylococcosis, Newcastle disease, Theileriosis, Toxoplasmosis is under process. NIAB has initiated a program to understand the existence and spread of AMR in microbes associated with poultry birds. Host pathogen interactions, virulence mechanisms, and molecular pathogenesis are being studied with the ultimate objective of technology and product innovation for development of efficient diagnostic tools and novel vaccines. Zoonotic and transboundary animal diseases impose a huge pecuniary burden on any nation, but particularly on lower- and middle-income countries. NIAB has initiated a One health program including major medical hospitals and veterinary universities for understanding the pervasiveness of the animal pathogens under study and their potential threat to human health. NIAB has also initiated a collaborative effort towards establishment of one health consortium to address the spread of zoonotic, food borne and transboundary diseases.

### Salient Achievements:

**Livestock Genomics:** The native variety of cows with great qualities of heat resistance, disease resistance, draught resistance, stabilized during million years in India are getting lost due to random artificial insemination, leading to large

number of crossbred animals with inferior health qualities. Under livestock genomics project, a high-density SNP chip is already developed by NIAB's team using NGS of 43 Indian breeds of cows at NIAB. The chip is currently under validation using 50 samples of each breed to identify breed specific signatures. This chip in near future, will help in conservation of indigenous breeds of cows, separating pure cows from mixed breeds of animals (स्वदेशीगौनस्लोंका संरक्षण).



Workplan of SNP chip development and Breed identification

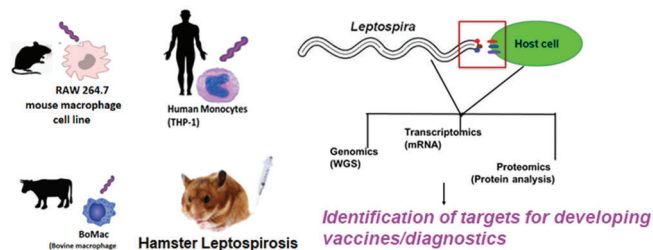
**Transgenesis and Animal reproduction:** Testicular transgenesis in farm animals to use them as bioreactor for producing therapeutic protein in milk has been initiated at NIAB. We have initiated work of expressing Bone Morphogenetic Protein2 (BMP2) in milk. For this work cDNA of BMP2 signal peptide was cloned under CMV promoter to check its functionality in cell lines. We have initiated a research aiming to prolong the ovarian life by finding novel primordial follicle apoptosis check points. These proteins will be targeted for modulation of its expression to prevent death of primordial follicles. In addition, three potential aptamers have been selected against progesterone that will be used for development of point of care diagnostics to detect estrous in buffalo.

**Animal Diseases:** Mastitis is a leading cause for the loss of production in farm animals. A technology has been developed for detection of subclinical and clinical mastitis and assessment of microbial quality of milk using magnetic nanoparticles, without the need of any high end equipment which can be visualized by pouring them onto the aggregation visualization module (AVM-made up specially designed membrane packed in a cassette). Results can be obtained within 10 minutes and a quick screening of several samples can be done with 200 times higher limit of detection as

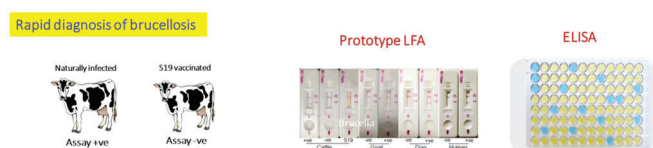
compared to “California Mastitis Test”. The overall cost to perform one test is less than US \$ 0.50/test. The materials used to prepare the test have no known toxicity and can be stored at room temperature. The test may find utility in routine screening besides barn-side diagnosis. *Toxoplasma gondii*, a parasite of medical and veterinary importance. The research carried out at NIAB has shown that antibodies to *T. gondii* are widely prevalent in small ruminants, which may cause public health problems. A lateral flow-based diagnostic has been developed to detect its antibodies in the serum. Brucellosis accounts for huge loss to the livestock sector and poses a serious threat to public health. A BM5 protein-based ELISA based assay having DIVA capability has been developed and its validation in field samples is being carried out. Newcastle disease is an economically important poultry disease across the globe caused by Newcastle disease virus (NDV). It is a highly contagious respiratory, neurological and/or enteric disease in chickens. In India, NDV is endemic and episodes of outbreaks despite strict vaccinations are common. Work is ongoing to develop reverse genetics system which is a valuable tool to study viral molecular biology, host-virus interactions and to establish viral vectors for developing effective multivalent vaccines. Theileriosis causes huge economic losses to the farmers. The current vaccine has lots of drawbacks such as need to maintain a cold chain, high cost, and short shelf life. Hence, there is need for development of novel subunit vaccine(s) for theileriosis. Several candidate antigens have been predicted as vaccine candidates. Multiepitope vaccine candidate has been designed which contains T cell epitopes from the antigenic proteins of *T. annulata*. Work is in progress for raising antibodies against the *T. annulata* recombinant proteins which will be used for making diagnostic kits for antigen detection in the field. Work is ongoing on understanding Host Parasite interactions to identify genes/proteins involved in disease pathogenesis during *T. annulata* infection.

Leptospirosis is a zoonotic and emerging infectious disease in India. Using comparative genomics and reverse vaccinology approaches, several novel surface antigens have been identified as potential vaccine candidates. Development of conjugate and mucosal vaccine for *Leptospira* has also been initiated. Standardization of time point for *Leptospira* infection in mouse, human and bovine cells *in vitro* are done and samples are being prepared for

transcriptomic analysis. Experiments on Hamster infection with *Leptospira* to analyze virulence genes and host response has been initiated.

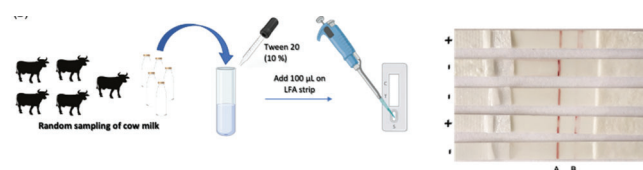


Workflow for studying *Leptospira* host interaction



Development of Lateral flow assay and ELISA based kit for detection of *Brucella* infection in livestock

**Point of care diagnostics and biosensors:** Milk and animal products are major source for the spread of antimicrobial resistance due to inadvertent use of antibiotics in livestock and poultry for better health and production. The present invention relates to the detection of the presence of oxytetracycline (OTC) in samples like water, buffer, milk, meat etc. In particular, the Invention provides high affinity aptamer against oxytetracycline and lateral flow assay based on the aptamers to detect the presence of oxytetracycline (OTC) in samples like water, buffer, milk, meat etc. A technology has been developed for identification of aptamers binding to snake venom. In addition, a rapid, efficient, and effective paper - based colorimetric strategy for screening of multiple aptamers has been developed. A monoclonal antibody based lateral flow assay for detection of cobra and krait venom in envenomed individual has been developed. An ultrasensitive portable device for rapid detection of SARS-CoV-2 surface antigen has been developed and the technology has been transferred.



Aptamer based LFA for detection of oxytetracycline antibiotic in milk.

**Societal Impact:** The chip developed under livestock genomics program will help in conserving all native breeds of cows with superior qualities. Kits for detecting antibiotics in milk and for brucellosis detection will be of great help to farmers. If therapeutic proteins can be generated at cheaper cost in milk, it will become affordable by general masses for health benefits and livestock centric proteins for various treatments to animals. Zoonotic and transboundary animal diseases impose a huge pecuniary burden on any nation, but particularly on lower- and middle-income countries, including India. NIAB established a One health center for carrying out surveillance of important bacterial, viral, and parasitic zoonotic and transboundary pathogens in Northeast and other states of India. The scope of the application lies in 1) understanding the pervasiveness of the animal pathogens under study, their potential threat to human health, and 2) preparing for the incursion and/or reappearance of animal diseases across India, including designing new disease detection kits, platforms for developing monoclonal antibodies, vaccines and animal models of emerging diseases. This is most timely taken step initiated at NIAB for animal and human welfare.

### CENTER OF INNOVATIVE AND APPLIED BIOPROCESSING (CIAB), MOHALI, PUNJAB

CIAB works mainly on Secondary Agriculture and development of value-added commercial products from different types of bio-resources. It has the mandate on R&D innovations, technology development and transfer to entrepreneurs. Institute is working towards “*Doubling the Farmer’s Income*” with the same inputs and “*Waste to Wealth*”, thus creating start-ups/entrepreneurs as well as supporting industries for societal well-being. CIAB has four R & D programmes; (i) Value addition to primary processing residue/wastes for edible products, (ii) Valorization of crop wastes for specialty products and chemicals, (iii) Nutritional, nutraceuticals, and upgradation of value or use of primary processing bioproducts and (iv) Biosynthetic technology/synthetic biology for low volume-high value products and industrial enzymes.

#### Major Initiatives:

CIAB’s flagship research program is on utilization of rice residues for value added product development for

commercialization. CIAB is a partner institution in a project entitled “Setting up of Secondary Agriculture/ Food Processing Entrepreneurial Network in Punjab” wherein institute’s focus is on scale up technology for tomato by-products and whey based value added products development as well as to establish an early translational accelerator (ETA) for startups and entrepreneurs. Second research program is on “Setting up of rural biotech innovation and application centre (RBIAC) in Kandi area of Punjab” in collaboration with Punjab State Council for Science and Technology (PSCST), Chandigarh. We are working on two Indo-UK projects where industries are partners with academia. These are “Development and optimization of fresh produce supply chain and storage systems” and “Enhanced rice milling and maximized valorisation of rice milling by-products”. CIAB has another important Indo-Sweden project on “development and validation of technology for production of high energy density biocoal from rice straw and other agri-biomasses”.

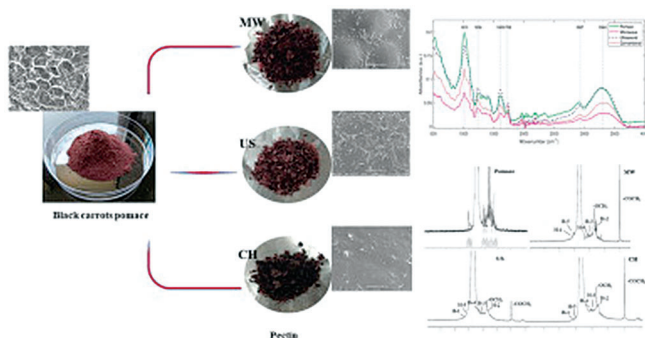
CIAB has received approval of BRICS proposal with all five countries on “BRICS Technology Platform for integrated bioprocessing of agriculture residues for eco-sustainable production of biofuels and by-products. Punjab Biotech Corporation, Punjab has funded a proposal on development of water soluble curcuminoids powder for use as a health additive. Punjab Biotech Corporation, Punjab has funded proposals on production of D-allulose, a functional ingredient, for development of low-calorie food products and Extraction of starch from potato processing waste and transformation into resistant starch molecules. CIAB has also received a research consultancy project entitled selective transformation of biomass-derived glycolaldehyde to C4-sugars using chemo catalysis funded by HaldorTopsoe. CIAB has also initiated working on developing therapeutics for COVID-19. Therapeutics are based on garlic essential oil and photodynamic therapy.

#### Notable Outcomes:

- Pectin from black carrots pomace was extracted in hot acidic water (2.5 pH) using microwave (MW) at 110 °C/5 min, ultrasound (US) at 70 °C/30 min and conventional heating (CH) at 110 °C/90 min. CH showed the highest yield (0.22 kg/kg pomace), followed by MW and US treatments. However, from kinetic modelling, MW extraction was found to exhibit the



highest rate of extraction among the three approaches. Pectin extracted via CH resulted in maximum retention of anthocyanins (1213 mg/l), phenolics (1832 mg/l) and antioxidant activity (180  $\mu$ M/ml). MW extraction resulted in pectin with a higher water holding capacity and larger particle size than the US. Pectin from CH and MW also evinced higher DE and GalA than from the US. FTIR,  $^1$ H NMR and XRD spectra confirmed the presence of characteristic functional groups in MW, CH and US pectin and these agreed with chemical analysis. Overall, MW extraction was found to be most cost effective, followed by CH and finally, US. Therefore, it is concluded that MW processing integrated with CH could result in rapid extraction and higher yield of pectin without impacting its functionality.

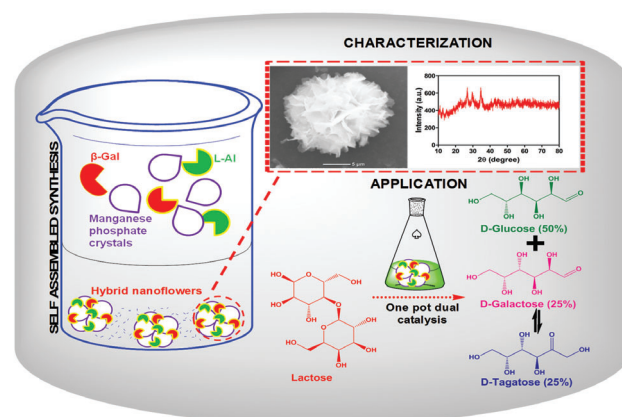


Extraction and characterization of pectin from black carrot.

Studied the effect of processing such as microwave, ultrasonication and conventional heating on pectin extraction.

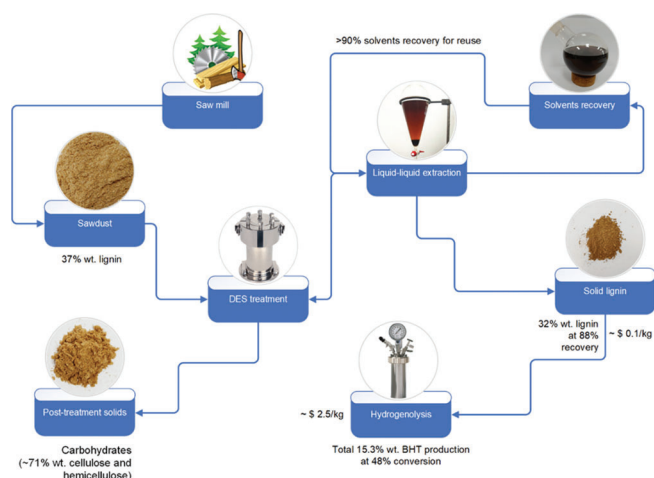
- To achieve one pot conversion of lactose to tagatose, a dual enzyme metal-organic hybrid crystal was constructed through self-assembling of manganese phosphate embedded with  $\alpha$ -galactosidase and L-arabinose isomerase for facile synthesis of rare sugar D-tagatose. Synthesised crystal-like hierarchical system (MnHC@ $\alpha$ -Gal+L-AI) was extensively characterized for structural features and catalytic reactions. Results indicated that upon immobilization onto hybrid crystal, the activity of  $\alpha$ -galactosidase and L-arabinose isomerase was enhanced by a factor of 1.6 and 1.5-fold, respectively. The developed MnHC@ $\alpha$ -Gal+L-AI exhibited an excellent efficiency with a net equilibrium level conversion of low cost substrate whey lactose (100%) into D-glucose (~50%), D-galactose (~25%) and D-tagatose (~25%). Hence, the developed dual enzyme-

based hybrid crystal provides a platform technology for the direct transformation of whey lactose into rare sugar D-tagatose.



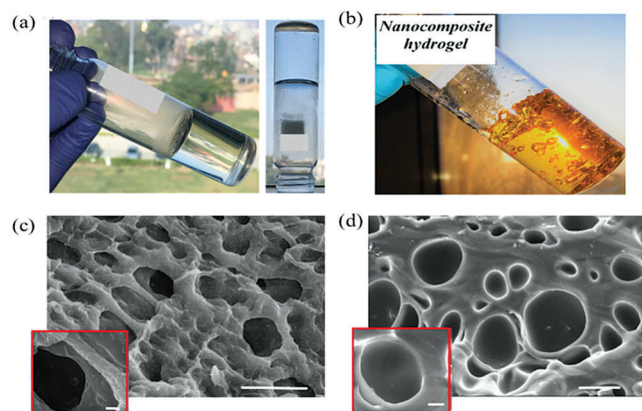
A dual enzyme metal hybrid crystal for the direct transformation of whey lactose into a high value rare sugar D-tagatose: synthesis, characterization, and a sustainable process.

- Two-fold higher lignin was recovered by employing  $H_2O$ -EtOH mixture for precipitation of wood substrate than the conventional DES protocol. All of the analytical characterization techniques, including  $^{13}C$  NMR, FT-IR, GPC and Py-GC/MS established its structural and morphological characteristics, proposing it as the apt feedstock for the potential aromatic chemicals production due to the dominance of  $\alpha$ -O-4 content and the limited residual constituents, including sugars and silica. Upon evaluation of its suitability for phenolics synthesis via hydrogenolysis, it allowed to obtain ~48% butylated hydroxytoluene (BHT) as a dominant product through the heterogeneous catalysis ( $Ru@V_2O_5$ ). Overall, DES was found to be proficient in the disintegration of biomass, which in turn promoted the release of lignin; however, the recovery of solid lignin depends on the extraction agent involved and the downstream steps.



Overall process flow scheme of the integrated setup of biomass lignin recovery and subsequent valorization for the production phenolics (BHT).

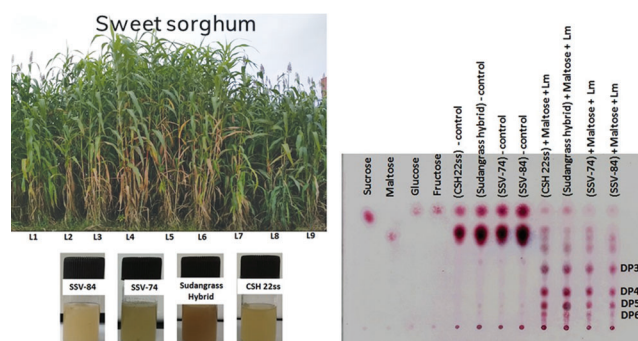
- Photodynamic antimicrobial hydrogels can be a game changer in enhancing therapeutic action of antimicrobial agents via localized drug delivery. Photodynamic nanoconjugates were prepared by us via conjugating a light activatable molecule called photosensitizer (rose bengal) with lignin derived metallic and bimetallic (silver and gold based) nanocomplexes. The nanoconjugates were very stable under physiological conditions for at least three days. Importantly, the nanoconjugates possessed promising photophysical properties (reactive oxygen species generation and photoluminescence) as found from their singlet oxygen and fluorescence quantum yields. Further, each of these nanoconjugates were incorporated into a polyacrylic acid (PAA) based hydrogel to develop antimicrobial photodynamic hydrogels with pH triggered release potential.



Confirmation of hydrogel synthesis by visual observation - no free movement was observed upon tilting of the glass vial (left),

- (ii) glass vial inversion for 15 min showed no movement (right), (b) visual appearance of a nanocomposite hydrogel (RB@AuAgLNCs embedded), scanning electron microscopy (SEM) images of (c) PAA hydrogel (bare hydrogel), (d) PAA hydrogel-RB@AuLNCs (scale 20 μm).

- Four sweet sorghum cultivars were grown in the experimental field of CIAB: CSH 22ss, Sudangrass hybrid, SSV-74, and SSV-84. At maturity, the stalks were harvested and subjected to a mechanical extractor for juice. About 0.18 to 0.29 L juice per kg of stalk biomass was obtained in the four cultivars. The juice was sterilized, centrifuged, and filtered. Physico-chemical characterization of juice was done. The sugar concentration was about 81-107 g/L in the juice, out of which 68-81% was sucrose. The stalk-juice also contained micronutrient minerals, sminerals, e.g., potassium (95 to 103 mM), magneium (14-15 mM), sodium (3-6 mM), and calcium (1.4-1.8 mM). The micronutrient minerals were also detected, e.g., zinc, iron, copper, and selenium. The total phenolic content was in the range of 60 to 71 mg gallic acid equivalent (GAE) per 100 grams of stalk juice. The total flavonoid content was recorded as 35 to 57 mg quercetin equivalent (QE) per 100 g juice. The ascorbic acid content was 10 to 12 mg per 100 g of juice.



Sweet Sorghum cultivars, SSV-84 (lane L1), SSV-74 (lane L2), Sudangrass hybrid (lane L3 to L6), CSH 22ss (lane L7 to L9) and their stalk-juice. TLC showing oligosaccharides production in sweet sorghum juice by microbial processing. (Lm: *mesenteroides*).

- The lactic acid bacterial genus, *Leuconostoc* sp., is largely considered as safe microorganism. It has a long history of its use in dairy industry. We have processed the juice with the bacterial strain, *L. mesenteroides* MTCC10508. The juice was then centrifuged and microfiltered to remove the bacterial

cells. The growth of this strain in sweet sorghum juice transformed sucrose into glucooligosaccharides, in the presence of the acceptor molecule, maltose. TLC and HPLC analyses confirmed the production of 5-6 g/L malto-glucooligosaccharides of 3-6 DP in the diluted sweet sorghum juice, containing about 20 g/L sucrose

### Societal impact:

CIAB has contributed towards adopting the advanced technology of the UK on rice milling in Rajdhani Rice Mill of Punjab. This process is highly efficient and less energy consuming. Similarly, CIAB has also demonstrated a bio coal plant of Sweden for the production of bio coal from Indian rice straw biomass. Success of bio coal has opened the scope of its adoption by Indian industries for societal benefits. CIAB has also contributed in the establishment of advanced storage facility of fresh Agriculture produce in the Sangha Farm, Jalandhar. Such technology will improve the shelf life of fruits and vegetables and ultimately benefit society. Technologies being developed by the CIAB will have a larger impact on societal growth. CIAB is benefiting the society by providing training to young peoples and startups.

### INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY (ICGEB), NEW DELHI

ICGEB New Delhi component's mandate is to carry out world-class research in genetic engineering and biotechnology focusing on issues relevant to the developing world. In accordance with its mandate, the ICGEB made remarkable advancement in all three core domains of research: Molecular Medicine, Plant Biology, and Integrative Biology during the year, but at the same time took robust initiatives to address the issues related to COVID-19. One of our scientists has been awarded the prestigious JC Bose Fellowship in the year 2020. ICGEB scientists during the year were able to raise 4.92 million USD through competitive external project funding and also published 104 publications in peer-reviewed journals. Institute has filed one (1) national and three (3) international Patents and was granted one (1) Patent in 2020.

**Molecular Medicine:** The major focus of Molecular Medicine domain is on Tuberculosis, Malaria and Dengue. Significant progress was made in all these areas.

*Mycobacterium tuberculosis* (Mtb) employs plethora of mechanisms to hijack the host defense machinery for its successful survival, proliferation, and persistence. Previously, the Cellular Immunology Group at ICGEB showed selectivity between basal autophagy and xenophagy i.e., between the homeostatic and defense arm of autophagy during *M. tuberculosis* infections. More recently, it is shown that autophagy serves as the central mechanism, which allows opportunistic mycobacterial infection during HIV co-infection. This is a remarkable finding and has potential to accelerate new treatment strategies during HIV-TB co-infection. Besides, in a recent study, it has been shown that Mtb upregulates one of the key epigenetic modulators, NAD<sup>+</sup> dependent histone deacetylase Sirtuin 2 (SIRT2), which upon infection translocate to the nucleus and deacetylates histone H3K18, thus modulating the host transcriptome leading to enhanced macrophage activation and also modulate T helper cell differentiation. SIRT2 inhibition activates *Mtb* specific protective T cell immunity and restricts the intracellular growth of both drug-sensitive and resistant strains of *Mtb*. Overall, this study provides a link between Mtb infection, epigenetics and host immune response, which can be exploited to achieve therapeutic benefits.

Over the years, it was found that the *Plasmodium falciparum* –organelle associated proteases play key role in cellular homeostasis, as well as components of lipid metabolism pathways in the malaria parasite. Detailed genetic and biochemical studies have helped to identify several novel drug targets; drug like compounds targeting some of these enzymes have been identified as potential leads to develop new anti-malarials. Using *in silico* and *in vitro* screening strategies, potent inhibitors of major cysteine proteases of the parasite, falcipain-2/3, were identified (*Bioorg Med Chem.* 2020. 28:115155.)

Considerable progress on ICGEB's Dengue vaccine project and dengue botanical drug project have been made. Human safety trials with Sun Pharmaceutical Pvt. Ltd for the clinical development of the botanical drug against dengue were initiated. At the same time, scale-up process is continued for the recombinant dengue vaccine candidate.

### Integrative Biology:

The Transcriptional Regulation Group successfully



determined the three-dimensional structure of an intermediate state during protein unfolding with increased conformational space sampling under urea denaturing conditions. The protein unfolds completely at 10 M urea but retains residual secondary structural propensities with restricted motion. The native state, observable intermediate state and unfolded state for ETR-3, RRM -3, which has canonical RRM folds have been described. These observations can shed more light on unfolding events for RRM (RNA recognition motif) containing proteins. (*Biophys. J.* 2020. 118, 352-365)

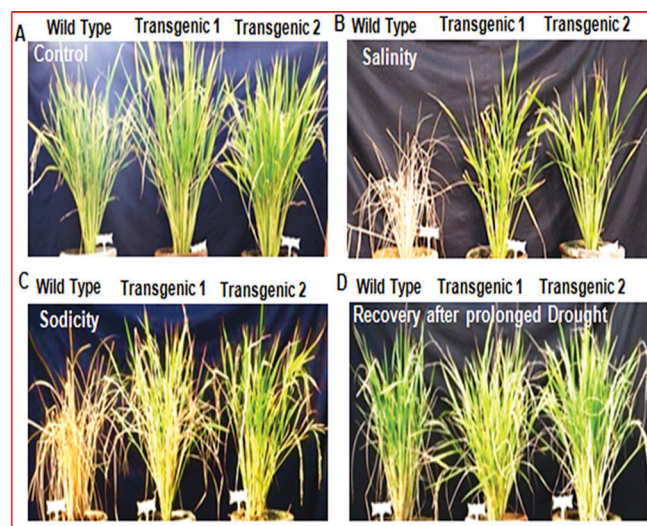
Recently, a study conducted by Structural Immunology Group aiming for Structural insights into the lipid transfer mechanism of a non-specific lipid transfer protein (nsLTP) was done. The nsLTPs are stabilized by four disulfide bonds and exhibit a characteristic hydrophobic cavity, which is the primary lipid binding site. Under the study, the lipid dependent conformational changes leading to opening of the cavity were revealed based on structural and spectroscopic data. Collectively, these studies support a model of lipid transfer mechanism by nsLTP via intermediate states. (Madni ZK et al. (2020) *Plant J.* 102:340)

Omics of Algae Group studied the physiological and metabolomic response occurring within marine oleaginous microalgae *Microchloropsis gaditana* NIES 2587, under the influence of very-low CO<sub>2</sub> (VLC; 300 ppm, or 0.03%) and high CO<sub>2</sub> (HC; 30,000 ppm, or 3% v/v). The results demonstrated that HC supplementation in *M. gaditana* channelizes the carbon flux towards the production of long chain polyunsaturated fatty acids (LC-PUFAs) and also increases the overall biomass productivities (up to 2-fold). Also, the qualitative metabolomics has identified nearly 31 essential metabolites, among which there is a significant fold change observed in accumulation of sugars and alcohols such as galactose and phytol in VLC as compared to HC. (*Frontiers in Plant Science.* 2020.*in press*)

It is a crucial challenge to improve the per-hectare yield of biomass and sugars in marine cyanobacteria. To this end, the Scientists at ICGB were successful in doubling the photoautotrophic glycogen productivity (mg/l/day) of a model marine cyanobacterium through genetic engineering (*Biotechnol. Biofuels.*, 2020).

## Plant Biology:

The Groups investigating plant response to biotic and abiotic stresses continued to make outstanding headway during 2020. The plant Stress Biology Group developed a solution wherein it got success to accumulate trehalose in transgenic rice plants. These plants have been found to tolerate multiple abiotic stresses such as salinity, drought and sodicity and show minimum yield penalty under stress conditions. Importantly, these plants are antibiotic marker-free which should improve their social acceptance.



Transgenic rice plants accumulating trehalose tolerate multiple abiotic stresses such as salinity, drought and sodicity

The Plant RNAi Biology Group has investigated the common miR circuits that are modulated in response to high temperature stress (HTS) and salinity stress (SS) in rice. The HTS deregulated miRs were mapped to the Quantitative trait loci (QTLs) to identify the traits related to agronomic performance. The identification of common miR regulatory loops highlights the dual regulation of the essential transcripts by HTS and SS thereby broadening the perspective about the stress-mediated regulatory mechanisms operative in rice.

A study conducted by Plant Transformation Group demonstrated that CelK1 transplastomic plants remain heteroplasmic, even after repeated selection steps and it does not impair the relatively high-level production of the recombinant enzyme. Post-translational modification does not have any significant impact on the enzymatic activity.

Further, the enzyme activity in the detached leaves stored at 4 °C is maintained up to 20 weeks without significant loss of activity.

Nutritional Improvement of Crops Group revealed that *Pseudomonas fluorescens* (YPS3 GenBank number—MH580200) and *Bacillus safensis* (YKS2 GenBank number—H539636) have found to possess effective chromium degrading capacity up to 84% and 72% respectively in the contaminated environment soil. Hence these can be explored as an effective green alternative for a polluted environment.

## PUBLIC SECTOR UNDERTAKINGS

### BIOTECHNOLOGY INDUSTRY RESEARCH ASSISTANCE COUNCIL (BIRAC)

**Biotechnology Industry Research Assistance Council (BIRAC)** is a Government of India Enterprise, not-for-profit, Section-8 company, set up in 2012 under the Department of Biotechnology, Ministry of Science & Technology. BIRAC as an enabler aims to strengthen and empower the emerging Biotechnology ecosystem to undertake strategic translational research and development and create innovative, globally competitive products/ technologies addressing unmet needs. As a central interface agency, it facilitates Biotechnology sector by nurturing a pipeline of entrepreneurs, Startups, capacity building, connecting Academia-Industry, Investors, Policy initiatives for Medium and Large-scale industries in the country. This includes dedicated schemes and programs meant for providing risk capital, targeted funding, establishing high-end Bio incubation centres; technical, business mentorship; legal, IP and regulatory guidance; technology management that help bring innovation excellence for biotechnology firms and making them globally competitive.

BIRAC has closely nurtured more than 1500 entrepreneurs, start-ups, SMEs as well as large industries. As a strategic alignment with several national missions, BIRAC has successfully inculcated a culture of entrepreneurship in biotech domain in the country. A world class incubation facility network of 50 BioNEST bio incubators has been established creating about 5,49,000+ sq. ft. of dedicated incubation space reaching to tier 2 cities. More than 10,000 people have been trained with high-end skills. These entrepreneurs

and Startups have created an intellectual property wealth reflected in 200+ patent filing. Importantly, there are 150+ biotechnology products and technologies that have been commercialized in the market by these Startups. Additionally, 125+ covid solutions (diagnostics, assistive, preventive and monitoring) have been launched in the market by the startups from BIRAC's incubator ecosystem.

BIRAC has established national and international strategic partnerships, networks and platforms involving industry-academia Innovation research and facilitate novel, high quality affordable products development through cutting edge technologies. BIRAC also integrates with National Missions (Make in India, Startup India, National Biopharma Mission, Ayushman Bharat), Policy initiatives, G2G and Multilateral collaborations for International Ecosystem Connect to scale the Biotechnology Innovation Ecosystem across India. BIRAC also contributes to the Government's national programs such as "Make in India", "Startup India", "Swachh Bharat", "Ayushman Bharat", international alliances through program management units for National Biopharma Mission, Bill & Melinda Gates Foundation, Wellcome Trust and USAID.

### Major Initiatives:

- In collaboration with DBT, two calls were announced under COVID 19 consortium,
- The technologies identified under 'Innovation Clean Technology' program are being implemented in collaboration with municipalities and gram panchayats
- DBT/BIRAC Clean Tech Demo Park, Barapullah, New Delhi was launched on 8<sup>th</sup> October by Hon'ble Minister Dr. Harshvardhan in the presence of LG Shri Anil Baijal. The Demo Park will demonstrate Waste to Value | Clean Environment | Clean Energy technologies developed by Startups.
- Five technologies have been identified for the treatment of sewage at Barapullah drain
- Seven applicants were selected under NHA and BIRAC-Ayushman Bharat PMJAY Start-Up Challenge
- Ten projects, in the areas of Fruits & Vegetables and Cereals & Grains, have been identified for funding under SAEN

## Salient Achievements

### BIG (Biotechnology Ignition Grant)

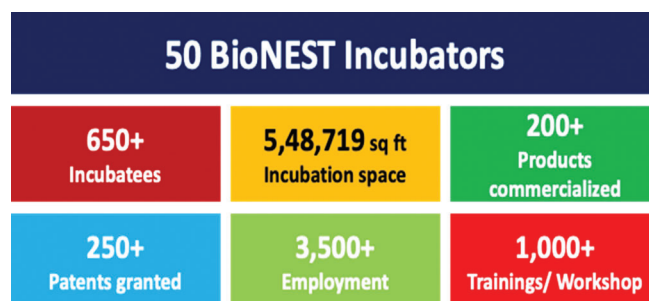
Biotechnology Ignition Grant (BIG as it is popularly known) is a pioneering early stage idea to proof-of-concept funding programme and it is India's largest early stage program in the biotech space. Through BIG, BIRAC has supported 550+ entrepreneurial ideas which have successfully translated into 50+ market deployed products/ technologies while another 120-30 are in validation stages. It is interesting to note that BIG has catalyzed setting up of more than 130 new start-ups and facilitated filing of 180+ IPs by BIG grantees. Another major highlight of the success of this programme is the ability of BIG grantees to secure follow-on funds through other sources including government and private funds. More than 80 grantees have been able to mobilize a sum of more than \$300 Cr through other sources. BIRAC implements the scheme in association with 8 BIG Partners. This year a new layer of BIG Associate Partners has been introduced with an aim to penetrate deeper pockets of the country and further enhance the footprint of the scheme.



### BioNEST (BIRAC Bio-incubation Nurturing Entrepreneurs for Scaling up Technology)

BioNEST is a dedicated scheme to create globally competent bioincubation facilities across the country. Through this scheme, BIRAC has established 50 Bioincubators across the Country creating a total incubation space of 549219 sq. ft. of incubation space. These specialized Bio incubation centres provide access to high end infrastructure, incubation facility, mentoring by technical, business experts, regulatory guidance, investor and industry connect to entrepreneurs and startups. More than 700 Biotech start-ups and entrepreneurs have been supported through the BioNEST

family. There are 6 BioNEST incubator soft clusters comprising 50 incubators across the country including tier 2 cities.



### SITARE (Students Innovations for Translation & Advancement of Research Explorations)

Students Innovations for Translation & Advancement of Research Explorations (SITARE) Scheme is aimed at supporting innovative student projects in the area of biotechnology. The scheme also provides an opportunity for orientation, training and mentoring through residential workshops etc. The scheme has two components:

- SITARE-GYTI: For postgraduate and doctoral students to undertake projects with commercial potential leading to creation of biotech startups. 15 innovative student projects receive funding support of upto INR 15 lakhs each annually
- SITARE-Appreciation Grant: Residential workshops called as Biotech Innovation Ignition School (BIIS) for undergraduate students are organized to provide hands-on-technical training and mentorship for problem identification in 3-4 weeks duration. Out of 50 students per workshop, 10 students are selected and provided a grant support of up to INR 1 lakh each to encourage their inquisitiveness and sustained efforts. In a year, 3 such workshops are conducted.

More than 60 projects have been supported under SITARE-GYTI and more than 200 students have been awarded under Appreciation award category.

### EYUVA (Encouraging Youth for Undertaking Innovative Research through Vibrant Acceleration)

EYUVA (Erstwhile University Innovation Cluster (UIC)) has helped in creating pre-incubation space where innovators



(Postgraduates/Postdoctoral fellows) with entrepreneurial ideas can perform preliminary studies and bring the same to (pre) proof-of-concept stage. Clusters have been created at 5 universities as mentioned below:

- Anna University, Chennai
- Panjab University, Chandigarh
- Tamil Nadu Agricultural University, Coimbatore
- University of Rajasthan, Jaipur
- University of Agricultural Sciences, Dharwad.

Through BIRAC support, each EYUVA Centre has created a dedicated incubation space ranging from 2500 to 3000 sq. ft. Post-doctoral/Post Graduate fellows are funded through fellowship as well as a one-time grant to conduct R&D. EYUVA fellows have been actively filing patents and seeking follow on funding through schemes such as BIG. The scheme has been expanded to also cater to Undergraduate students. New EYUVA Centres are also being set up.

### Equity Funding Schemes

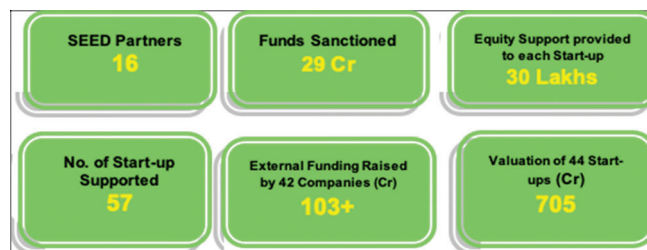
While the Bioincubators are able to support the “Space, Services and Knowledge” requirements of startups, a wide gap exists in financial support required by a technology driven start up in the initial phase. Equity schemes of BIRAC offer support for early stage startups which has potential for differential growth. It also helps them attract investment opportunities from prospective investors.

- SEED (Sustainable Entrepreneurship and Enterprise Development) Fund
- LEAP (Launching Entrepreneurial Driven Affordable Products) Fund
- Biotechnology Innovation (AcE – Accelerating Entrepreneurs) Fund of Funds

### SEED (Sustainable Entrepreneurship and Enterprise Development) Fund

The scheme provides equity-based capital assistance to start-ups with new and meritorious ideas, innovations and technologies. The SEED fund support is positioned to act as a bridge between promoters’ investment and Venture/Angel

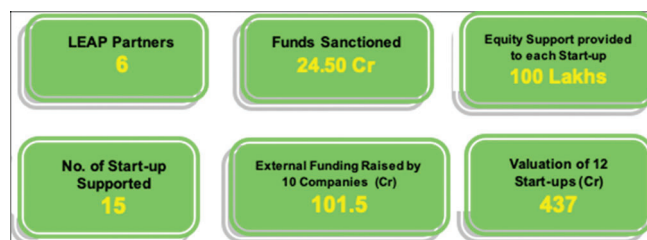
investment and is provided to the start-ups through bio incubators for scaling up enterprises. BIRAC provides Grant-in-aid Assistance to selected BIRAC funded BioNEST incubators up to INR 100 -200 Lakhs for implementation of SEED Fund. SEED Fund Partner provides funding to start-ups upto INR 30 Lakhs per start-up as equity linked instrument. Till now 50+ startups have availed SEED Funding through 16 SEED Fund Partners. These startups have a cumulative valuation of over 700 Cr.



*Impact of SEED fund*

### LEAP (Launching Entrepreneurial Driven Affordable Products) Fund

The LEAP Fund will enable potential startups to pilot/commercialize their products/Technologies. BIRAC’s LEAP fund is aimed at providing next level funding support of upto INR 1 Cr/start up against equity and equity linked instruments. This scheme is also implemented through BioNEST incubators who have experience of handling BIRAC’s SEED fund. Upon exit 50% of gross returns will be retained by LEAP Fund partner Incubator and 50% will be shared with BIRAC for it to plough back in the ecosystem. So far, BIRAC has sanctioned INR 24.50 Cr. To 6 LEAP Fund Partners.



*Impact of LEAP fund*

### Biotechnology Innovation Fund - AcE (Accelerating Entrepreneurs) Fund of Funds

AcE Fund is being implemented by BIRAC to promote Private Equity mobilization in the Biotech Innovation Ecosystem – an area where VC and Early Stage Angel funding is limited.

The AcE fund partner is mandated to invest 2X of co-investment done by BIRAC under the AcE fund. The core focus of daughter funds would be able to develop domestic innovation & manufacturing capabilities. Thirteen AcE Fund partners are now operational taking the total commitment to INR 150 Cr. AcE Fund has been invested into 27 Startups.



## MENTORSHIP

BIRAC's Regional Centres:

BIRAC now has 4 regional centres: BRIC at IKP, Hyderabad; BREC at CCAMP, Bangalore, BRBC at Venture Centre, Pune and BRTC (for East & NE) at KIIT-TBI.

### BRIC (BIRAC Regional Innovation Centre) at IKP Knowledge Park BioNEST, Hyderabad

BRIC has carried out an extensive RIS mapping (Phase-I & II) for 10 clusters Hyderabad, Bengaluru, Chennai+Vellore, Thiruvananthapuram+Kochi and for Ahmedabad, Mumbai, Pune, Bhopal-Indore, Bhubaneswa and Vizag to understand the knowledge generation capacity and to identify the gaps that hinder commercialization of innovations. Studies carried out during Phase I & II were culminated in the form of reports that summarize the findings of the studies and intend to provide inputs to frame policies for sustained development of life sciences innovation ecosystems. A similar study in other clusters of North and Eastern India has also been initiated to map 12 clusters. So far, BRIC has conducted around 100 workshops and networking meetings on IPR, funding opportunities, regulatory guidance and capacity building in Tier-1 and Tier-II cities to engage innovators and carried out >250 Key Opinion Leaders (KOLs).

### BREC (BIRAC Regional Entrepreneurship Centre) at C-CAMP BioNEST, Bengaluru

BIRAC Regional Entrepreneurship Centre (BREC) completed Phase 1 of its operations in January 2020 and conducted various awareness events, workshops, national level entrepreneurial challenges, boot camps etc. with a view to boost entrepreneurship in the Indian biotech sector. During Phase 1, BREC reached out to 1900+ students, mentored 600+ startups, facilitated more than 500 one-on-one meetings between startups and investors and mobilized participation of 6000+ startups and individual entrepreneurs for NBEC. Phase II of BREC has been sanctioned with enhanced scope of activities.

**BRBC (BIRAC Regional Bio innovation Centre) at Venture Centre BioNEST, Pune:** BIRAC Regional Bioinnovation Centre (BRBC) provided training to 20 incubation managers and assisted 80+ startups for regulatory queries, provided mentor match service to 130+ entrepreneurs, facilitated 200+ one on one meetings with specialized experts.

**BRTC-E & NE (BIRAC Regional Techno-Entrepreneurship Centre for East & North East Region) at KIIT-TBI BioNEST, Bhubaneswar:** BIRAC Regional Techno-Entrepreneurship Centre for East & North East (BRTC-E&NE) is the 4th regional centre set up at KIIT-TBI with a mandate to perform mining & assessment of Techno-commercial resource pool in East & NE and human resource development programmes such as Design Workshops, NE Immersion Program, Showcase Events, training for rural women, incubation practice school etc. This centre has reached out to 900+ Innovators, forged collaborations with 7 Institutes and encouraged establishment of bio incubators at 5 academic institutions.

**IGNITE :** BIRAC supports participation of 5 BIG grantees every year for last 7 years in the CfEL's (Centre for Entrepreneurial Learning Cambridge Judge Business School) mentorship and capacity building programme-IGNITE. The program provides the participants access to the Cambridge start up ecosystem and an opportunity to learn best practice through international mentors. So far, 39 BIG grantees have been benefitted.

## NEW PARTNERSHIPS

- **NASSCOM (National Association of Software and Services Companies):** BIRAC-NASSCOM partnership would provide Innovation platform for enterprises, enablers and innovators in emerging technologies of AI, ML, IoT, Big Data, Analytics, AR/VR and Robotics for Digital Transformation. It is aimed at improving accessibility, affordability and quality of healthcare by working with digital solution providers.
- **UKRI (UK Research and Innovation), Innovate UK:** BIRAC – UKRI partnership along with Innovate UK as an implementing partner would facilitate Innovation Ecosystem connect between UK and India for the Biotech Sector.

## THE BIOTECH ECOSYSTEM: EMPOWERMENT & SCALE-UP

**Make in India (MII) Facilitation Cell and Start Up India:** The Make in India Cell at BIRAC ensures wider dissemination of the Government programmes and other information relevant to the establishment and growth of startups, SMEs and Companies. After the successful completion of Make in India 1.0, the facilitation cell at BIRAC under the guidance of DBT has formulated the Make in India Action Plan 2.0. The progress of this action plan is reviewed by DPIIT. It also contributes under the Start-up India action plan integrating through BIRAC's facilitating funding and incubation support to start-ups.

The cell carries out regular mapping of Indian Bioeconomy status and guides the investors, Startups and entrepreneurs onto the gamut of business related issues in biotechnology such as regulatory landscape in the country, entry options and procedures, investment opportunities and routes, FDI/ EXIM/ Industrial policies. Policy level suggestions, initiatives, identifying and creating opportunities at national and international forums for Innovators are also being supported by this cell.

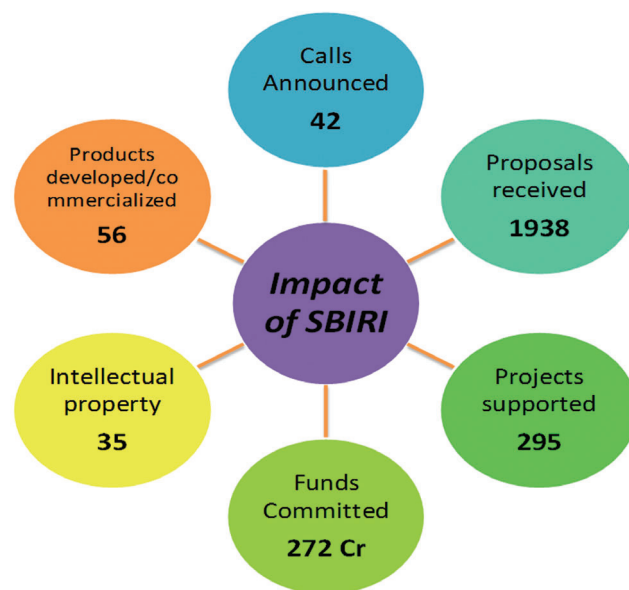
## Intensifying the Impact of Industrial Innovation (i4)

During the financial 2019-20, SBIRI and BIPP schemes were brought under a common umbrella “i4” (Intensifying the

Impact of Industrial Innovation) to serve the common mandate of providing impetus for pulling the translational ideas past PoC and taking them further along the innovation chain for validation, scale-up, demonstration and pre-commercialization of products and technologies. The programme supports biotechnological product/technology development by strengthening R&D capabilities of start-ups/ companies/ LLPs.

## Small Business Innovation Research Initiative (SBIRI):

SBIRI is India's first Biotech funding scheme launched by DBT in 2005 to promote Public Private Partnership. The scheme facilitates early stage research undertaken by industry/start-ups/LLPs either alone, or in collaboration with academia in the field of biotechnology for developing a product or a technology. So far, 303 projects involving 233 sole companies and 70 collaborative projects have been supported under the scheme. 56 products/ technologies have been developed/ validated through the scheme.



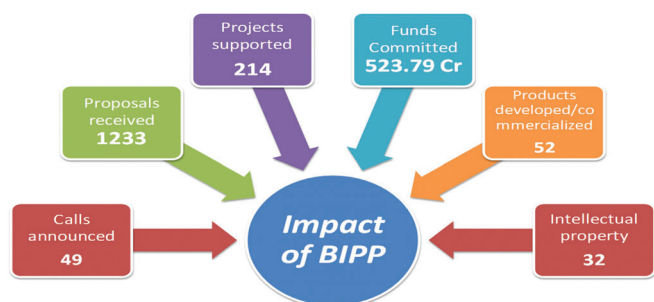
*During 2020-21, 3 calls for proposals were announced out of which two were challenge based calls. A total of 175 proposals were received in last 2 calls, out of which 7 have been recommended for support and 3 are at an advanced stage of evaluation. In addition to this, 8 proposals were recommended for financial support from the calls announced during the year 2019.*



## Biotechnology Industry Partnership Programme (BIPP):

Under the umbrella of i4, BIPP is BIRAC's Flagship "Late Stage Funding" scheme. The Scheme was launched in January 2009 and serves for scaling and commercializing high risk innovations through cost sharing between BIRAC and the industry. No incremental development is supported under BIPP. The scheme is focused on IP creation with ownership retained by Indian industry and wherever relevant, by collaborating scientists. Since its inception, BIPP has made a tremendous impact and has supported 218 projects which include 154 sole and 64 collaborative projects. Total funds committed under the Scheme are Rs. 1254.38 crores with BIRAC contribution of Rs. 529.74 crores and Company contribution of Rs. 724.64 crores. Through the support provided under this scheme, 56 Products/technologies have been successfully developed, many of which have already been commercialized and some are ready to hit the market. In addition, 36 new IPs have been generated.

In the year 2020-21, 3 calls for proposals have been announced. In the 49<sup>th</sup> and the 50<sup>th</sup> call, 77 proposals were received out of which 3 proposals were recommended for financial support and 3 are currently under evaluation. 51<sup>st</sup> Call for Proposals was announced on 15<sup>th</sup> October, 2020 which closed on 30<sup>th</sup> November, 2020. In addition, mentoring and monitoring of ongoing projects was pursued.



**Promoting Academic Research Conversion to Enterprise (PACE- AIR and CRS):** To encourage/ support academia to develop technology/product (up to PoC stage) of societal/national importance and its subsequent validation by an industrial partner, BIRAC operates Promoting Academia Research Conversion to Enterprise (PACE) Program. The Programme has two components as below.

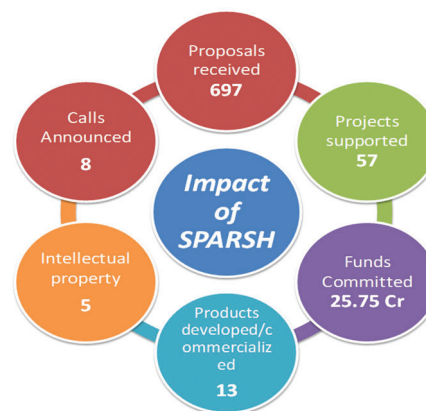
**Academia Innovation Research (AIR):** The objective of Academia Innovation Research (AIR) programme is to

promote development of Proof-of-concept (PoC) for a process/product by academia with or without the involvement of industry.

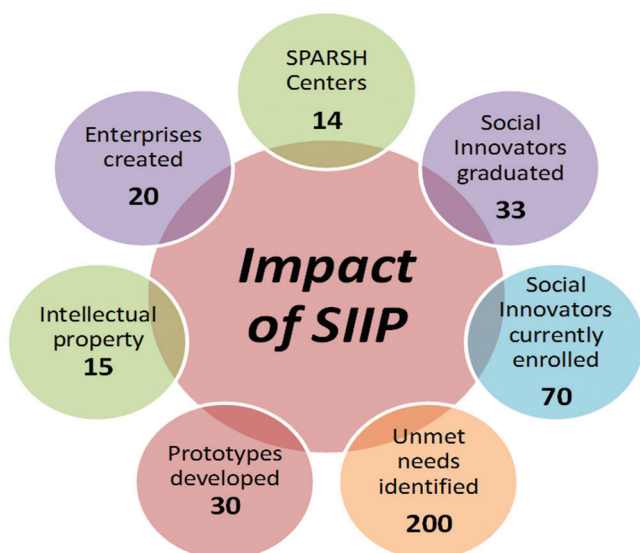
**Contract Research Scheme (CRS):** Contract Research Scheme (CRS) aims at validation of a process or prototype (developed by the academia) by the industrial partner.

During 2020-21 three calls of PACE were announced. So far, 22 calls have been launched and 114 projects have been sanctioned involving 94 unique academic institutions and 33 companies have been supported. 7 technologies/products have been developed under the scheme and 6 IPs have been generated. In the year 2020, 3 calls for proposals were announced out of which two were challenge based calls. A total of 378 proposals were received under 20<sup>th</sup> & 21<sup>st</sup> calls, out of which 6 were recommended for support and 9 are under consideration. In addition to this, 12 projects were recommended for financial support from the calls announced during 2019-20.

**SPARSH (Social Innovation programme for Products: Affordable & Relevant to Societal Health)** is the programme aimed at promoting the development of innovative solutions to society's most pressing social problems through biotechnological interventions. So far, a total of 8 calls have been announced under **Affordable Product Development** component, through which 57 projects have been supported and 18 products/prototypes/technologies have been developed. 5 new Intellectual Property (IP) has been generated. 61 beneficiaries have been supported which include 34 companies and 27 Institutes. 10 women entrepreneurs have been supported. In the FY 2020-21, 5 projects have achieved TRL 7 & and 1 project has achieved TRL 8.



**The Social Innovation Immersion Program (SIIP)**, a component of SPARSH scheme, is BIRAC's social Innovation fellowship/award program aimed at creating a pool of biotech "Social Innovators" who could identify the needs & gaps within communities and then can help bridge the gaps either through innovative product development or services. The Program is implemented through SPARSH Centres and mentored by TISS (Tata Institute of Social Sciences), SPARSH Knowledge partner. Currently, 14 SPARSH Centres spread over 9 states are incubating, and mentoring 67 SPARSH fellows in six thematic areas of social relevance viz. (i) Maternal and Child Health, (ii) Ageing and Health, (iii) Food and Nutrition, (iv) Waste to Value, (v) Combating environmental pollution and (vi) Agri-Tech (including reducing post-harvest losses).



So far, a total of 8 calls have been announced under **Affordable Product Development** component, through which 57 projects have been supported and 18 products/prototypes/technologies have been developed. 5 new Intellectual Property (IP) has been generated. 61 beneficiaries have been supported which include 34 companies and 27 Institutes. 10 women entrepreneurs have been supported. In the FY 2020-21, 5 projects have achieved TRL 7 & and 1 project has achieved TRL 8.

**BIRAC focuses on catalysing transformation** of young academic discoveries (publications/ patents) into possible commercially viable ventures and technologies through Early Translation Accelerators (ETAs) as well as provides support for market launch and large scale commercialization of

successfully validated products/technologies through Product Commercialization Program (PCU) fund. In addition, provides support to innovators through regulatory workshops, regulatory committee meetings and testing/standardization services. In addition to providing support for waste management/waste to energy solutions, support was given to secondary agriculture (in the state of Punjab) and medical electronics areas through Secondary Agricultural Entrepreneurial Network (SAEN) and Industry Innovation Program on Medical Electronics (IIPME) respectively

### Societal Impact:

❖ **Products with potential to majorly improve quality of life:** There are several products in this category including assistive and rehabilitation devices. 2 important examples are given below:

- **AUM Prosthesis** by Inaummation Medical Devices. The device is used to restore the voice of throat cancer patients. >400 Cancer patients have been treated and were able to speak once again using this device. Product is covered by Hospitals under Ayushman Bharat.
- **Sampoorti Kit** by Aarna Biomedical. The kit provides affordable breast prosthesis for breast cancer patients. >2000 breast cancer survivors have been rehabilitated using the kit; 57 Sampoorti Trial Systems deployed pan-India.

❖ **Products for weaker sections of the society (Low Resource Settings):** Many start-ups are working of making ease to use products for resource constrained settings. Such products find application at PHC/CHC level. Some important examples are mentioned below:

- **SanMitra** by Jeevtronics is World's first-hand cranked defibrillator, which works battery-free and electricity-free even in rural settings. The device could save lives in Tier 2, Tier 3 cities.
- **ReMeDi** by Neurosynaptic Communications: Comprehensive e-health solution for screening, primary diagnosis & triaging that connects the entire healthcare ecosystem 190 Units installed in India, Sub-Saharan Africa, South & South-east Asia

- SmartScope by Periwinkle: Hand-held trans-vaginal digital Colposcope. Sold >100 units in less than a year, penetrated up to PHC Level

❖ **Products with potential to convert waste to value:** Sanitation and waste to value is an important focus area of BIRAC. Several start-ups have been supported in this domain. Few important examples are mentioned below:

- Rope production centre: A machine for making long ropes from banana pseudo stem to produce eco products which are alternative to plastics. Value added products like bags, fruit bags, weaving mat, weaving grill and other products. The banana farmers are getting additional income of Rs 5/Pseudo stem. More than 40 rural women have been employed. Total sales: Rs. 3.5 cr
- Aspartika Biotech: A complete reclamation of silk industry wastes in and around Bangalore by converting them into high value omega-3 fatty acids and low value high volume poultry feed. Total sales: Rs 51.29 lakhs
- Flycatcher Technologies: Rhino Digestor System for conversion of food waste to biogas. The waste is fed into the system through an integrated crusher mounted below a sink that pulverizes and injects waste into the system. Total sales: Rs. 1.25 cr

❖ **Encouraging women led start-ups:** Nearly one-third of the BIRAC supported projects are led by women. Some of the women entrepreneurs have achieved remarkable recognition and have created an impact. Some of the examples are mentioned below:

- Niramai Health Analytix led by Ms. Geetha Manjunath. Non-contact non-invasive radiation-free solution for early detection of breast cancer using artificial intelligence. More than 32000 women screened so far. Multiple free camps conducted and detected women with early stage breast abnormalities (cancer and even Breast TB). Raised 7 Million USD investment from venture capitals.

- Zumutor Biologics led by Ms. Kavita Iyer. Developing Natural Killer (NK) cells therapeutics with a first-in-class antibody to treat prostate cancer. Also has a pipeline of immuno-oncotherapeutics molecules developed using its own antibody engineering platforms. Raised \$20 Million so far.
- Codon Biotech led by Dr. Tripti Bhatnagar. Offers a large range of Biotech teaching kits designed and developed for understanding basic techniques Best Biotech Company in Micro Enterprise segment by Zee Business and Achievers India Group
- String Bio led by Dr. Ezhil Subbaine. Manufactures and provides feed and food ingredients produced through biotechnology-based solutions. One of 5 top synthetic biology & cleantech startups worldwide by Forbes. Raised an undisclosed sum of money from a bunch of investors.
- Xcellence in Bio innovations & Technologies led by Dr. Suman Kapur. Indigenous low-cost, ultra-rapid portable device to test antibiotic sensitivity of human urinary pathogens. Reduces time for culture assay to 4 hrs. More than 20 units sold.

**Economic Impact: Economic impact can be assessed in following ways:**

❖ **Valuation of Companies:** Several companies supported by BIRAC have high valuation ranging up to 350 Cr. Cumulative Valuation of various start-ups supported by BIRAC is as high as 3750 Cr. Given below are some examples of high valuation companies:

- Companies with Valuation in the range of 50-100 Cr
  - Pandorum Technologies. Company has also raised private investment of INR 25 Cr.
  - Samplytics Technologies. Investment Raised: INR 15 Cr. Selected for Y Combinator
  - EyeStem. Investment Raised: INR 19 Cr.
  - Turtle Shell Technologies. Investment Raised: INR 18 Cr



- OCT Therapies. Investment Raised: INR 60 Cr
- Companies with Valuation of 50-100 Cr
  - Terrals Technologies: Valuation: INR 180 Cr.
  - Bugworks. Fund Raised: \$ 19 Million. Valuation: \$ 50 Million
- ❖ **Sales of products/technologies:** More than 100 products and technologies have been developed through BIRAC support. While many of these are start-ups currently trying to penetrate into market, some of the early supported companies have been able to click sales figures as high as 50 Cr. Some of the examples are mentioned below:
  - Products with Sales >50 Cr
    - Rotavirus Vaccine (ROTAVAC) developed by Bharat Biotech International Limited. Launched in 2015. Doses sold: 152.35 million. Geographies covered: India & 10 UNICEF countries. Sales more than Rs 100 Cr.
    - Inactivated Japanese Encephalitis Vaccine (JEEV) developed by Biological E Limited. Launched: 2012. Doses sold: 7 million (standing order for 8 - 10 million doses for 2020-21). Geographies covered: India & UNICEF markets. Sales more than Rs 50 Cr
    - PTCA balloon catheters developed by Sahajanand Medical Technologies Pvt. Ltd. Launched in 2014. Product used as Stent delivery system. Units sold: 1 to 1.5 million units manufactured. Geographies covered: Europe, Latin America, Asia Pacific. Sales approx. Rs. 50 Cr
  - **Products with Sales >10 Cr**
    - Accukine (Portable Compact Mobile Lab) by Accuster Technologies Private Limited. Launched: 2018. Units sold: 650. Geographies covered: India and Asia. Sales of Rs. 19.5 Cr
    - 3nethra Neo: Neonatal Screening for Retinopathy of Prematurity (ROP) developed by Forus Health Private Limited. Launched: 2019. Units sold: 104. Geographies covered: Europe, US, India and Asia. Sales: Rs 14.40 Cr
    - AINA: Blood glucose, HbA1C, lipids, creatinine and Haemoglobin measuring device developed by Janacare Solutions Private Limited. Units sold: 3567. Total test volume: 15.08 Lakh tests. Sales: Rs 14.00 Cr
    - Rasburicase – Tuly: Biosimilar to Rasburicase (Recombinant powder for injection) developed by Virchow Biotech Pvt. Ltd. Units sold: 48484. Geographies covered: Pan-India. Total sales: Rs. 10 Cr.
    - BioUrja: Cost- effective biogas solution developed by: GPS Renewables Pvt Ltd. Units sold: 88. Geographies covered: Sweden, Indonesia, Maldives, Sri Lanka. Total sales: Rs. 34 crores
    - A large number of companies have been able to generate sales in the range of Rs 1 – 10 crore including Biosense Technologies, Aristogene, Scigenics Biotech, Vivira, Nanoclean Global, Dhiti Life Sciences,, Fibroheal Wound Care, Clensta, Neurosynaptic communications, Varuna Biocell, AP Organics Pvt Ltd.
- ❖ **Import Substitution:** An important parameter for economic growth is development of products with potential for import substitution. BIRAC schemes have supported several products with a “Make in India” approach. Important examples are mentioned below:
  - SYNC by BioSense is a Smart & All-in-one compact sized Glucometer designed, developed and manufactured in India with most affordable glucose test strips. More than 80,000 units sold. Penetrated in >10 States.

- Multi deck shaker by Scigenics is a multi-deck shaker which facilitates large scale microbial cultivation. Pan India Outreach with Sales >5 Cr.
- Fibroheal by Fibroheal wound care is a Made in India silk protein based low cost surgical wound care product for Low Exudating wounds. More than 36,000 units sold and 20,000 patients benefitted

#### ❖ **Infrastructure creation (high end facilities):**

Biotech research requires specialized instrumentation and high-end facilities. BIRAC's BioNEST scheme has played a critical role in setting up of specialized infrastructure (Bioincubators) providing access to high end instrumentation and facilities at affordable price. This is particularly important for start-ups. Another BIRAC scheme BIPP has also supported setting up of facilities. Highlights mentioned below:

- 50 BioNEST Incubators across the country
  - 650+ incubatees supported
  - 200+ Products / Technologies commercialized
  - 54,8719 sq. ft. incubation space created
- Natural Remedies: A facility set-up for the isolation of phytocompounds. Sold > 2910 units Sales >10.55 Cr

#### ❖ **First-in-class discoveries with potential for global impact:**

There are examples of start-ups working on first-in-class discoveries that have potential for global impact in terms of improving quality of life as well as huge economic gains for the country.

- Aten Porus Life Sciences Pvt Ltd. developed beta-cyclodextrin based polymer prodrugs (ORX-301). First-in-Class Therapeutics for Niemann-Pick Type C Disorder, which is a rare, inherited, fatal disorder affecting lipid metabolism. Entered into an Exclusive Option Agreement with Oraxion Therapeutics, Inc., on ORX-301 with the potential to reach over US\$125 million in royalties.
- Hanugen Therapeutics Pvt Ltd. developed 20-

methyl phosphorothioate antisense oligonucleotide-based exon skipping in patients with Duchenne Muscular Dystrophy (DMD). First of its kind in India. Personalization of the therapy is possible by the ability of this technology to specifically to skip an exon anywhere in the dystrophin gene and restore the dystrophin protein. Full scale clinical trials to be initiated.

- Pandorum Technologies Private Limited developed proprietary technology platforms to design and manufacture functional human tissues. Intended for medical research and therapeutic applications. Pre-clinical studies involving clinically relevant corneal wound models in rabbits are currently underway.
- Innacel technologies Pvt Ltd. (Earlier Coeo Labs Pvt Ltd) developed VAPCare - an intelligent secretions and oral hygiene management systems to reduce chances of aspiration pneumonia in the patients who are on the ventilator for more than 48 hours. Market launched as secretion management system. Currently undergoing large scale clinical investigation in India and Abroad
- Actorius Innovations and Research Pvt Ltd. developed OncoDiscover® Liquid Biopsy Technology. A proprietary technology, for detection and enumeration of circulating tumour cells in peripheral blood. Technology is now available to oncologists in India with affordability as it provides critical information about disease progression and potentially can act as a personalized diagnostic tool.
- Curadev Pharma Ltd. developed IDO1 and TDO inhibitors to treat cancer. Entered into a research collaboration and exclusive license agreement with Roche for the development and commercialization. Upfront payment of \$25 million. Eligible to receive up to \$530 million in milestone payments, as well as escalating royalties potentially reaching double digits for the first product.

The above-mentioned case studies are few examples of the overall impact created by the BIRAC support. Summary of the impact created by BIRAC is mentioned below:

- Supported 1000+ technology driven Entrepreneurs, Start-ups and SMEs
- Infused INR 1100 Cr funds and mobilized INR 957 Cr funds through partnering with Public, Corporates, Philanthropic organizations at national and international level to harness growth synergies for the of Ecosystem
- 50 incubators supported creating an Incubation space of 5,00,000+ sq. ft. with high end infrastructure providing access to instrumentation, technical, IP, Legal and Business mentorship for Biotech Startups
- Intellectual wealth generated (200+ IP filed)
- 130+ products and technologies in the market
- 10,000+ manpower has been supported through various projects
- Total valuation of start-ups supported exceed 3750 Cr.
- >350 Cr of private investments have been raised by BIRAC supported startups

### Grand challenges India:

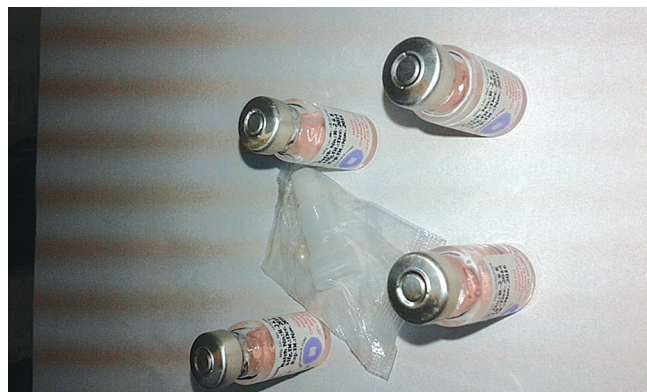
Grand Challenges India (GCI) is the Indian arm of Global Grand Challenges, launched in 2012 and is the flagship program managed by the PMU at BIRAC and is collaboratively funded by the Department of Biotechnology (DBT), Bill & Melinda Gates Foundation (BMGF) and the Wellcome Trust. GCI is committed to providing solutions for major public health problems, especially for developing countries. GCI is seeking and rewarding established researchers, young entrepreneurs, and innovators from both academia and industry. GCI aims to help innovators expand the pipeline of ideas for developing new preventive and curative therapies, piloting new technologies, and exploring new ideas. Over the years, GCI has grown both as an idea and as a partnership covering varied themes from maternal and child health to agriculture, nutrition, infectious diseases, vaccines, AMR, health systems strengthening, big data, and Medical Technologies (MedTech), etc. to respond to the ever-changing needs of research in public health in India. GCI is also supporting programs on

Sewage Surveillance, Sero-Surveillance, Mobile Diagnostic Labs to find solutions for the COVID-19 pandemic. Till now, GCI has supported seven open calls and Thirteen specialized programs in the sectors mentioned above and has funded 122 projects across India.

### BHARAT IMMUNOLOGICALS AND BIOLOGICALS CORPORATION LIMITED (BIBCOL), BULANDSHAHR

Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL), a central PSU under the administrative control of DBT is a listed company and having authorized and paid up capital of Rs 43.18 crores. It started its commercial production in 1996 and since then has supplied billion of doses of oral polio vaccine to Ministry of Health & Family Welfare for its polio eradication program.

1. In the year 2019-20, BIBCOL has produced about 170 million doses of oral polio vaccine and achieved a turnover of Rs 66.93 crores.
2. Company is striving hard to diversify into other products for its long-term sustainability and growth. In this endeavour company has taken up two projects
  - (i) Setting up of pilot scale manufacturing facility for production of oral cholera vaccine with financial and technical support from BIRAC under NBM, with technology transfer from IVI (international vaccine Institute) Korea and THSTI as collaborating partner.
  - (ii) Fractionation of Albumin and Immunoglobulin from Plasma fractionation, with collaboration with NII and funded under NBM by BIRAC.



Oral polio vaccine (with dropper)-Manufactured by BIBCOL



### 3. Rising to the occasion

#### (i) Hand sanitizer:

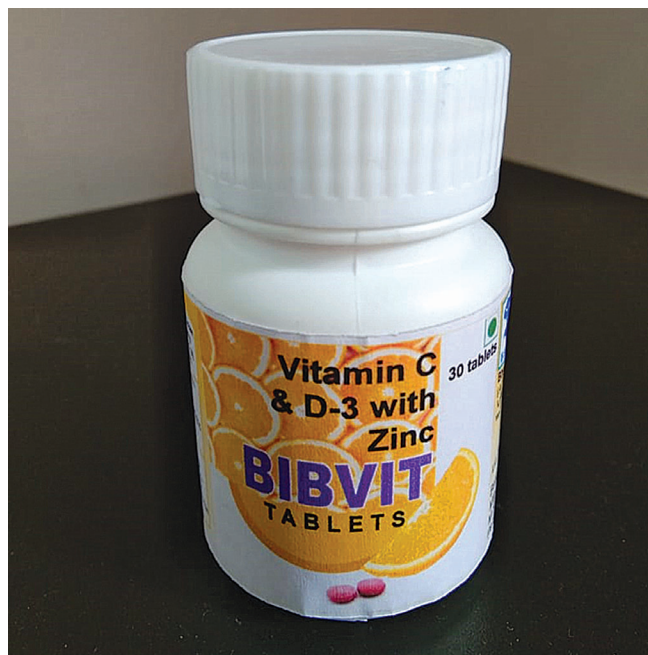
BIBCOL has quickly responded to the pandemic and so far, following milestones have been achieved:

- Four formulations have been developed in R&D stage and license obtained at small scale production.
- BIBCOL has produced and supplied IPA based WHO formulation to various institutions at affordable rates.
- BIBCOL has submitted project proposal to BIRAC for funding the setting up of pilot scale facilities and conducting further studies like efficacy and effectiveness of sanitizer over long term use. The proposal has been shortlisted by BIRAC.
- To reduce the cost further, ethanol-based formulation has been started.
- Up to Oct 2020, about 3000 liters of hand sanitizer has been supplied to various institutions.
- The production will be scaled up as soon as we receive funding from BIRAC
- The products have been registered in GEM



#### (ii) Zinc+Vitamin Tablets:

The formulation has been developed and license has been obtained as an immunity booster tablets under FSSAI Act under food supplement category. We will begin with our R&D lab scale facility for initial production and after catching the market the capacity shall be scaled up. The production is expected to begin within this month. The formulation consists of Zn, vitamin D3 and Vitamin C as active ingredients as per RDA recommendations. The formulation is being targeted as general immunity enhancement food supplement.



#### INDIAN VACCINES CORPORATION LIMITED (IVCOL)

Indian Vaccines Corporation Limited was incorporated in March 1989 as a Joint Venture Company promoted by Govt. of India (Dept. of Biotechnology-DBT,) Pasteur Meraux Serum & Vaccines (PMSV) France and Indian Petrochemicals Corporation Ltd. (IPCL- an erstwhile PSU which was taken over by as Reliance Industries Limited- a non-PSU) with a paid up capital of Rs. 18.78 crores, with the objective of manufacturing vaccines based on Vero cell Technology to be supplied by PMSV France. The company came into existence after a joint venture (JV) agreement was signed on 1<sup>st</sup> February 1989. The main objective of the company was to manufacture Injectable Polio Vaccines (IPV) to be incorporated in the mass immunization programme of the

government. However, IPV was not approved by W.H.O. and as a result the project was put on “HOLD” in February 1992. Thereafter, P.M.S.V. exited from the JV in 1998 by selling its shares to DBT. In the year 1999, National Brain Research Centre (NBRC) (an autonomous Body of the Department) was given 46.20 acres of land on thirty years lease, at a nominal lease rent of Rs.11.91 lakhs per annum which is the only ‘source of income of the company at present. The company has no trading or commercial activity at present and is maintaining establishment to look after site and complying with the statutory obligations under the Companies Act 2013.

The shareholding of IVCOL at present is Govt. of India (DBT): 66.67% and Reliance Industries Limited: 33.33%. IVCOL is presently being controlled by a board of Directors, with two Directors representing RIL and two Directors representing the DBT. The company has been incurring losses for the last two years (Rs.1149.19 lakhs for 2017-18 and Rs.1197.13 lakhs during 2018-19) and has accumulated losses of Rs.1241.64 lakhs as of 31.03.2020. The Department is exploring ways on how the immovable assets of the company can be utilized in a better way for the overall benefit of the society.



# 10

## REGULATION, INTELLECTUAL PROPERTY & LEGISLATIONS



## REGULATION, INTELLECTUAL PROPERTY & LEGISLATIONS

The activity of the Department aims at implementation of the Rules, 1989 of Environment (Protection) Act, 1986 for the manufacture, use, import, export and storage of hazardous microorganisms, GE organisms or cells and products thereof for research and development. The Rules, 1989 delegated the Department of Biotechnology to administer functioning of i) Institutional Biosafety Committees (IBSCs) which operate directly from the premises of the institutions and ensures on-site assessment and monitoring of adherence to the biosafety guidelines with overall oversight of the regulatory process, at the institutional level and ii) Review Committee on Genetic Manipulation (RCGM) that monitors & reviews all ongoing research projects involving high risk category and confined field experiments and ensure the compliance of biosafety rules & regulations, as well as framing and implementation of safety measures and guidelines, while conducting research on high risk group microorganisms and GE organisms.

### KEY REFORMS IN REGULATION:

*Reform in regulation and policy making as well as and process facilitation is a continuous process of DBT. The Department worked in close association with other relevant Government Agencies on development of simplified procedures, guidelines and various reforms in the existing policy frameworks essential towards harnessing the potential of Biotechnology for national development and well-being of society and to make India globally competitive in Biotechnology research, innovation, translation, entrepreneurship and industrial growth. During recent past, the Department has played key role in formulation, adoption, and operationalization of the following policies and guidelines:*

- Release of 'Regulations and Guidelines for Recombinant DNA Research and Biocontainment, 2017, and bringing out several reforms in implementation process of these guidelines.
- Creation of Indian Biosafety Knowledge Portal (IBKP) to provide new scientific information on biotechnology and allow online submission of forms and their tracking. IBKP also provide India's Biosafety Regulatory information for scientific community and for the public as well.

- Framing of Rapid Response Regulatory Framework for COVID-19 wherein the regulatory approval process of applications for development of vaccines, diagnostics, prophylactics and therapeutics in association with CDSCO to fast-track approval process within 7 to 10 days. ]
- Release of 'Guidelines for Evaluation of Nano-pharmaceuticals in India' jointly with CDSCO and ICMR
- Formulation of 'Guidelines for Evaluation of Nano based Agri input and Food Products in India' jointly with Ministry of Agriculture and FSSAI
- Release of National Guidelines for Stem Cell Research, 2017 jointly with ICMR
- Release of National Guidelines for Gene Therapy Product Development and Clinical trials 2019, formulated jointly with ICMR
- Regulatory Framework and Guidelines for Risk Assessment of Genome Edited Organisms is being formulated
- Formulation of Biological data storage, access and sharing policy of India (under consideration for cabinet approval)

**Biosafety Research:** During the period April-November 2020, the RCGM evaluated 488 applications in the RCGM meetings (182<sup>nd</sup> (held on 07.04.20) to 193<sup>rd</sup> (held on 12.11.20) Meetings) during year 2020-21. Further, in-depth desk review was carried out for each of the application/reports submitted by the applicants on confined field trials (CFTs) and pre-clinical trials (PCT). 03 RARM documents for Agri-Biotechnology related applications were prepared. In Biopharma, the RCGM assessed 75 Import/ Export/ Transfer/ Receive applications, 63 Product development related applications and 276 Research & Development information applications during this period. As a measure to enhance compliance of biosafety guidelines for rDNA activities across the nation undertaken by universities, public & private institutions, laboratories, and industry through the Institutional Biosafety Committees (IBSCs) of the respective organizations, 215 new IBSCs have been constituted and registered on the Indian Biosafety Knowledge Portal (IBKP) during the period April-October, 2020.

Number of RCGM Meetings	13
Total Applications Considered	517
Number of IBSCs registered	235

## Major Initiatives

- i. Notifications for augmenting Covid-19 research for expediting the development of vaccines, diagnostics, prophylactic and therapeutics: DBT-RCGM undertook a major activity of notifying various guidelines related to biosafety of Covid-19 research with issuance of the following,
  - 1) Rapid response regulatory framework for COVID-19 to deal with applications for development of vaccines, diagnostics, prophylactic and therapeutics. Department of Biotechnology and Central Drugs Standard Control Organization, March 20, 2020.
  - 2) Interim guidance document on laboratory biosafety to handle COVID-19 specimens for R&D purpose. Department of Biotechnology, April 08, 2020.
  - 3) Rapid Response Regulatory Framework for COVID-19 Vaccine development; Checklist for application to conduct pre-clinical toxicity (PCT) studies for recombinant vaccine for COVID-19. Department of Biotechnology, May 26, 2020.
- ii. **Reduced timelines for approval process:** DBT-RCGM is in the process of streamlining the approval process of applications submitted to RCGM. To reduce the timelines, the RCGM meetings are now being conducted every 15 days instead of 30 Days. The IBKP portal and online application submission, reviewing and monitoring, has augmented the reduction of timelines.
- iii. **Indian Biosafety Knowledge Portal (IBKP):** In line with Government of India's easing doing business and digital India, an online web portal launched in 2019 by the Department of Biotechnology was enabled the process of receiving RCGM applications exclusively online April, 2020 onwards. The platform provides new scientific information on biotechnology and allow online submission of forms and their tracking. IBKP also provide India's Biosafety Regulatory information for scientific community and for the public as well. A total

of number of 215 IBSCs were registered during April-October 2020.

- iv. **Handbook for Institutional Biosafety Committees (IBSCs)- Department of Biotechnology, September 02, 2020:** DBT had released a "Handbook for IBSC members" in 2004 which was subsequently revised in 2011. The handbook has proven to be instrumental in laying down the principles and practices for ensuring biosafety in research and development. Due to several reforms undertaken in the in the regulatory ecosystem such as online submission of applications to the RCGM and empowerment of the IBSCs with Revised Simplified Procedures/ Guidelines on Import, Export and Exchange of GE organisms and products thereof for R&D purpose. (Department of Biotechnology, January 17, 2020), the handbook for IBSCs required comprehensive revision and update. Consequently, the revised Handbook for Institutional Biosafety Committees (IBSCs) was released by the Department of Biotechnology on September 02, 2020.

## HANDBOOK for INSTITUTIONAL BIOSAFETY COMMITTEES (IBSCs)



**Department of Biotechnology**  
Ministry of Science & Technology,  
Government of India

Third Revised Edition September, 2020

- v. **Interactive sessions for IBSCs:** DBT is committed to promote the advancement of research and teaching activities. For the same, DBT regularly facilitates interaction with IBSCs through online sessions and workshops. In this regard 04 Interactive sessions for IBSCs registered on IBKP have been held (dated September 24, October 08, October 22, and November 05, 2020). The sessions were primarily organized for making the Member Secretaries, IBSCs well versed with the current Rules and Guidelines as well as the responsibilities of Member Secretaries, as detailed in Handbook for Institutional Biosafety Committees (IBSCs), 2020. In totality, these interactive sessions were attended by 176 Member Secretaries/Members of IBSCs from Universities, Institute and Private organizations. The presentations entitled Presentation on Indian Biosafety Knowledge Portal (IBKP)", "Presentations on Biosafety Rules and Guidelines (with special emphasis on Import/Export for R&D purpose)" and "Handbook for Institutional Biosafety Committees (IBSCs), 2020" were delivered. The presentations were received well by the Member Secretaries and other members, who actively participated in the session. The question answer round was highly appreciated.
- vi. Presentation on Biosafety Rules and Guidelines and Indian Biosafety Knowledge Portal (IBKP) was organized

during the Session entitled "Biosafety and Biocontainment Requirements for Biopharma Research and Manufacturing" under NBM Webinar Series on Environment, Health and Safety Management, on October 15, 2020. The Webinar was attended by more than 350 participants.

**Foreign Trade and other issues:** Trade plays an indispensable role and always been a decisive parameter for the growth of country's economy. The Department sent comments on 17 SCOMET applications comments. Comments on import of 09 restricted items were also shared with Directorate General of Foreign Trade (DGFT) to facilitate trade in biotechnology. Incentivize the core research & developmental capabilities of various public and private establishments' remains a major boost for innovation driven industrial growth in the country.

**Patent facilitation and Capacity Building:** The Biotechnology Patent Facilitating Cell (BPFC) provides single window awareness-cum-Patent facilitation to scientists and researchers for filing of Patent Co-operation Treaty (PCT) and National phase applications on inventions pertaining to Life Sciences and Biotechnology through empanelled IPR firms. During the period under report, 2 new patent applications were filed, and 9 Indian patents have been granted from out of the applications filed earlier.



# 11

## DATA MONITORING AND ANALYSIS

## DATA MONITORING AND ANALYSIS

### Socio-Economic Impact Assessment and Analysis of the various schemes and Programs

Department of Biotechnology carved out as a separate Department in 1986 under the Ministry of Science & Technology is responsible for fostering programmes and strengthening indigenous capabilities in the newly emerging discipline of Biotechnology which is a frontline area of science with immense potential for the benefit to the mankind. DBT is now in the forefront of fostering cutting edge research and innovation, with strong emphasis on translational research. The Department has set itself a Mission for -

- Realising full potential of biotechnology
- A well-directed effort, significant investment for generation of products, processes, and technologies
- Enhance efficiency and productivity and cost-effectiveness of agriculture, nutritional security, molecular medicine, environmentally sustainable technologies, scientific and technological empowerment of human resource, a strong infrastructure for research and commercialization, enhance the knowledge base, nurturing the leads of potential utility, bringing the bioproducts to the market place
- Socio-economic development / applicants of biotech for upliftment of women, rural, SC & ST population
- Promote biotech industry

Department of Biotechnology, Government of India decided to conduct ***“Socio-Economic Impact Assessment and Analysis of the various schemes and Programs” by an external agency.*** This is a pertinent response to the growing demand for validating and justifying the financial investments, human and scientific resources for societal development. Due to the COVID-19 pandemic, restrictions were imposed on travelling, meetings, and social Interactions across the country. Hence, various field and travel related activities could not be carried out completely by the agency. This has constrained the coverage of the study to a great extent. However, efforts were made to approach the stakeholders through virtual platforms. So, the current results of the study are preliminary in nature.

The objectives of the study are as following:

- To assess socio-economic impact of DBT interventions in various sectors,
- To look into the macro-economic impact of the DBT programmes, and
- To assess the impact of DBT interventions in specific areas: human resource development, agriculture, health, environmental, regional and societal.
- This study covers the socio-economic impact of projects that have been completed during April 2014 to March 2019. On-going projects have not been considered for detailed impact assessment except in the case of Star College Scheme and Infrastructure development.

For sampling, the Study Team has taken more than 10 percent of the DBT funded projects completed during the period of April 2014 to March 2019 for doing detailed analysis. Based on the list of completed projects during 2014-19, the Study Team prepared a list of about 2,700 projects and 290 samples were selected for detailed analysis in the first phase. Coverage of the study includes: **HRD programme:** (i) Teaching; (ii) Training (iii) Fellowships & Awards; DBT Special Programmes viz. Biotechnology for **Societal Development** and Biotechnology Career Advancement & Reorientation Program (BioCare); NER programme; **Mission Programmes:** Biotech KISAN Programme, Bio-Pharma Mission Programme, Mission Innovation etc.; **Research & Development:** (i) Medical Biotechnology, (ii) Agriculture & Allied Areas, (iii) Knowledge Generation, Discovery and research, new tool and technologies, (iv) Energy Environmental and Bio- Resource Based Application (iv) Bioinformatics, (vi) Human Genetics, (vii) Bio-Design; Translational & Industrial Development Program.

### Domain wise highlights of the study

#### i) Human Resource Development

The core components of the programme are: Teaching, training and fellowships & awards. These schemes are aimed at building a skilled workforce for strong, sustainable and balanced growth of the biotechnology sector across the country.

The facilities created / supported under HRD activities have immensely contributed to strengthening the faculties to enhance their existing skills and core expertise. Furthermore,



this has aided in expanding the infrastructural facilities through R&D grants and accessing the existing facilities in nearby institutions engaged in biotechnology R&D etc.

This has also created a demand among students to pursue for higher educational courses in the Biotechnology sector. Instance, the spread of STAR colleges across India serves as an example for the same (coverage depicted Fig). From mere 39 Star colleges in the year 2008 (year of inception), there is a manifold increase in the number of STAR colleges to approximately 200 in the year 2019.

The visits done as part of the study have noted that the colleges showed vibrant lab sessions, highly active student population experimenting in number of local issues, such as monitoring local lake water quality, testing the water quality in local drinking sources, blood grouping and hemoglobin testing for the entire college, organizing and participating in science fairs, establishing science promotion events in local schools etc. The improved infrastructure facilities in the labs and redesigned experiments have created more hands-on opportunities for the students. Many of the star colleges have pooled in resources from various sources such as UGC, CE, CPE, FIST and occasionally state government schemes to systematically build a laboratory infrastructure. Apart from life science and physical sciences departments, even departments like mathematics and statistics, have benefitted from this largesse by setting up relevant labs. Students get practical experience in coding and analyzing data with software like R, Mathematica etc. in such cases.

It was observed from the study that the colleges with the STAR status initiated by DBT made commendable achievements with the improved infrastructure and curriculum. In addition to this most of the students graduated from STAR colleges have pursued higher education (Masters, PhDs, Post-Doctoral research). The study has revealed that most of the students who have received various awards and fellowships and worked in the DBT funded projects got employed in the various teaching, research and industrial organization of repute within and outside the country.

## ii) Research and Development

Majority of the DBT funding are focused on Research and development activities in the Biotechnology sector. The current study focuses on five main domains (Biotechnology)

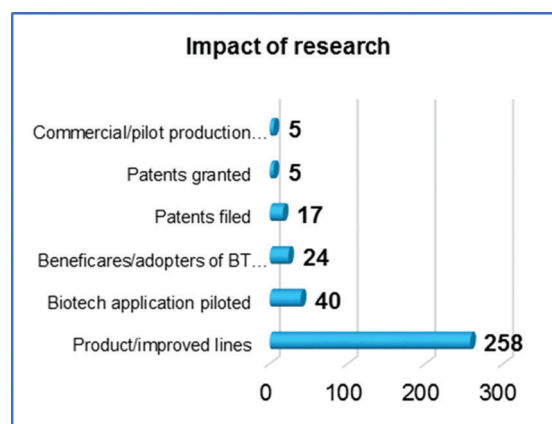
namely agriculture and allied, medical, societal, environmental and Human resource development. The study is being conducted on the stakeholders of completed Projects supported by DBT.

The overall impact of the aforementioned projects can be categorized as follows:

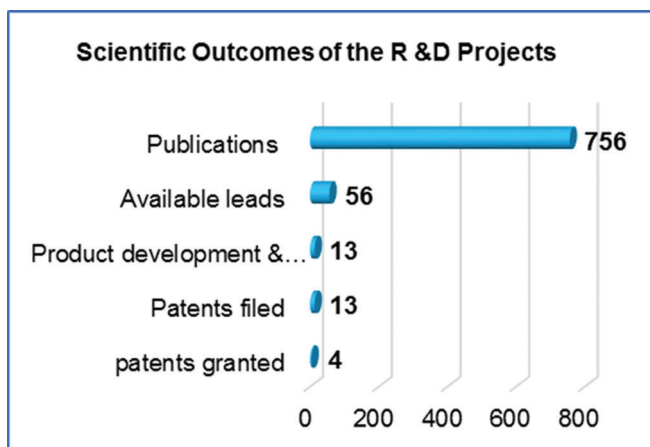
**Knowledge Output:** The study conducted so far has revealed that each project has the potential to produce on an average of 3-4 research articles in high impact Journals, 2-3 conference presentations etc. Besides this, most of the publications were made in international journals of repute as shown in the pie chart.



Some of the projects even at an exploratory phase have guaranteed promising research leads, patents and/or a marketable outcome which have had direct impact on the society at large. Based on analysis of 108 projects it can be seen that impact of research activities of R & D projects as well as the scientific outcomes are immensely promising (as shown in bar graphs)

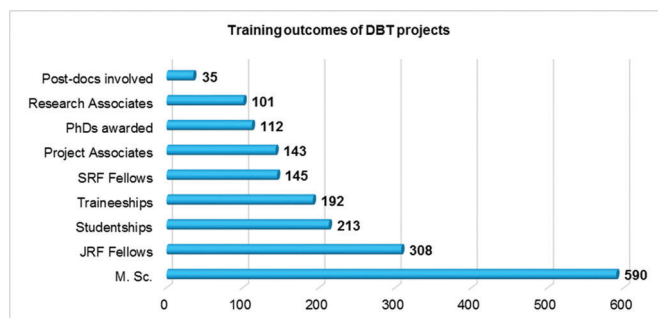






**Capacity Building:** A typical project would train 2-3 researchers directly and about 10-15 students/researchers through internship opportunities. The resultant infrastructure from the projects does make an impact on another 50-100 students during its lifecycle. These students / researchers who have had hands on training during their academic program, stand a better chance at advancing careers in academia, research or industry.

**Training Outcomes:** As the biotech industry is an emergent and growing sector in the country, this sector has an immense potential to create more and more employment opportunities. The trainings in this sector have also opened up various avenues for advanced studies/research in India and abroad. It is learnt from the various investigators of the completed projects that an influential research project can inspire several PhD scholars to pursue various leads or directions emerging from the project.



**Infrastructure Development:** Apart from the primary outputs of the project, one of the major additional impacts is the equipment infrastructure it has created with long term potential use, and the number of human resources it has directly or indirectly impacts.

**Lead Research to Long Term Outcomes:** It was also observed from the study that considerable number of investigators who got leads from the secured projects of DBT at the baseline, further continued their research to create marketable outcomes over a period of time.

## Sub area wise impact of the Projects

### Agriculture and Allied sectors

DBT Bio-tech initiatives in the agriculture and allied sectors could be categorized into basic science research, research in crop improvement using various techniques, and biological solutions for plant protection and nutrition enhancement. Several projects under review fall under these categories. Some of them are exploratory in, some to demonstrate technologies and in certain cases, it involved field trials of some of the proven technologies.

- Much of the actual market landscape of these technologies are in the nascent stage and the markets are slowly, but systematically evolving. For example, the biocontrol / biopesticide / bio fertilizer market which roughly stood around 2.8 percent of the total market share in the last decade had slowly moved to 4.8 to 5 percent according to the latest available data. Bio control of crops, despite the successful field trials is in the nascent stage in India.
- Around 150 companies are manufacturing products based on these wherein 22 units are supported by DBT. The total market landscape includes about 15 microbial species and 970 formulations. The interviews with farmers who were part of the field trial indicate the success of the program, but many of them are not continuing to use them often due to lack of commercial availability or due to price viability. Maybe with growth of industry the demand and supply could get rationalized. The larger demand could bring better volume pricing or a policy framework which support better pricing and availability could address this bottleneck.
- The growth and establishment in commercial scale plant tissue culture also in part facilitated by efforts of DBT in establishing standards and protocols in place. For example, the NCSTCP (National certification system for

Tissue Culture raised plants) helped establish 12 tissue culture product standards, certified over 43 tissue culture raised plant varieties and established 4 accredited labs. At present, there are about 200 commercial tissue culture companies in India with gross installed production capacity of about 500 million plantlets per annum. The industry witnesses an actual production of approximately 350 million plants.

- The major crops grown with the help of plant tissue culture are Banana, potato, sugarcane, apple, pineapple, strawberry, gerbera, anthurium, lillium, orchids, bamboo, date palm, teak and pomegranate.

The study has revealed that the technology developed with the support of DBT projects have transformed from lab to field. As a result, it not only enhanced the income but also has huge potential for other farmers upon adoption with respect to various crops such as *BT*-Cotton, ginger, tomato, black pepper etc. The details of the impact are indicated in the table below.

Impact of BT adoption	Results
• Income Increase	3 – 4 times
• Demand Higher	60%
• Ease of adoption	Easy to adopt
• Soil status	100% improvement
• Environmental. Pollution	Decreased
• Family Health	Good improvement

### Biotechnology for conservation of endangered plant species

DBT has also supported various studies of environmental significance. Based on the morphological and taxonomical verification of the samples collected from the wild (Western Ghats), the researchers could successfully multiply the species in the lab. This model could be used for *in-situ* conservation of wild species.

### Medical Biotechnology

Medical biotechnology utilizes organisms and organisms-derived components for research and to develop therapeutic and diagnostic products that help to cure and protect various diseases. DBT supports medical biotechnology through its

programs by focusing on Vaccine Research and Development, Public Health and Nutrition, Stem Cells & Regenerative Medicine, Biomedical Engineering and Bio design (Devices, Diagnostics and Implants), Infectious Disease Biology, Chronic Disease Biology, Maternal & Child Health - Developmental & Disease Biology and Human Genetics & Genome Analysis. Increased emphasis on prevention rather than on cure is the order of the day and as a result of it there is relevance of vaccines. This is a great opportunity for India to increase its share in global vaccine production. Fortunately, the private and the public sector have combined to work towards introducing new vaccine-based products in the market. The a study so far conducted has revealed that DBT has made concerted efforts in the area of healthcare and medical biotechnology. The researchers in the field were able to produce promising vaccine candidates for life threatening diseases (Hepatitis C, Malaria, dengue etc.). It may be pertinent to note here that Rotavirus vaccine developed with support of DBT has far reaching positive impact in terms of reduction of cost of healthcare and child Mortality in India.

### Success story of Indigenous Rotavirus Vaccine:

Rotavirus diarrhoea among children <5 causes globally 29% and in India 40% mortality. Of India's more than 2.3 million annual deaths among children, about 334,000 (15%) are attributable to diarrheal diseases. The cost of rotavirus vaccines has been prohibitively high (\$200 in developed countries). DBT has been actively involved in supporting the Rota Vaccine. The Rotavac<sup>®</sup> vaccine was developed by Bharat Biotech Ltd (BBL), Hyderabad (2016) with DBT support. Now BBL supplies about 80% of the requirement of Rotavac<sup>®</sup> vaccine costing just Rs.70 per dose for inclusion in the Universal Immunization Programme (UIP) of the Government of India. Based on the great success and impact with Rotavac<sup>®</sup>, Bharat Biotech has recently (2019) released an improved Rotavac 5D vaccine costing about Rs.100 a dose. With effective child health initiatives such as UIP, child mortality rates in India has steeply declined from 47 per thousand live births in 2010 to 29.8 per thousand live births in 2020, a decennial decline of 60%. There are 16 such Indian vaccines that have been prequalified by WHO. India has more than 12 major manufacturing facilities that manufacture vaccines for 150 countries around the world. India is a global leader in the supply of DPT and measles vaccine.

*One out of every 6 children over the world receives vaccines manufactured in India at low cost*

Other examples of DBT supported Projects which have significant impact on the healthcare sector.

- A diagnostic test for TB meningitis with nearly 100% sensitivity and about 91% specificity was developed jointly by DBT institute and AIIMS, New Delhi.
- In one of the DBT funded Projects a special nanostructured membrane material has been fabricated which showed superior biocompatibility and separation performance with respect to protein adsorption, oxidative stress, platelet adhesion, contact activation and complement activation on comparison with commercial hollow fiber membranes.
- The indigenous development of the membrane will help in wider population reach of the treatment device. Also, it will also decrease the overall cost of the treatment and could enable newer modalities of treatment with lesser side effects the researchers were able to design bio membrane for haemodialysis.
- Further, with the support of DBT projects researchers are developing various screening and diagnostic tools which help in understanding the magnitude of the various diseases/ disorders (such as anaemia & related blood disorders and other communicable and non-communicable diseases) for e.g. Under Bio Design programme, two technologies namely “Intra-Osseous Device (Ozyn-D)” and a “Chest Tube Fixator and Sealing Device (PleuraGoh®)” were licensed to start-up companies- “M/s RCupe Lifesciences Pvt Ltd., Bangalore and M/S UNINO Healthcare Pvt. Ltd., Mumbai respectively.

**Energy, Environment and Bio resource-based applications**

Department of Biotechnology has been promoting R&D for biofuel technology development recognizing the need for clean and renewable energy for transportation. It was observed from the study that significant efforts were made to make cost-effective biofuel technology, improvement of

biofuel production technologies, development of enzymes/ microorganisms for higher yields of biofuels, development of advance biofuels, development of value-added products from by-products etc. With the aid of DBT project i.e. **“Investigating the effect of co-digestion and advanced sludge pre-treatment methods on the anaerobic conversion potential of the organic wastes,”** developed the technology and established a plant at NIT Warangal, Telangana state. This plant is managing the waste from the two hostel dining halls generates biogas for the kitchens, and the resultant slurry is used as manure for campus gardens. In order to strengthen transfer of technology which cater to the needs of industry, academic courses such as MTech and MBA program in Waste Management and Social Entrepreneurship has been developed by MHRD. This clean technology for waste management can be scaled up and used at various levels.

**North Eastern Region Programmes**

DBT-NER twinning programmes have benefited the scientists in the region to enhance their research capacity to undertake projects resulting in various research outcomes.

- One of the interesting examples is that funding received by the scientists in the NER region helped them in analysing the nutraceutical (total phenolic, flavonoids, total antioxidant and anti-inflammatory activities) properties of underutilized fruits and vegetables in the North Eastern Hill Region of India. In addition to this, the study enabled the scientists to evaluate variation in nutraceutical properties in selected fruits and vegetables on processing (Minimal processing: Cutting, Blanching; Primary processing: Irradiation; Secondary processing: Product development) and to standardize appropriate processing strategy for the production of nutrition rich food products.

To develop, standardize and evaluate sensory attractive nutraceuticals in functional food products. As a result of the study, over 70 products were developed for secondary processing and commercial production. Products like ketchups, purees, chocolates, health drinks etc. were analysed and commercialized.

- Various training programmes for teachers and researchers of NER were organised at the premiere



Biotechnological institutions across India for capacity building and research innovations to cater local needs and aspirations. The program has benefitted 69 faculty members and 110 research scholars of the NER over the last five years.

### Biotechnology based Societal programmes

There are projects aimed directly towards societal impact where attempts were made to transfer the technology to community level (SC/ST women rural/urban and farmers) or to develop business models. These projects directly impact the livelihoods of farmers and other stakeholders.

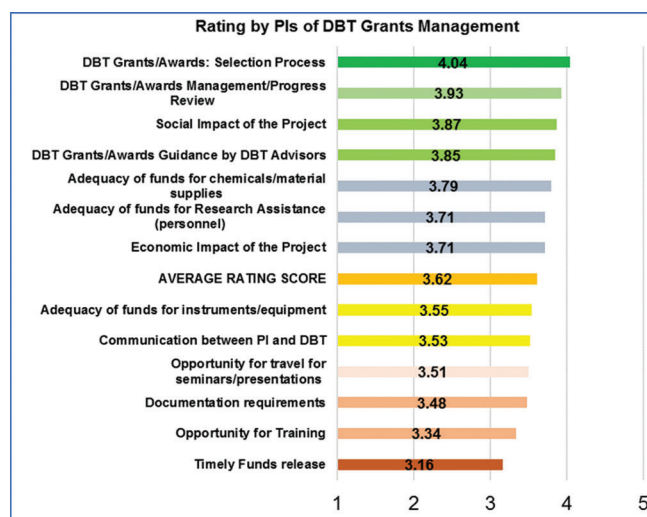
*Some of the observations from the study are listed below:*

- A DBT funded study in Mizoram i.e. “Techno-Economic Empowerment of Rural Women through Sustainable Piglet Production Units in Aizawl District of Mizoram” was aimed at creating additional income generating opportunities for local women. 102 women from 10 villages were selected and trained in modern pig keeping under the project. The training was provided for 4 days in pig keeping and its scientific aspects. Modern pigsties modelled on “raised housing system for intensive pig production with better manure management and labour-intensive system” were made in the backyard of each beneficiary. The project recorded about 67% additional annual income to the beneficiary households. The pigsties are durable with a lifespan of 3-4 decades and the farmers can replicate this model for sustainable, environment friendly pig production.
- **Socio Economic Empowerment of Rural Women through Bakery Entrepreneurship:** the project targeted the marginalized sections of the society. The bakery unit of the Karnataka Agriculture University under this project successfully established 5 bakery units, all run by women’s self-help groups in various parts of Karnataka. The units together provide employment to about 40 women.
- Income of the tribal farmers were also enhanced through capacity building and awareness about the various technologies in Kerala.

**BioCare** is a path breaking scheme to re-involve women scientists back to research after a career break. Given the large number of women researchers in the biological sciences and various obligations keeping them away from career track, the program offers unprecedented opportunity to scientists and researchers. The scheme was announced in 2011 for women scientists up to the age of 55 years for whom this is the first extramural grant. Out of 165 women scientists who were unemployed at the time of getting their respective BioCARE projects, 22 have got permanent employment. In the last five years, the BioCARE scholars produced 100 papers, 2 patents and 22 scholars have got back into permanent employment.

### Perceptions of stakeholders regarding DBT’s Research Support :

The study has revealed that the policies and programmes of the DBT is well aligned with the requirements and aspirations of the society. The programmes are designed by focusing on gender and social equity, outreach to vulnerable sections of the society as well as to address the regional imbalances. Transparency in processing of the projects and strong mentoring support to existing and upcoming researchers.



### Conclusions

The preliminary results of the current study have revealed that there is immense scope to achieve DBT's vision of “Attaining new heights in biotechnology research and innovation for creation of wealth and ensuring social justice

– specially for the welfare of the poor.” *The findings mentioned above are based on a subset of samples envisaged initially.*

### ANALYSIS BASED ON OUTPUT-OUTCOME MONITORING FRAMEWORK (OOMF)

To strengthen monitoring of various activities, Department of Biotechnology has set annual targets against each output and outcome indicators based on the framework provided by NITI Aayog. These outputs and outcomes are in measurable terms, bringing-in greater accountability in the execution of schemes and programmes of the Department. Output refers to the direct and measurable product of program activities, often expressed in physical terms or units. Outcomes are the collective results or qualitative improvements brought about in the delivery of these services. The progress against the targets is updated by the Department quarterly on the dashboard developed and maintained by NITI Aayog. Budgetary utilization, OOMF compliance and their progress for FY 2018-19 and FY 2019-20 of the Department of Biotechnology for the two Central Sector Namely Research

and Development and Industrial and Entrepreneurship developments are given below.

### Budget Utilization Summary and OOMF Compliance

**status:** Budgetary utilization for Department of Biotechnology (DBT) for FY 2017-18, 2018-19 and 2019-20 is mentioned in the Table1 below:

Table 1: Budgetary utilization

Financial Year	Funds Allocated (BE) Rs in Cr	Revised Estimate Rs in Cr	Actuals Rs in Cr	% of Actual over RE
2017-18	2222.1	2260.1	2230.3	98.7
2018-19	2411.5	2411.5	2379.1	98.7
2019-20	2580.3	2381.1	2357.9	99.0
2020-21	2786.8			

*Note: 30% of the funds allocated are earmarked for Autonomous Institutions of the Department.*

Table 2: OOMF Compliance status for the year 2018-19 and 2019-20.

Compliance	FY 2018-19						FY 2019-20					
	Output			Outcome			Output			Outcome		
	No. of Indicators	No. of Indicators reported	Compliance (%)	No. of Indicators	No. of Indicators reported	Compliance (%)	No. of Indicators	No. of Indicators reported	Compliance (%)	No. of Indicators	No. of Indicators reported	Compliance (%)
Overall	110	91	83%	62	45	73%	94	94	100%	69	69	100%
R&D	98	81	82%	57	40	70%	85	85	100%	58	58	100%
IED	12	10	83%	5	5	100%	9	9	100%	11	11	100%

From the Table 1 and Table 2 it can be inferred that with respect to RE, the department could spend up to 99% which is extremely satisfactory. Similarly, OOMF compliance rate is also observed to be impressive for both the schemes for the year 2019-20 as compared to the year 2018-19.

The core objective of the **Research and Development (R & D)** schemes of the department are to focus and promote collaborative research to address needs for developing technological and clinical solutions to the domain

such as agriculture, Medical, Environmental and Societal related challenges. In addition to this, to create and develop highly trained/skilled Manpower in the field of Biotechnology through various schemes and programs.

### Industrial and Entrepreneurship Development (IED)

scheme focusses to develop high quality basic infrastructure and high-end equipment facilities with research and development, product development, piloting and validation by SMEs and Biotech industries.

Table 3 below indicates progress of output activities supported (includes ongoing projects, new projects, workshops and training activities, facilities supported etc.) for both the schemes namely Research and Development (R&D) and Industrial and Entrepreneurship Development (IED).

**Table 3: Progress of Output activities of R&D and IED schemes.**

FY 2018-19			FY 2019-20	
Output Activities	Target	Achievements	Target	Achievements
R&D	15183	11717	12469	17028
IED	749	790	993	1041

Table 4 and 5 demonstrates the progress on outcome indicators of R&D and IED for the year 2018-19 and 2019-20 respectively.

**Table 4: Outcome indicators (R&D) for the year 2018-19 and 2019-20.**

Outcome indicators	2018-19		2019-20	
	Target	Achievements	Target	Achievements
Manpower trained	13838	13716	9137	20874
Publications	2975	3573	2450	3758
Patents Filed	84	100	71	76
Technology Developed/ transferred/ commercialized	75	85	74	119

**Table 5: Outcome indicators (IED) for the year 2018-19 and 2019-20.**

Outcome indicators	2018-19		2019-20	
	Target	Achievements	Target	Achievements
No. of users using facilities in clusters	-	-	150	50
Technologies commercialized	10	8	13	15
International collaborations			5	5
Number of professional trainings under various schemes/programmes/ workshops for high end skills	235	226	3000	3089
Total no. of patents filed	35	45	40	46
Number of Affordable Products/Technologies/ Early Stage Technologies developed (at 5% success rate)	18	20	19	12
Start-up generating follow-on funding (more than 10 Lakhs)	-	-	25	27
No. of incubates	210	377	500	530



Based on the performance of the OOMF indicators the observations of NITI Aayog are as follows:

- It was suggested that Biotechnology Industry needs a revolution, like the green revolution and the white revolution, which could provide better crops and therapeutics.
- The successful model of DBT-BIRAC needs to be replicated for conducting directed basic research and applied research, in association with the industry.
- There is a need for an integrated biotech policy, with concurrent attention to education, social mobilization and regulation to ensure orderly progress of the biotech sector.
- Synergy between technology and public policy should be encouraged for adding both years to life and life to years.

# 12

## ADMINISTRATION AND FINANCE

## ADMINISTRATION AND FINANCE

**ADMINISTRATION SECTION:** The admin Section of the Department has been consistently taking up steps to provide better infrastructure, amenities and ambience to the scientists, officers and staff working in the Department. The Department being a scientific department, a large number of scientific meetings have been held almost every day with scientists, technical experts, academicians and scholars across the country and abroad. Administrative meetings are being conducted for implementation of Govt policies/schemes/ceremonies/events etc from time to time. All logistics and technical support has been provided by the Admin Section for smooth functioning of meetings. Necessary arrangements were also made for virtual meetings as and when required by the Scientists.

**e-Office:** The e-Office is one the Mission Mode Project (MMPs) under the Digital India Programme is being implemented in the Department of Biotechnology. The product is development by NIC and aims to use in more efficient, effective and transparent inter-government and intra-government for file/record transactions and processes. Certificate of Appreciation in implementation of e-Office in the Department has been received from M/o Personnel, Public Grievances and Pensions. All new recruited scientists have been imparted in house training on e-Office and 95% of the files are routed through e-office mode.

**Government e-Market Place (GeM):** As per the instructions of Government of India, the Department has made its public procurement of goods and services through GeM portal for the goods and services available therein.

**Swachh Bharat Abhiyan:** Single use of plastic has been suitably replaced in the Department. Chairs/sofas and carpets etc. dry cleaned, broken furniture repaired, office premises whitewashed, hanging wires bunched in the corridors, old almirahs painted. Apart from this Service books/cash/PAO vouchers stitched and bound. All water coolers and dispensers cleaned frequently for clean drinking water. Old records segregated by the scientific divisions for weeding out and for safe keeping of the same in file compactors. Toilets renovated at Block No.3. Repairs for arresting seepage in all washrooms of the office. All AC air filters are cleaned frequently. Biomedical waste dustbins were

placed at corridors and rooms in this Department to contain COVID-19 pandemic. e-Waste items collected for auction as per Government rule. Conventional lights replaced with LED lights for energy saving efficiency. Repair/re-fitment of old water taps and installed Aerators in taps to save water and also to contain COVID 19 pandemic. Awareness activities have been carried out in connection with Plastic Waste Management in the Department. All the Single Use Plastics such as PET bottles, cups, folders, artificial flowers etc. have been suitably replaced in the Department. As per the guidelines, the Department of Biotechnology has constructed adequate number of Unisex/Divyangjan toilets, through CPWD, in each Block for the Divyangjan under the Swachh Bharat Abhiyan and the Right for Persons with Disabilities Act, 2016, so that the Divyangjan can easily access them and the same were inaugurated by Divyangjan officers/staff.

**COVID-19 Pandemic:** Adequate Sanitizer provided to all employees for general cleaning hand sanitisation to contain COVID-19 pandemic and sanitisation/pest/rodent control services were done on weekly basis. Fumigation done in closed rooms, stores and file compactor rooms for pest/insect control. Face Mask provided to all employees and hand wash liquid soap placed in washroom. Automated hand sanitizer dispensers are kept in all floors for hand rubs. Common areas were thoroughly cleaned/disinfected as a precautionary measure of COVID-19. Banners were placed on all floors for awareness of the COVID-19 pandemic and to follow social distancing, hand washing and to wearing face mask. Awareness on COVID 19 pandemic also made through e-Notice from time to time to all employees to keep clean and maintain hygiene.

**e-waste/ Obsolete Items:** e-Waste and other obsolete items were collected for auction as per Government rules. A standing committee with the approval of Competent Authority has been constituted for timely disposal of the same. Conventional lights replaced with LED lights for energy saving efficiency.

**ESTABLISHMENT SECTION:** Establishment Section in the Department is entrusted with the following functions:

**Recruitment, confirmation, and promotion to various posts:-** Young Professionals have been engaged on contract basis. A proposal for creation 8 posts of Scientist 'D' and 5



posts Scientist 'G' has been initiated and is presently under reference to IFD. Cases of completion of probation and confirmation of newly recruited Scientist 'C' have been processed and orders of confirmation of 20 such scientists have been issued. Promotion cases of Scientists under Modified Flexible Complementing Scheme are being processed from time to time.

**Recruitment Rules:** - The Department of Biotechnology, (Group 'A' Scientific Posts) Amendment Rules, 2020 for the post of Scientist 'H' in this Department have been notified in the Gazette of India. A proposal for amendment in the Recruitment Rules for the posts of Scientist 'D' and Scientist 'G' is also being processed.

**Training:** - More than 20 employees were nominated for various training programmes conducted by the Institute of Secretariat Training & Management (ISTM), Indian Institute of Public Administration, New Delhi, and other institutes to enhance their skills in relevant fields.

**Modified Assured Career Progression Scheme (MACP):** - Process for grant of Modified Assured Career Progression Scheme (MACP) to the eligible employees is being processed.

**Review under FR-56 (J):** - Process for reviewing eligible Scientific Officers of this Department under FR-56 (J) in terms of guidelines issued by the Department of Personnel & Training (DOPT) has been initiated.

**Grant of Advances and Reimbursement:** - The cases of grant of various advances, medical reimbursement and other allowances were processed as per rules in a time bound manner.

**Miscellaneous:** - Order has been issued for abolishing 1 post of Junior Account Officer and 3 posts of Multi-Tasking Staff which were lying vacant since long. Proposals for cadre restructuring of Technical and EDP Cadres of this Department are being processed in consultation with Department of Expenditure. Requisitions have been sent to Staff Selection Commission for filling up of vacant posts of Junior Technical Assistant and Multi-Tasking Staff on direct recruitment basis. Pension cases of retiring officials have been processed in time so as to enable the PAO to release the pensionary benefits on the next day of retirement.

**PARLIAMENTARY MATTERS:-** The meeting of the Parliamentary Standing Committee on Science and Technology, Environment & Forests was held on 17.02.2020 in the Parliament House Annexe regarding detailed demand for grants of the Department of Biotechnology. Replies to about 06 Parliamentary questions pertaining to the Department were duly replied within the prescribed timeframe.

**GRIEVANCE REDRESSAL:** Department has established an effective grievance redressal mechanism to deal with the public as well as staff grievance petitions. The Department regularly updates progress, disposal and pendency of public grievances on the website of Department of Administrative Reforms & Public Grievances. A total of 736 grievances were received by the Department, from 01.01.2020 to 20.11.2020, through the CPGRAMS portal, out of which 702 have been disposed of.

**VIGILANCE UNIT:** A Vigilance Cell is functioning in the Department to handle vigilance and complaint cases expeditiously. In pursuance of the instructions of the 'Central Vigilance Commission', a Vigilance Awareness Week was observed in the Department and the Autonomous Institutes(AI) and Public Sector Undertakings(PSUs) under its administration from 27<sup>th</sup> October, 2020 to 2<sup>nd</sup> November, 2020. An office-wide integrity pledge taking was organized in the Conference Room of the Department. A banner was displayed at the entrance of the Department, to facilitate focus on the theme of "Vigilant India - Prosperous India - सतर्कभारत-समृद्धभारत, which was adopted by the Central Vigilance Commission(CVC) as theme for the year 2020.

**RTI Cell:** RTI Cell is functioning in the Department & quarterly reports are filed timely on the RTI portal.

**PROGRESSIVE USE OF HINDI IN THE DEPARTMENT:** Hindi division ensures progressive use of Hindi and implementation of Government policy on Official Language in the Department. An Official Language Implementation Committee constituted under the chairmanship of the Joint Secretary (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, Cash section and Library in the Department have been notified to do their 100% work in Hindi. During the year, 27 officers and employees were imparted training in Hindi workshop. Hindi fortnight was organized in the Department during 01-15th September 2020, in which 5 different competitions namely, Vaigyanikshodh par bhashan, Noting & Drafting, General knowledge competition in hindi and Hindi Vyavahar competition, Essay writing were held. The competition for general knowledge was especially held for encouraging the multi-tasking staff and speech on scientific thesis for all scientific in the department. 62 officers/employees participated in various competitions, out of which 41 officials won different prizes.

Successful participation in different competitions of Hindi fortnight were 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. With a view to encourage writing of original books on biotechnology related subjects in Hindi, the Department has been implementing an award scheme namely “Dr. Jagadish Chandra Bose Hindi Granth Lekhan Puraskar Yojna” since 2002. Under this scheme, first prize of Rupees one lakh rupees, second prize of rupees fifty thousand, third prize of rupees twenty five thousand and two consolation prizes of rupees ten thousand each is given. The process for scheme this year is ongoing.

**INTEGRATED FINANCE DIVISION:** Department of Biotechnology has been allocated an amount of Rs. 2786.76 crore of Budget Estimates (BE) in FY 2020-21. The allocation of the Department has been reduced to Rs. 2300 crore at the stage of RE 2020-21. The Financial Statement showing the details of Actual Expenditure during 2019-20, B.E. for 2020-21, R.E. for 2020-21 and B.E. for 2021-22 in respect of various Programmes/Schemes are given in table below:

(Rs. in crores)

SL No.	Name of the Programme/Scheme	Actual 2019-20	BE 2020-21	RE 2020-21	BE 2021-22
1	2	3	4	5	6
	<b>REVENUE SECTION</b>				
1	Secretariat Economic Services				
1.01	Secretariat	30.33	36.48	28.00	35.18
2.01	Biotechnology Industry Research Assistance (BIRAC)	31.00	32.00	28.00	40.00
2.02	Support to Autonomous R&D Institutions*	761.53	815.61	577.00	806.91
3.01	Biotechnology Research and Development, Human Resource Development, Research Resources Facilities	1305.36	1580.00	1323.23	1660.28
4.01	Industrial and Entrepreneurship Development	230.60	322.67	343.77	960.00
	<b>TOTAL = Revenue Section</b>	<b>2358.82</b>	<b>2786.76</b>	<b>2300.00</b>	<b>3502.37</b>

\* Institute includes 16 Autonomous Bodies namely National Institute of Immunology (NII), New Delhi, National Centre for Cell Science (NCCS), Pune, Centre for DNA Fingerprinting & Diagnostics (CDFD), Hyderabad, National Brain Research Centre

(NBRC), Gurgaon, National Institute for Plant Genome Research (NIPGR), New Delhi, Institute of Bioresources & Sustainable Development (IBSD), Imphal, Institute of Life Sciences (ILS), Bhubaneswar, Translational Health Science & Technology Institute (THSTI), Faridabad, Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram, National Institute of Biomedical Genomics (NIBMG), Kalyani, Regional Centre for Biotechnology (RCB), Faridabad, National Agri-Food Biotechnology Institute (NABI), Mohali, Institute for Stem Cell Research and Regenerative Medicine (InStem), Bengaluru, National Institute of Animal Biotechnology (NIAB), Hyderabad, Centre of Innovative and Applied Bioprocessing (CIAB), Mohali, International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi.

**Status of C&AG Audit Paras:** The Status on Action Taken Notes (ATN) on pending C&AG Paras pertaining to the Department is as follows:

Sl. No.	Para Number and year Report.	Number of Paras	No. of para settled during year	Present Position
1.	Para No. 4.2 of C&AG Audit Report No. 2 of 2018 (Irregular grant of Promotion & entitlement) pertaining to NCCS, Pune.	One	Nil	ATN furnished has been vetted by the Audit. The Audit has sought further information. 2nd ATN was sent to C&AG on 04.09.2019. The C&AG after vetting the 2nd ATN, has sent their 3rd Report for additional information. This is being prepared in consultation with the NCCS.
3.	Para No. 4.3 of C&AG Audit Report No. 2 of 2018. (Non-utilization of land procured for construction of staff quarters) pertaining to national of Immunology (NII) New Delhi.	One	Nil.	ATN furnished on 03.05.2019, was vetted by the Audit. The Audit vide their communication dated 31st July, 2019 sought further information. Accordingly, 2nd ATN has been sent to C&AG on 06.01.2020. Information from C&AG is awaited whether our reply has been accepted and para settled.



## ABBREVIATIONS:

ACTREC	Advanced Centre for Treatment, Research and Education in Cancer
ABLE	Association of Biotechnology Led Enterprises
ADBS	Accelerator Program for Discovery in Brain Disorders Using Stem Cells
AEF	Avoided Emissions Framework
AFMC	Armed Forces Medical College
AGR	Anaerobic Gas Lift Reactor
AI	Artificial Intelligence
AI	Autonomous Institute
AIIMS	All India Institute of Medical Sciences
AIS	Acute Ischemic Stroke
AMD	Age-Related Macular Degeneration
AMG	Amniotic Membrane Grafts
AMPs	Antimicrobial Peptides
AMR	Mission Antimicrobial Resistance
AMTZ-	Andhra Med-Tech Zone
APL	Acute Promyelocytic Leukaemia
ARPCS	Advanced Research Platform for Crop Sciences
ASDs	Autism Spectrum Disorders
ASHD	Application of Stem Cell Technology in Human Disease
ATLs	Accredited Test Laboratories
ATN	Action Taken Notes
ATO	Arsenic Trioxide
ATPC	Advanced Technology Platform Centre
AUC	Analytical Ultra Centrifuge
AVT1	Advanced Varietal Trial-1
AAYUSH	Ayurveda, Yoga & Naturopathy, Unani, Siddha, Sowa Rigpa and Homoeopathy
B4	Building Bharat-Boston Biosciences Programme
B.E.	Bachelor of Engineering
B.Tech.	Bachelor of Technology
B-ACER	Bioenergy-Awards for Cutting Edge Research
BCG	Bacillus Calmette–Guérin
BDIs	Biodesign Innovators
BEAMing	Beads, Emulsion, Amplification and Magnetics Methodology
BEVS	Baculovirus Expression System
BGWL	Bermuda Grass White Leaf
BGYMV	Bittergourd Yellow Mosaic Virus
BHU	Banaras Hindu University

BIN	Bangur Institute of Neurosciences
BioCARE	Biotechnology Career Advancement and Re-Orientation Programme
BIPP	Biotechnology Industry Partnership Programme
BiSEP	Biotechnology Skill Enhancement Programme
BITP	Biotech Industrial Training Programme
BITP	Biotech Industrial Training Programme
BLISS	Biotechnology Labs in Senior Secondary Schools
BMGF	Bill & Melinda Gates Foundation
BMP-2	Bone Morphogenetic Protein-2
BPFC	Biotechnology Patent Facilitating Cell
BTCIF	Biotechnology Core Instrumentation Facility
BTISNet	Biotechnology Information System Network
BTV	Blue Tongue Virus
BUILDER	Boost to University Interdisciplinary Life Science Departments for Education and Research Programme
CaCx	Cervical Cancer
CAHC, Vellore	C. Abdul Hakeem College
CAP	Centre for Aromatic Plants
CAV	Chicken Anemia Virus
CBR	Cancer Biology Research
C-CAMP	Centre for Cellular and Molecular Platforms
CCBT	Centre for Cancer Biology & Therapeutics
CCBT	Centre for Chemical Biology & Therapeutics
CDA	Congenital Dyserythropoietic Anemia
CDSA	Clinical Development Services Agency
CDSCO	Central Drugs Standard Control Organisation
CDTI	Centre for The Development Of Industrial Technology
CDV	Canine Distemper Virus
CEEB	Combined Entrance Examination For Biotechnology
CEPI	Coalition for Epidemic Preparedness Innovations
CFTRI	Central Food Technological Research Institute
cGMP	Current Good Manufacturing Practices
CHIKV	Chikungunya Virus
chTOG	Colonic Hepatic Tumor Over-Expressed Gene
CIARI	Central Island Agricultural Research Institute
CII	Confederation of Indian Industry
CIMAP	Central Institute of Medicinal and Aromatic Plants
CMD	Common Mental Disorders
CMT	Canine Mammary Tumour
CNP	Cancer Network Program
CNT	Carbon Nanotube

CNV	Copy Number Variation
CoE	Centre of Excellence
CoE	Centre of Excellence
COI	Cytochrome Oxidase Subunit I
COPD	Chronic Obstructive Pulmonary Diseases
COVID-19	Coronavirus Disease 2019
CPV	Canine Parvovirus
CPWD	Central Public Works Department
CRC	Clinical Research Centres
CRTP	Clinical Research Training Programme
CRUK	Cancer Research UK
Cryo-TEM	Cryo- Transmission Electron Microscope
CSCR	Centre for Stem Cell Research
CSIR	Council of Scientific and Industrial Research
IHBT	Institute of Himalayan Bioresources Technology
CSRTI	Central Sericultural Research & Training Institute
CTEP	Conference, Travel, Exhibition And Popular Lectures
CTL	Catalytic Thermo Liquefaction
CTN	Clinical Trial Network
CTN	Clinical Trial Network's
CTTI	Clinical Trials Toolkit for India
CVD	Cardio Vascular Diseases
DALI	Dyslexia Assessment for Languages of India
DBA	Diamond Blackfan Anemia
DBH	Dopamine $\beta$ -Hydroxylase
DBS	Dried Blood Spots
DBT	Department of Biotechnology
DBT-JRF	Junior Research Fellowship
DBT-NECAB	North East Centre for Agricultural Biotechnology (DBT-NECAB)
DBT-RA	Research Associates
DCFR	Directorate of Cold Water Fisheries Research
DDR	DNA Damage Response
DEA	Dog Erythrocyte Antigen
DHA	Docosahexaenoic Acid
DIID	Deciphering Idiopathic Intellectual Disability
DIOLC	Decoupled Input–Output Linearizing Controller
DIVA	Differentiate Infected from Vaccinated Animals
DNA	Deoxyribonucleic Acid
DOHaD	Developmental Origins Of Health And Disease



DoS	Department of Space
DPITT	Department for Promotion of Industry and Internal Trade
DSC	Differential Scanning Calorimetry
DTU	Delhi Technology University
EAM	Electroactive Molecule
EDP	Electronics Data Processing
ELISA	Enzyme-Linked Immunosorbent Assay
EMBC	European Molecular Biology Conference
EMBL	European Molecular Biology Laboratory
EMBO	European Molecular Biology Organization
EPA	Eicosapentaenoic Acid
EPI	Efflux Pump Inhibitors
EPS	Exopolysaccharides
ESRC	Economic and Social Research Council
ESRF	European Synchrotron Radiation Facility
EVANS	Eigen Value Analysis
FAARD	Foundation For Advancement of Agriculture and Rural Development
FCR	Feed Conversion Ratio
FFIRST	Facilitation of Innovation & Regulation For Start-Ups and Innovators
FRIGE	Foundation for Research in Genetics and Endocrinology
FSSAI	Food Safety and Standards Authority of India
FXS	Fragile X Syndrome
GABA	Gamma Aminobutyric Acid
GADVASU	Guru Angad Dev Veterinary and Animal Sciences University
GAPDH	Glyceraldehyde 3-Phosphate Dehydrogenase
GBU	Gautam Buddha University
GCI	Grand Challenges India
GCP	Good Clinical Practice
GD	Gaucher Disease
GeM	Government E-Market Place
GESPREM	Genome Sciences And Predictive Medicine
GETin	Genome Engineering/Editing Technologies Initiative
Ginir	Genomic Instability Inducing Rna
GIPMER	Govind Ballabh Pant Institute Of Postgraduate Medical Education And Research
GKVK	Gandhi Krishi Vignana Kendra
gMECs	Goat Mammary Epithelial Cell
GRP	Global Research Programme
GSCs	Glioma Stem-Like Cells
GTR	Glucosinolate Transporters

Hap	Hydroxyapatite
Hap	Hydroxyapatite
HCPs	Host Cell Proteins
HeLTI	Healthy Life Trajectories Initiative
hF8	Human Blood Coagulation Factor 8
HFSP0	Human Frontier Science Programme Organization
HGW	High Grain Weight
HIPC	Human Immunology Project Consortium
HITAP	Health Intervention And Technology Assessment Program
HLB	Huanglongbing
HNB	Hydroxynaphthol Blue
hPSCs	Human Pluripotent Stem Cells
HPV	Human Papillomavirus
HQ	Headquarters
HRD	Human Resource & Development
HTIC	Healthcare Technology Innovation Centre
hTPA	Human Tissue Plasminogen Activator
IA	India Alliance
IABF	Indo-Australian Biotechnology Fund
IACS	Indian Association for the Cultivation of Science
IASST	Institute of Advanced Study in Science and Technology
IAVI	International Aids Vaccine Initiative
IBAB	Institute of Bioinformatics and Applied Biotechnology
iBEC	Indian Biological Engineering Competition
IBIN	Indian Bioresource Information Network
IBSCs	Institutional Biosafety Committees
IBSD	Institute of Bioresources and Sustainable Development
IBTPs	Industrial Biotechnology Parks
ICGC	International Cancer Genome Consortium
ICGEB	International Centre for Genetic Engineering & Biotechnology
ICKD	Indian Chronic Kidney Diseases
ICMR	Indian Council & Medical Research
ICRISAT	International Crops Research Institute for The Semi-Arid Tropics
IFS	Integrated Farming System
iGEM	International Genetically Engineered Machine
IGIB	Institute of Genomics and Integrative Biology
IGKV	Indira Gandhi Krishi Vishwavidyalaya
IGRA	Interferon-Gamma (IFN- $\gamma$ ) Release Assay
IHT	Institute of Horticulture Technology

IICB	Indian Institute of Chemical Biology
IICT	Indian Institute of Chemical Technology
IIIT	International Institute of Information Technology
IIRR	Indian Institute of Rice Research
IIRS	Indian Institute of Remote Sensing
IISc	Indian Institute of Science
IISER	Indian Institutes of Science Education and Research
IISF	India International Science Festival
IIT	Indian Institute of Technology
IIT	Indian Institute of Technology
IITM	Indian Institute of Technology Madras
ILBS	Institute of Liver And Biliary Sciences
ILS	Institute of Life Sciences
IMCs	Indian Major Carps
INAE	Indian National Academy Of Engineering
INCLIN	International Clinical Epidemiology Network
Ind-CEPI	India Centric Epidemic Preparedness Innovation
INMAS	Institute of Nuclear Medicine & Allied Sciences
INORMS	International Network of Research Management Societies
INSA	Indian National Science Academy
inStem	Institute For Stem Cell Science and Regenerative Medicine
IPGMER	Institute of Post-Graduate Medical Education And Research
IPN	Interpenetrating Network
IRMI	India Research Management Initiative
IRRI	International Rice Research Institute
ISI	Indian Statistical Institute
ISO	International Organization for Standardization
IYBA	Innovative Young Biotechnologist Award
JAM	Joint Admission Test
JIPMER	Jawaharlal Institute of Postgraduate Medical Education & Research
JNCASR	Jawaharlal Nehru Centre for Advanced Scientific Research
JNU	Jawahar Lal Nehru University
JWG	Joint Working Group
KINFRA	Kerala Industrial Infrastructure Development Corporation
KRIBS	KSUM-RGCB Innovation and Bioincubation Society
KUSUM	Kerala Start Up Mission
LAMP	Loop-Mediated Isothermal Amplification
LC-HRMS	Liquid Chromatography-High Resolution Mass Spectrometry
LFA	Lateral Flow Assay



LoI	Letter of Intent
LSHTM	London School of Hygiene & Tropical Medicine
LSPCA	Locality-Sensitive PCA
LSSSDC	Life Science Sector Skill Development Council
M.Sc.	Master In Science
M. Tech.	Master of Technology
M. V.Sc.	Master of Veterinary Sciences
MABC	Marker Assisted Back Cross
MACP	Modified Assured Career Progression Scheme
MALF	Marine Algal Liquid Fertilizer
MAP	Multiple Antigenic Peptides
MCI	Mild Cognitive Impairment
MFC	Microbial Fuel Cell
MLL	Mixed-Lineage Leukemia
MMP	Mission Mode Project
MoEF &CC	Ministry of Environment, Forest and Climate Change
MoU	Memorandum of Understanding
MRI	Magnetic Resonance Imaging
MSMF	Mazumdar Shaw Medical Foundation
MTECH	Institute of Microbial Technology
MyDAN	Mycobacterial Diseases in Animals Network
NABI	National Agri-Food Biotechnology Institute
NABL	National Accreditation Board for Testing & Calibration Laboratories
NADES	Natural Deep Eutectic Solvent
NAFLD	Non-Alcoholic Fatty Liver Disease
NAHD	Novel Approaches to Hematological Disease
NAHD	Novel Approaches to Hematological Disorders
NARI	National Aids Research Institute
NATRAD	National Alliance for Translational Research In Autoimmune Diseases
NBFGR	National Bureau of Fish Genetic Resources
NBRI	National Botanical Research Institute
NCBI	National Centre for Biotechnology Information
NCBS	National Centre for Biological Sciences
NCMR	National Centre for Microbial Resource
NCMR	National Centre for Microbial Resource
NCMR	National Centre for Microbial Resource
NCRI	National Cancer Research Institute
NCS-TCP	National Certification System For Tissue Culture Raised Plants
NDV	Newcastle Disease Vaccine

NECBH	North East Centre for Biological Sciences and Healthcare Engineering
NEERI	National Environmental Engineering Research Institute
NER	North Eastern Region
NERC	Natural Environment Research Council
NERC	Natural Environment Research Council
NET	National Eligibility Test
NGS	New Generation Sequencing
NGTS	Next Generation Treatment For Snakebite)
NIDAN Kendras	National Inherited Disorders Administration Kendras
NII	National Institute of Immunology
NIIST	National Institute for Interdisciplinary Science And Technology
NIMHANS	National Institute of Mental Health and Neuro-Sciences
NIPER	National Institute of Pharmaceutical Education and Research
NIPGR	National Institute of Plant Genome Research
NIRT	National Institute for Research In Tuberculosis
NISER	National Institute of Science Education and Research
NLDB	National Liver Disease Biobank
NRCM	National Research Centre On Meat
NSCLC	Non-Small Cell Lung Carcinoma
NtCD	Nitrogen-Doped Carbon Dots
NUS	National University of Singapore
OBC	Other Backward Classes
OF	Oviductal Fluid
OPUS	Optoacoustic Ultrasound
OSCC-GB	Gingivo-Buccal Oral Squamous Cell Carcinoma
OTUs	Operational Taxonomic Unit
PARR	PCR For Antigen Receptor Rearrangements
PAU	Punjab Agriculture University
PBMNCs	Peripheral Blood Mononuclear Cells
PBR	Photo Bioreactors
PCOS	Poly Cystic Ovary Syndrome
PDMS	Poly-Dimethyl Siloxane
PDP	Project Directorate On Poultry
PEG	Polyethylene Glycol
PEM	Proton Exchange Membrane
PG	Post Graduate
PGIMER	Postgraduate Institute of Medical Education And Research
PhD	Doctor of Philosophy
PHST	Pre-Harvest Sprouting Tolerance

PIs	Project Investigators
PLAP+	Placental Alkaline Phosphatase Positive
PMNS	Pune Maternal Nutrition Study
PoCs	Perform Proof-of-Concepts
PPI	Protein Protease Inhibitor
PRIYA	Pune Rural Intervention In Young Adolescents
PSUs	Public Sector Undertakings
PUFA	Polyunsaturated Fatty Acids
PYMoV	Pepper Yellow Mosaic Virus
R&D	Research & Development
RAD	Rapid Anaerobic Digestion
RBCs	Red Blood Cells
RBIAC	Rural Biotech Innovation And Application Centre
RCGM	Review Committee on Genetic Manipulation
RePORT	Regional Prospective Observational Research in Tuberculosis
RF	Radio Frequency
RISE	Research Internships In Biotechnology Based - Sciences And Engineering
RMRC	Regional Medical Research Centre
RNA	Ribonucleic Acid
R-PAC	R-Phenyl Acetyl Corbinol
RYD	Rice Yellow Dwarf
S & T	Science & Technology
SR – NBACD	S. Ramachandran - National Bioscience Award For Career Development'
SAHAJ	Scientific Infrastructure Access For Harnessing Academia University
SAP	Swachhta Action Plan
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SAU	State Agricultural University
SBE	Snakebite Envenoming
SBIRI	Small Business Innovation Research Initiative
SBRL	Seribiotechnology Research Laboratory
SC/ST	Scheduled Castes/ Scheduled Tribes
SCGS	Sugarcane Grassy Shoot
SciComm101	Science Communication
SCTIMST	Sree Chitra Tirunal Institute For Medical Sciences And Technology
SDG	Sustainable Development Goals
SERS	Surface-Enhanced Raman Scattering
SFA	Saturated Fatty Acids
SGPGIMS	Sanjay Gandhi Postgraduate Institute Of Medical Sciences
SGRH	Sir Ganga Ram Hospital



SHG	Self-Help Group
SHRs	Spontaneously Hypertensive Rats
SHS	Second Hand Smoke
SHS	Swachhta Hi Seva
SiB	School of International Biodesign
SICCT	Single Intradermal Comparative Cervical Test
siRNA	Small Interfering RNA
SIT	Single Intradermal Tuberculin Test
SKAU	Sher-E-Kashmir University
SKUAST-K	Sher-E-Kashmir University Of Agricultural Sciences & Technolog
SLE	Systemic Lupus Erythematosus
SLN	Solid Lipid Nanoparticles
SNP	Single-Nucleotide Polymorphism
SNSF	Swiss National Science Foundation
SOP	Standard Operating Procedures
SPCE	Screen Printed Carbon Electrodes
SPR	Surface Plasmon Resonance
SPRERI	Sardar Patel Renewable Energy Research Institute
SPR-	Surface Plasmon Resonance
STAG	Scientific and Technical Advisory Group
STEM	Science Technology Engineering & Mathematics
STEM	Structural Topology-Based Electrostatic Model
SyMeC	System Medicine Cluster
TANUVAS	Tamil Nadu Veterinary And Animal Sciences University
TaSE	Towards Sustainable Earth
TB	Tuberculosis
TCPF	Tissue Culture Production Facility
(TDP1)	Tyrosyl DNA Phosphodiesterase I
TERI	The Energy And Resources Institute
TGL	Triacylglycerol Lipase
TiLV	Tilapia Lake Virus
TMC	Tata Medical Centre
TMC	Tata Medical Centre
TNBC	Triple Negative Breast Cancer
TPD	Tonnes Per Day
TRC	Translational Research Consortia
TRP	Translational Research Program
TRPVB	Translational Research Platform For Veterinary Biologicals
TSG	Team Science Grants

TSWV	Tomato Spotted Wilt Virus
TTA	Technology Transfer Agreement
TTOs	Technology Transfer Offices
TWAS	Tomato Spotted Wilt Virus
UAS, Bengaluru	University of Agricultural Sciences
UDSC	University of Delhi South Campus
U-Excel	Units of Excellence
UG	Under Graduate
UHMWPE	Ultra High Molecular Weight Polyethylene
UK	United Kingdom
UMMID	Unique Methods of Management of Inherited Disorders
UNATI	Undertaking Nationally Relevant Technology Innovation
UNESCO	United Nations Educational, Scientific And Cultural Organization
USA	United State of America
VFCW	Vertical Flow Constructed Wetland
VLP	Virus Like Particle
VNCI	Virtual National Cancer Institute
VNOCI	Virtual National Oral Cancer Institute
VNPs	Virus Nano Particles
WAO	Wet Air Oxidation
WES	Whole Exome Sequencing
WHO	World Health Organization
WRCB	Wadhvani Research Centre For Bioengineering
WSSV	White Spot Syndrome Virus
WT	Welcome Trust
X-ALD	X-Linked Adrenoleuko Dystrophy
XRD	X-Ray Diffractometer
YIM	Young Investigator Meetings
YVMV	Yellow Vein Mosaiv Virus







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