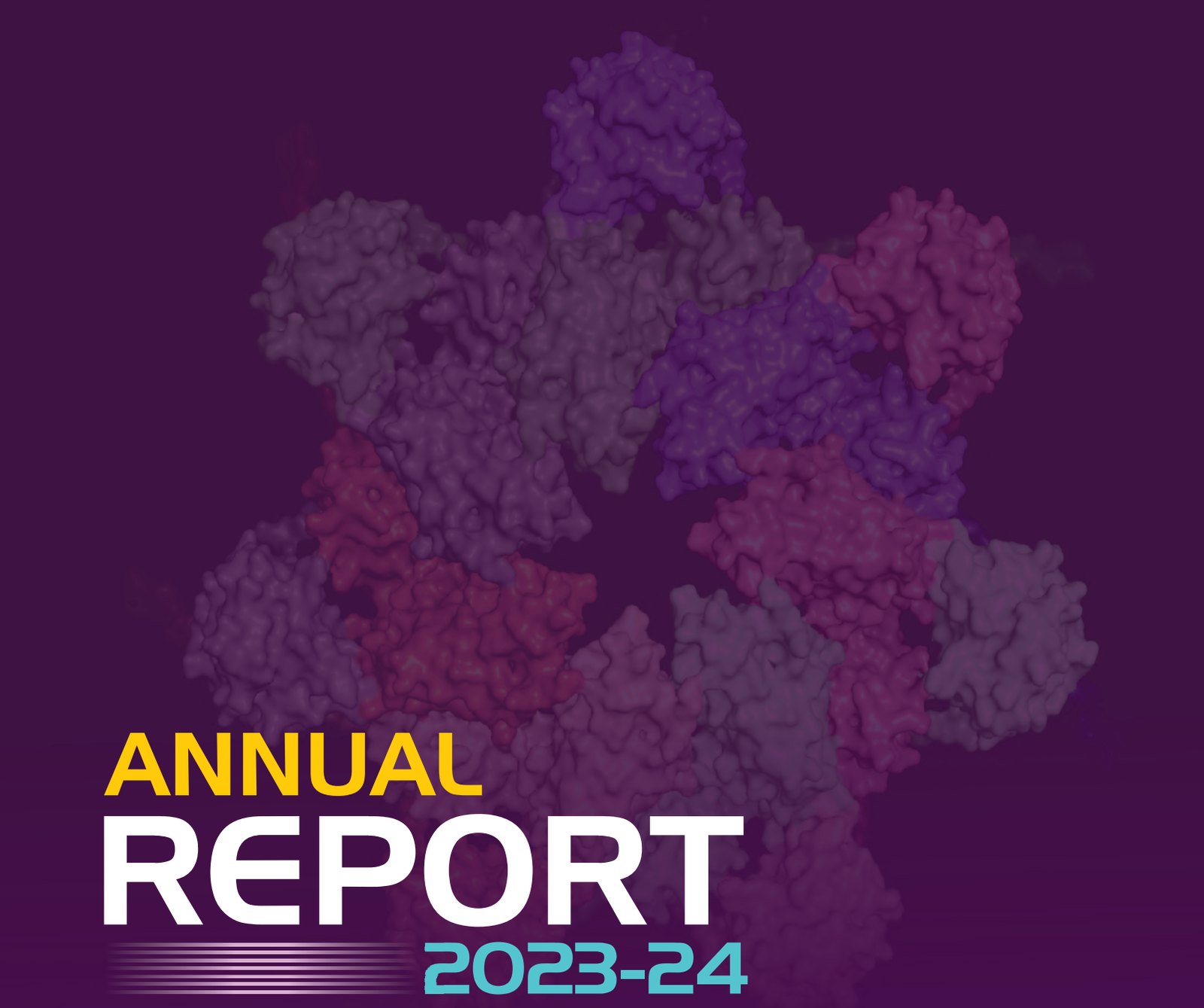


ANNUAL REPORT 2023-24

United Nations
Educational, Scientific and
Cultural Organization

क्षेत्रीय जैव प्रौद्योगिकी केन्द्र
Regional Centre
for Biotechnology

Photo Credit: Anamika Singh


Advanced Technology Platform Centre

CONTENTS

Mandate of Regional Centre for Biotechnology

The mandate of the Regional Centre for Biotechnology (RCB) is to provide a platform for biotechnology education, training and research at the interface of multiple disciplines. The programmes of the Centre are designed to create opportunities for students to engage in multi-disciplinary research where they learn biotech science while integrating engineering, medicine and natural sciences, to provide solutions for human and animal health, agriculture and environmental technologies.

The vision is to produce human resource tailored to drive innovation in biotechnology, particularly in areas of new opportunities and also to fill talent gaps in deficient areas. The Centre is regarded as a "Category 2 Centre" in terms of the principles and guidelines for the establishment and functioning of UNESCO Institutes and Centres.

The objectives of the Regional Centre are:

a. to disseminate and to advance knowledge by providing instructional and research facilities in such branches of biotechnology and related fields as it may deem fit including technology policy development,

b. to provide capacity-building through education, training, research and development in biotechnology and related academic fields for sustainable development objectives through regional and international cooperation,

c. to facilitate transfer of knowledge and technology relating to biotechnology at the regional level,

d. to create a hub of biotechnology expertise and to address human resource needs in the countries in the region,

e. to promote and strengthen international co-operation to improve the social and economic conditions and welfare of the people,

f. to promote and facilitate a network of satellite centres in the region as well as within India.

The functions of the Regional Centre are:

a. to establish infrastructure and technology platforms which are directly relevant to biotechnology education, training and research,

b. to execute educational and training activities including grant of degrees in education and research in biotechnology and related fields,

c. to produce human resource tailored to drive innovation in biotechnology, particularly in areas of new opportunities and to fill talent gap in deficient areas,

d. to undertake research and development and scientific investigations in collaboration with relevant research centres in the region,

e. to hold scientific symposia and conferences within India or in the region or outside the region and to conduct short-term and long-term training courses and workshops in all areas of biotechnology,

f. to collect universally available information with a view to setting up data banks for bio-information,

g. to collect and disseminate, through networking, the relevant local knowledge in the field of biotechnology, ensuring protection of intellectual property rights of local stakeholder communities,

h. to develop and implement a policy for intellectual property rights which is equitable and just to the stakeholders involved in research in the Regional Centre,

i. to disseminate the outcome of research activities in different countries through the publication of books and articles,

j. to promote collaborative research and development networking programme in specific areas of biotechnology with national, regional and international networks and promote exchange of scientists, at the regional level having regard to issues pertaining to intellectual property rights of collaborating institutions promoting equitable sharing of benefits with collaborating institutions.

From the Executive Director's Desk

RCB is dedicated to providing world-class education and training, and conducting cutting-edge research at the connexion of multiple disciplines in biotechnology. The objective is to develop high-quality human resources in biotechnology, addressing global challenges by nurturing innovation in both disciplinary and interdisciplinary areas.

The Centre has made significant strides in fulfilling its mission, particularly in the key areas of biotechnology education, research, and training.

The RCB's rapport with UNESCO has remained strong, with the Centre continuing its Category-2 institution status under UNESCO. This collaboration is instrumental in augmenting RCB's global visibility, besides strengthening the Centre's ability to engage in universally relevant programs and initiatives, further supporting its mission of furthering biotechnology education, research, and training across multiple disciplines.

This annual report delivers a comprehensive synopsis of the Centre's activities, highlighting the depth of education, research, and training initiatives that are contributing to the global progression of biotechnology, thus cultivating the next generation of competent professionals in the field.

Research-based learning is the hallmark of the RCB's education and training programs. By emphasizing hands-on, inquiry-driven learning, RCB ensures that students not only gain theoretical knowledge but also develop the critical thinking, problem-solving, and skills crucial for tackling real-life challenges, thus integrating research into the learning process, thereby fostering a deeper understanding of both fundamental and applied aspects of the discipline. The RCB Ordinance has the provision to conduct the following four programs: 1. Doctor of Philosophy (PhD) Degree Programme; 2. MS-PhD Programme; 3. Master of Science (MSc) Degree Programme; 4. Post Graduate Diploma Programme. While RCB is already running the PhD and MS-PhD programmes in Biotechnology, RCB intends to initiate the Postgraduate Diploma Programme in Industrial Biotechnology (PGD IB), aimed at preparing industry-ready graduates to be recruited and deployed in biopharma companies.

RCB offers doctoral degree programs in three key areas: Biotechnology, Bioinformatics, and Biostatistics. These programs are designed to provide advanced research training through a combination of rigorous academic coursework and hands-on research, thus equipping students to contribute to cutting-edge biotechnological advancements and tackling global challenges in health, agriculture, and the environment. Currently, 105 students are pursuing PhD Programme in Biotechnology at RCB. During the period of this report, 12 students graduated with a PhD degree in Biotechnology. The interdisciplinary doctoral programme in Biostatistics and Bioinformatics is supported through a collaboration with the global pharmaceutical giant, GlaxoSmithKline Pharmaceuticals India Private Ltd. (GSK). Currently, 10 students are pursuing PhD Programme in Biostatistics/Bioinformatics at RCB. During the period of this report, one student graduated with a PhD degree. RCB has been entrusted with the responsibility of implementing the 'i3c BRIC-RCB PhD Programme in Biosciences', a common PhD program for all the Department of Biotechnology (DBT)-supported autonomous institutions which have been subsumed under the newly set up Biotechnology Research and Innovation Council (BRIC). The programme was launched by the Hon'ble Minister S&T on 5 February, 2024. RCB has also received funding support for implementing this PhD programme. RCB's MS-PhD programme is also gaining popularity and attracting the best talent nationally and

internationally. In this programme, 15 out of 72 students opted to exit after completing their MS degree, while 57 students continued for PhD. Besides above, RCB, the co-patron of the Summer Research Internship Programme facilitated by Gujarat State Biotechnology Mission GSBTM), allotted 100 students to around 13 DBT institutions who registered their request for summer research internship training under this programme. Thirteen out of these 100 students were imparted training at RCB.

As empowered by the RCB Act, this year RCB has granted academic recognition to two esteemed institutions: Institute of Advanced Virology (IAV), Thiruvananthapuram and Max Society of Medical Academics Innovation and Research (MSMAIR), New Delhi, thus bringing the total number of the recognized centre to 15. A total of 115 students from these recognized centres were registered for their Master's degree and 546 for the PhD degree with RCB. This recognition further strengthened the Centre's role in shaping a highly skilled workforce in the field of biotechnology.

RCB organized various events during the reporting period. The 14th AFOB Regional Symposium (ARS) 2023 was held at RCB in collaboration with the Asian Federation of Biotechnology (AFOB) on the theme 'Innovations and Emerging Technologies in Asian Biotechnology' and focussed on the recent research findings on bioscience and biotechnology among the researchers, scientists & entrepreneurs from various countries under AFOB's partnership. Interactive sessions were held on diverse domains of biotechnology such as agriculture and food biotechnology, vaccines and biopharmaceuticals, biofuel and bioenergy, environmental biotechnology, bio-industry promotion and bio-entrepreneurship. Eminent researchers from across the globe, along with young scientists and students, participated in the symposium.

The workshop on 'Basics to Create Successful Bioenterprise' conducted by RCB was attended by 130 participants from academia and industry.

In celebration of 'World Science Day for Peace and Development', RCB, UNESCO, UNEP and WHO, owing to mutual concern about air pollution on human health, organized a Panel Discussion on 'Mobilising Biotechnology for Clean Air' at RCB, Faridabad. This event was attended by about 200 participants, including school children, students, researchers, clinicians, start-ups, entrepreneurs, farmers, scientists and researchers.

RCB successfully organized its 2nd Convocation Ceremony, where degrees were conferred to students who completed their PhD and Master's programs in the academic sessions up to 2022-23. The ceremony was adorned by Prof. P. Balaram, Chair Professor at NCBS-Bangalore, who served as the Chief Guest. The event was presided by Dr. Rajesh S. Gokhale, Secretary, DBT and Chairperson, RCB-BoG. A total of 130 scholars graduated during the ceremony. Of these, 53 students were awarded a PhD in Biotechnology, and 77 students received their Master of Science in Biotechnology degrees. This milestone reflects RCB's commitment to nurturing highly skilled professionals ready to contribute to innovations in biotechnology and related fields.

Through the partnership between RCB and the European Synchrotron Radiation Facility (ESRF), the Indian researchers gained access to world-class facilities at the experimental stations at ESRF in Grenoble, France, enabling advanced research in macromolecular crystallography, small-angle X-ray scattering, and Cryo-Electron Microscopy. This program continued to provide tremendous support to Indian structural biologists and has benefited a large number of young research students.

Regional Centre for Biotechnology (RCB) and the European Synchrotron Radiation Facility (ESRF) had entered into an agreement concerning the medium-term use of synchrotrons for non-propriety research for the benefit of the Indian scientific community as a whole, and notably the structural biology research groups in the country. The program provided access to Indian investigators to experimental stations for macromolecular crystallography, small angle X-ray scattering and Cryo-Electron Microscopy located in ESRF, thus enabling them to publish more than two hundred research papers (during the tenure of collaboration) involving basic and applied research, in international peer-reviewed journals.

The scientific programs at RCB are broadly categorized into 6 major verticals: Structural Biology, Infectious Disease Biology, Molecular Medicine, Cancer and Cell Biology, Plant Biotechnology and Systems and Synthetic Biology, addressing critical challenges in biotechnology and life sciences. Throughout the year, significant advances were made

across these diverse research domains. Summarized below are some of the major impactful highlights of the year.

Dr. Sudhanshu Vrati's group revealed that the RNA-dependent RNA polymerase activity of JEV NS5 protein, together with several host and viral proteins, constitutes the replication complex necessary for virus replication. The group has identified Nucleolin (NCL) as a crucial host protein interactor of JEV NS5, having a pro-viral role in virus replication. The NS5-interacting NCL binds to the G-quadruplex (GQ) structure sequence in the 3'-NCR of JEV RNA. This may smoothen the movement of the replication complex along the genomic RNA, thereby facilitating the virus replication. This study is the first report on how NCL, a host protein, helps in JEV replication through GQ-binding.

Dr. Manjula Kalia's group tested 42 FDA-approved drugs that were shown to induce autophagy for antiviral effects. The results revealed that the antipsychotic phenothiazines Methotrimeprazine (MTP) & Trifluoperazine possess a significant survival benefit with reduced virus titers in the brain and inhibition of neuroinflammation. The group showed that both the drugs were potent mTOR-independent autophagy flux inducers. This study suggested that MTP exerts a combined antiviral and anti-inflammatory effect in JEV infection, and has therapeutic potential for JE treatment.

Dr. Rajendra P. Roy's group has shown that the reversible acetylation of specific Lysine residues of histones plays a crucial role in the epigenetic regulation of chromatin activity. Their study has revealed that the perturbations of acetylation-deacetylation dynamics have important implications for cancer and neurological disorders. Acetyl marks on specific Lysine residues of histones are installed by HATs and erased by HDACs. Their work involved assembling the designer nucleosomes embedded with a well-defined acetyl mark in H2B to delineate its specific eraser among the 18 human HDACs. These studies have led to the identification of HDAC1 as the preferred eraser of acetyl mark at Lys-5 in H2B.

The research findings of Dr. Prem S. Kaushal's group in nature Communications reports a 2.8 Å resolution Cryo-EM structure of *Mycobacterium smegmatis* 70S ribosome in complex with RafH protein. The RafH, a dual domain hibernation promotion factor (HPF), is essential for survival under hypoxia stress, the major stress encountered by the pathogen (*M. tuberculosis*) in host macrophages. The structure revealed that the RafH N- terminus domain is conserved. In contrast, the RafH C- terminus domain is larger and binds to a unique binding site that has not been reported before. The linker region connecting these two domains, which till now has been reported as disordered, interacts with the anti-Shine Dalgarno sequence of 16S rRNA. The group proposed that RafH has a distinct mode of ribosome hibernation, which inhibits protein synthesis and protects ribosomes from RNase attack by blocking the crucial binding sites. RafH binding site also overlaps with the binding of the aminoglycoside class of antibiotics, which hints about its role in antibiotic resistance.

Dr. Deepti Jain's group has elucidated the involvement of FleR, a transcription modulator, in the regulation of flagellar assembly in *Pseudomonas aeruginosa.* Through an integrated structural approach involving Small-Angle X-ray Scattering (SAXS), negative staining electron microscopy (EM), and X-ray crystallography, the three dimensional architecture of FleR was examined. The key discovery reported was that phosphorylation acts as a molecular switch, prompting FleR to transition from the inactive dimeric to the active heptameric state. This conformational change is essential for activating its regulatory function. Further, the group revealed that the mutagenesis of the amino acid residue undergoing phosphorylation results in the loss of flagella in the bacteria, underscoring the significance of this molecular switch in flagellar assembly.

Additionally, RCB not only continued to participate in multi-institutional projects such as GRBHIni, aimed at understanding the biology of preterm birth to identify possible biomarkers to predict birth outcomes, but also initiated following new multi-institutional projects: i) Mitigating Potato leafroll virus (PLRV) incidence through genetic and chemical interventions and ii) Addressing Neurodegeneration in Diabetes. As detailed in the report, BSC BioNEST Bio-Incubator (BBB), a BIRAC's Associate Partner, continues to foster Bio entrepreneurship as a leading startup ecosystem enabler in the National Capital Region. The year was eventful, with BBB bagging the best incubator award among the Tier 1 category at Global Bio India 2024. Besides, the start-ups incubated at BBB performed exceptionally well, with Dharaksha Ecosolutions Pvt Ltd. grabbing the spotlight to showcase its vision on 'Shark Tank India'; Inte-e-labs Pvt. Ltd. receiving 'Best Women Entrepreneur Startup Award' at Global Bio India 2024; Anziam Bio Pvt. Ltd. securing a

'CDSCO Manufacturing licence' for the manufacturing of Class C and D medical devices; and Sleepiz India Pvt. Ltd. coming up with 'Sleepiz One+ Connect' - world's first remote contactless, radar-based respiration monitor and medical device. The Advanced Technology Platform Centre (ATPC) at RCB offers state-of-the-art equipment and technical support to researchers from both industry and academia across India, facilitating cutting-edge scientific work and innovation. The Biosafety Support Unit (BSU) at RCB continues to provide support to the Department of Biotechnology, Govt. of India in its regulatory activities. The Human Resource Development (HRD) Project Management Unit at RCB has been effectively overseeing and managing a range of HRD initiatives supported by the Department of Biotechnology (DBT), Government of India, contributing to the development of skilled professionals and advancing biotechnology research in the country.

IBDC, established by RCB with support from the Department DBT, is the first national repository for life science data in India. The centre is a collaborative project of RCB, NII, ICGEB and NIC. It has a data storage capacity of about 4 petabytes with a disaster recovery storage site located in NIC, Bhubaneshwar, of 1 petabyte. IBDC houses the 'Brahm' High Performance Computing (HPC) facility with a computing capacity of 961 teraFLOPs. By the end of the FY 2023-2024, IBDC has developed portals for archiving and sharing of nucleotide, crop phenome, macromolecular structure, and metabolomics data. IBDC served as a data hub for the DBT-sponsored pan-Indian genomics initiatives such as the Indian SARS-CoV-2 Genomics Consortium (INSACOG), GenomeIndia project and the Pediatric Rare Genetic Disorders (PRaGeD). For the INSACOG program, IBDC curated and analyzed the virus genome data on a real-time basis for the identification of prevailing SARS-CoV-2 variants in India. IBDC personnel also participated in the development of the FeED (Framework for Exchange of Data) Protocols for implementation of the Biotech-PRIDE (Promotion of Research and Innovation through Data Exchange) Guidelines that govern the submission and sharing of life science data within India. During FY 2023-24, IBDC organized multiple online training sessions for the deposition of data and webinars for outreach. The development of portals for submission and dissemination of proteomics and imaging data had reached advanced stages of completion by the end of FY 2023-2024.

In the end, I would like to extend my heartfelt thanks to all my colleagues for their outstanding cooperation. I also acknowledge the continued support of the Department of Biotechnology (DBT) and UNESCO, as well as the invaluable contributions of the RCB Board of Governors, the Programme Advisory Committee, and the various other statutory committees, whose guidance has been crucial in helping us achieve the Centre's scientific and academic objectives.

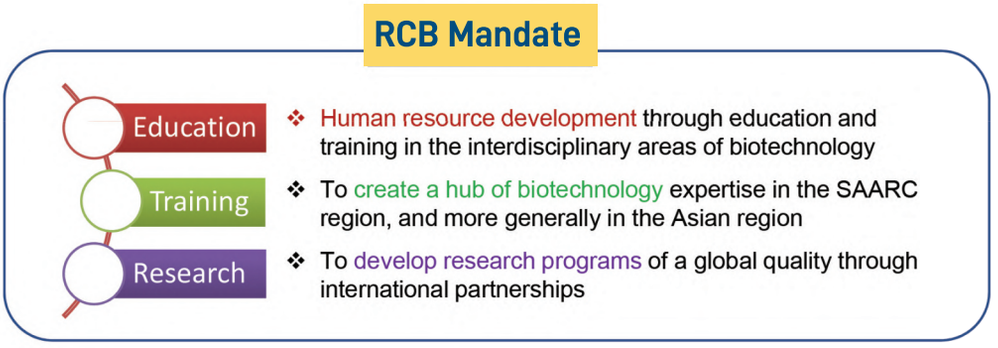
Jai Hind!

Arvind K Sahu
Executive Director

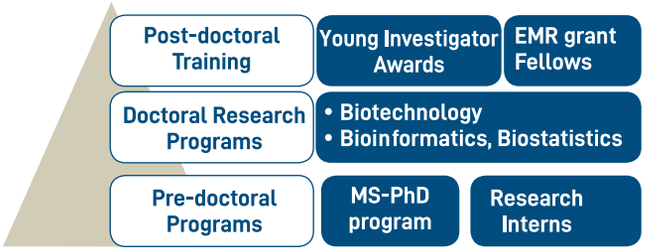
EXECUTIVE SUMMARY

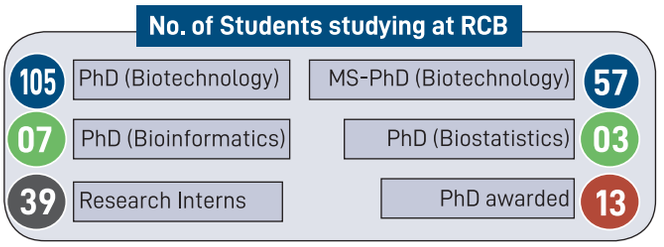
Photo Credit: Sahil Kumar

RCB Mandate

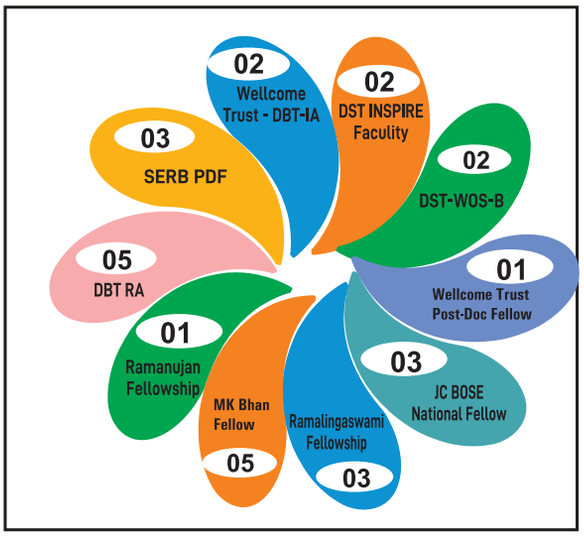


Academic and Training Activities

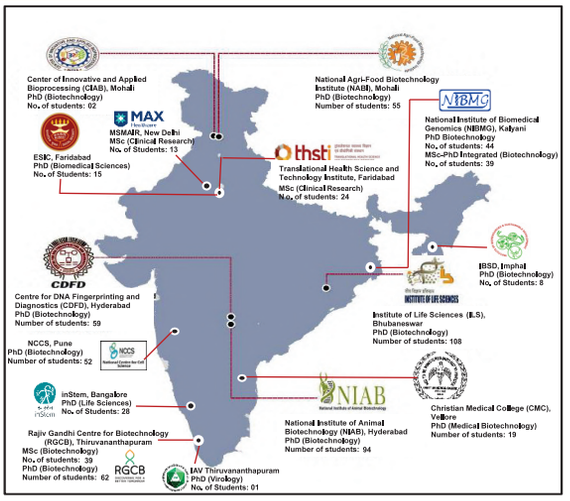




Awards and Fellowships



RCB Recognized Centres

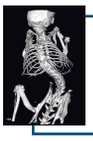


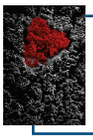
Total number of students registered at RCB: 661

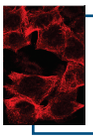
Date	Events Organized
27-29 April 2023	14th AFOB Regional Symposium
14 to 29 September 2023	Hindi Pakhwada 2023
15 September to 2 October 2023	Swachhata Pakhwada 2023
27 October 2023	Workshop on 'Basics to Create Successful Bioenterprise'
30 October 2023 to 5 November 2023	Vigilance Awareness Week 2023
7 November 2023	Panel Discussion on 'Mobilising Biotechnology for Clean Air'
12 December 2023	2nd Convocation Ceremony 2023
5 June 2023 to 4 July 2023	Summer Research Internship Programme Facilitated by Gujarat State Biotechnology Mission GSBTM)
28 February 2024	National Science Day 2024
1 March 2024	RCB Foundation Day 2024
8 March 2024	International Women's Day 2024

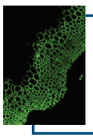
Research Areas

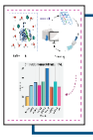

Structural Biology


Molecular Medicine


Infectious Disease Biology


Cancer & Cell Biology


Plant Biotechnology

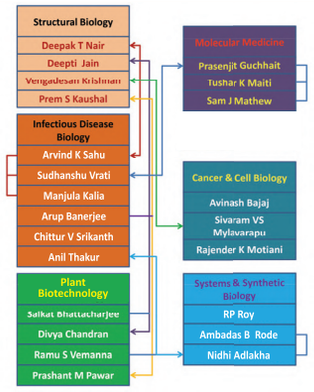

Systems & Synthetic Biology

Publications : 76
Patent Filed : 02

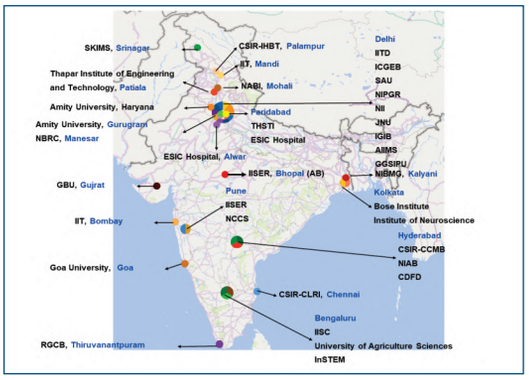
Research Highlights

- **2.8 Å cryo-EM structure of the mycobacterial 70S ribosome in complex with ribosome hibernation promotion factor RafH revealed the molecular mechanism of mycobacterial survival under hypoxia stress, which is quite different from other eubacteria.**
- Nucleolin, a cellular protein, interacts with the Japanese encephalitis virus NS5 protein and the G-quadruplex forming sequence in the viral genome. This interaction enhances the virus replication.
- **The active open-lid form of sortase from S. sanguinis was captured. Its crystal structure showed how the enzyme recognizes substrates. Structure-based virtual screening identified potential inhibitors that could block pili formation to control oral biofilm growth and infection.**
- Developed the first mouse model to understand and treat rare genetic diseases caused by mutations in the MYH3 gene. The YAP signalling pathway was upregulated upon loss of Myh3 function, and inhibitors of the YAP pathway rescued the abnormalities exhibited by Myh3 knockouts.
- Characterized the function of the Myh8 gene, mutations in which leads to congenital diseases such as Trismus-pseudocamptodactyly. It was revealed that Myh8 is required for proper skeletal muscle differentiation, metabolic properties and regeneration.
- Identified TLE3, the Wnt-pathway and KMT1A as excellent drug targets to treat rhabdomyosarcoma tumors. A novel interaction between the corepressor TLE3 and the histone methyltransferase KMT1A underlies target gene repression and inhibition of differentiation in rhabdomyosarcoma.
- A panel of autophagy-inducing FDA drugs were tested for antiviral and anti-inflammatory effects in the animal model of Japanese encephalitis. Two antipsychotic phenothiazine drugs: Methotrimeprazine & Trifluoperazine showed reduced neuroinflammation and significant survival benefit. These drugs have the potential to be repurposed as antivirals for the treatment of JE.
- One of the study provided evidence that dengue virus serotype-2 can influence the myeloid cell differentiation in the bone marrow to produce a more immature sub set of neutrophils than a mature subset as a response to acute inflammation and have significant impact on disease pathogenesis
- Demonstrated that the neutrophil– dengue virus interaction modulates the phenotype of neutrophils and releases prosurvival and antiviral secretome, underscoring the complex role of neutrophils in exacerbating dengue pathology.

Intra-institutional collaborations



National Collaborations



International Collaborations

Infrastructure and Support Services

Advanced Technology Platform Centre

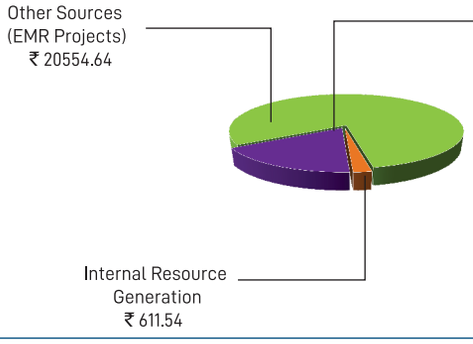
Biosafety Support Unit

BSC BioNEST BioIncubator

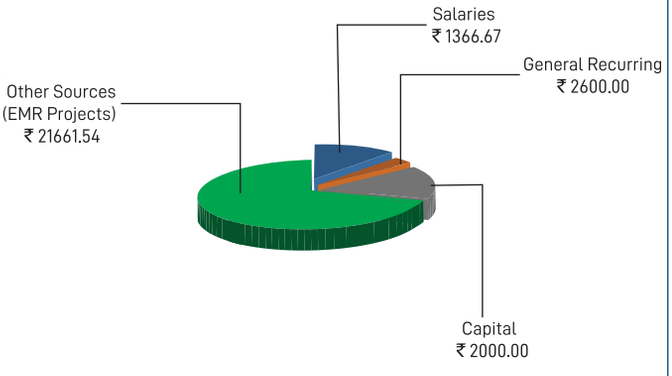
IBDC & DBT HRD-PMU

Financial Figures

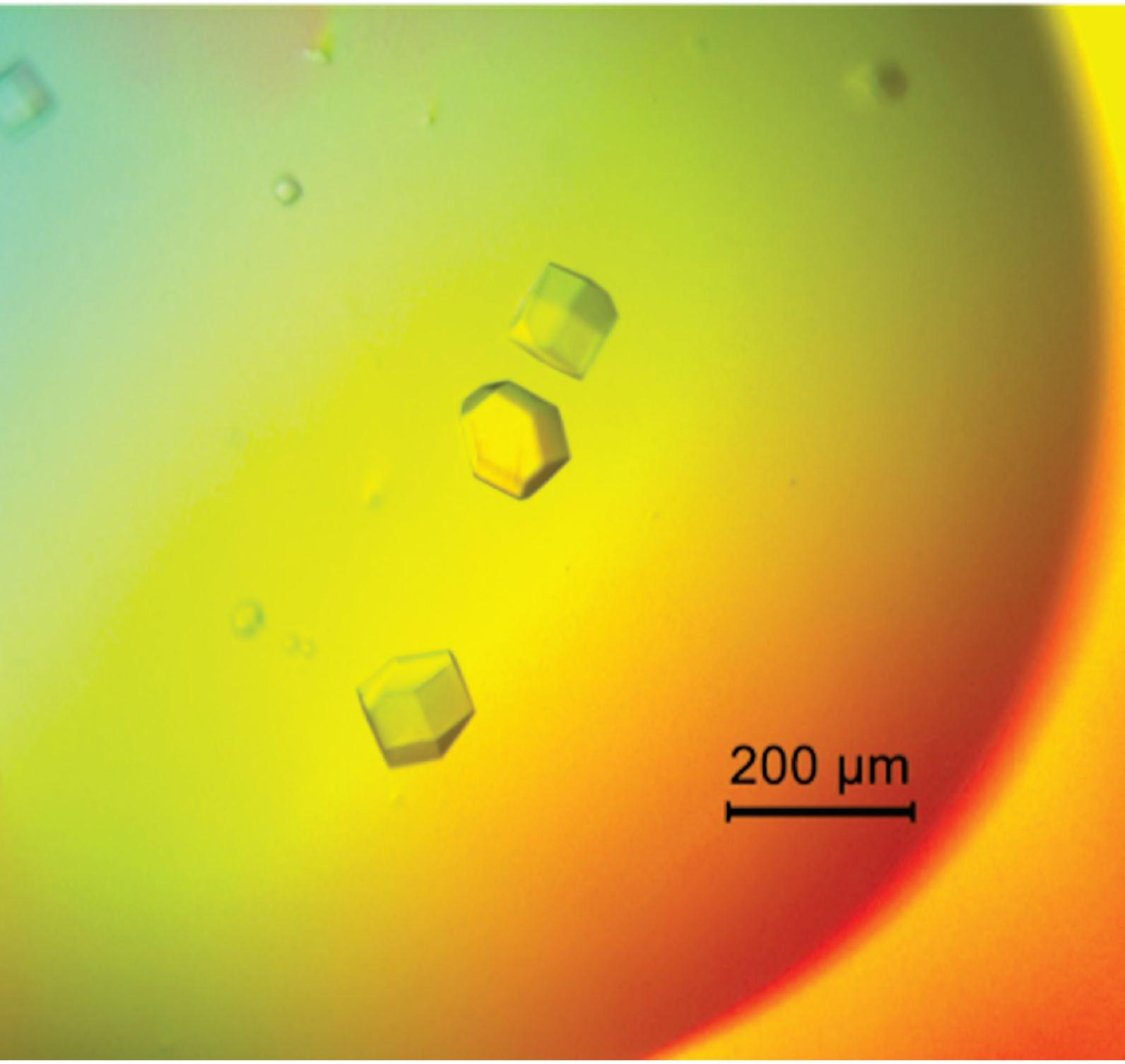
Total Income (Rs. In lakhs) 2023-2024



Total Expenses (Rs. In lakhs) 2023-2024



SCIENTIFIC REPORTS



Structural Biology

Photo Credit: Vengadesan Krishnan

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Thangaraj V
Bhawna Mawri
Ritika
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Dhiraj Kumar

Project Staff

Sunil Kumar Yadav
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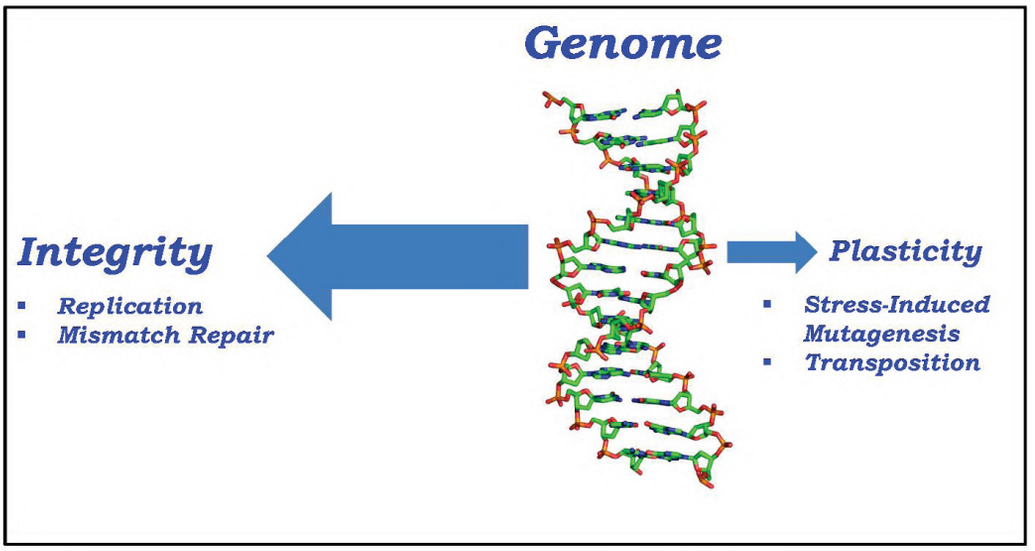
Namadurai Sivakumar
Amit Rathour

Molecular Determinants of Genomic Integrity and Plasticity

For all cellular processes to function optimally, the integrity of the genome has to be maintained. Conversely, plasticity in the genome can relieve selection pressures imposed by an adverse environment. These two conflicting requirements have led to the presence of molecules and pathways that either prevent or facilitate changes in the genome. In the case of pathogenic bacteria and viruses, genomic plasticity is implicated in the onset of drug resistance and reduction in vaccine efficacy. We aim to elucidate the structural mechanisms utilised by different molecular determinants of genomic integrity and plasticity to achieve function. Within this broad aim, the biological processes under scrutiny in our laboratory are DNA replication, Mismatch Repair, Stress-Induced Mutagenesis, RNA virus genome replication and Transposition. The insight from our studies sheds light on how organisms evolve and provides a robust platform for developing novel therapeutic strategies against pathogenic bacteria and viruses.



DNA Replication

DNA-dependent DNA polymerases (dPols) are the primary enzymes responsible for the accurate duplication of the genome. Also, errors that appear during DNA synthesis by dPols give rise to mutations that fuel evolution. Based on structure and sequence, these enzymes are classified into seven families- A, B, C, D, X, Y and RT. We study different dPols from diverse organisms to understand the chemical mechanisms utilised by these enzymes to achieve their role in replication and evolution.

In A-family DNA polymerases (dPols), a functional 3'-5' exonuclease activity is known to proofread newly synthesised DNA. The identification of a mismatch in substrate DNA leads to the transfer of the primer strand from the polymerase active site to the exonuclease active site. To shed more light regarding the mechanism responsible for detecting mismatches, we have utilised DNA polymerase 1 from *Aquifex pyrophilus* (ApPol1). The enzyme synthesised DNA with high fidelity and exhibited maximal exonuclease activity with DNA substrates bearing mismatches at the -2 and -3 positions. The crystal structure of apo-ApPol1 was utilised to generate a computational model of the functional ternary complex of this enzyme (Fig. 1A). The analysis of the model showed that N332 forms interactions with minor groove atoms of the base pairs at the -2 and -3 positions (Fig. 1B). The majority of known A-family dPols show the presence of Asn at a position equivalent to N332. The N332L mutation decreased the exonuclease activity for representative purine-pyrimidine and pyrimidine-pyrimidine mismatches at -2 and -3 positions, respectively. Overall, our findings suggest that conserved polar residues located towards the minor groove may facilitate the detection of position-specific mismatches to enhance the fidelity of DNA synthesis.

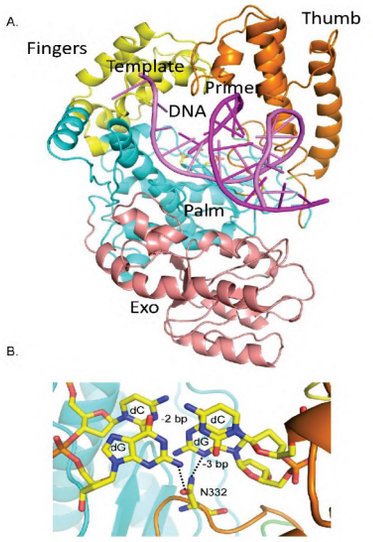
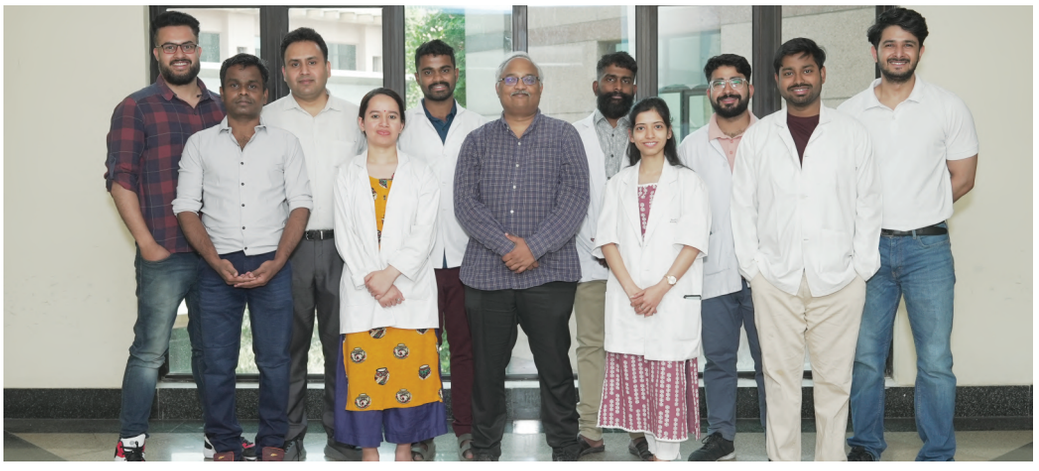


Figure 1: Computational model of ApPol1 in complex with DNA. A) The model of ApPol1 bound to DNA was prepared using the structure of the binary complex of Taq DNA polymerase 1 (3KTQ) as a template (B) The model suggests that the N332 residue forms interactions with the minor groove atoms of the primer nucleotide at the -2 and -3 position.

A database of experimental-derived cellular toxicity information for potential drug molecules

In the last four years, we have started using computational drug discovery tools to identify candidate lead molecules that inhibit target proteins in pathogens to develop novel therapeutic strategies. However, we observed that many drug discovery exercises fail because small molecules that are effective inhibitors of target proteins exhibit high cellular toxicity. Early and effective assessment of toxicity and pharmacokinetics is essential to accelerate the drug discovery process. Conventional methods for toxicity profiling, including *in vitro* and *in vivo* assays, are laborious and resource-intensive. In response, we developed the Small Molecule Cell Viability Database (SMCVdb), a comprehensive resource containing toxicity data for over 24,000 compounds obtained through high-content imaging (HCI). SMCVdb seamlessly integrates chemical descriptions and molecular weight data, offering researchers a holistic platform for toxicity data, aiding compound prioritisation and selection based on biological and economic considerations.

Data collection for SMCVdb involved a systematic approach combining HCI toxicity profiling with chemical information and quality control measures to ensure data accuracy and consistency. The user-friendly web interface of SMCVdb provides multiple search and filter options, allowing users to query the database based on compound name, molecular weight range, or viability percentage. SMCVdb empowers users to access toxicity profiles, molecular weights, compound names, and chemical descriptions, facilitating exploring relationships between compound properties and their effects on cell viability. The database provides experimentally derived cellular toxicity information for over 24000 drug candidate molecules to academic researchers and pharmaceutical companies. The SMCVdb will keep growing and will prove to be a pivotal resource to expedite research in drug discovery and compound evaluation.



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Structural Biology of Host-Microbial Interactions in Health and Diseases

Microbial attachment to the host surfaces is the first step in colonization. Subsequent events in the pathogenesis or probiosis depend highly on the initial interaction. Targeting the host-microbial interface is an attractive approach for improving health and combating infections. Since this approach does not directly kill bacteria, it may also serve as an alternative to antibiotics, which often results in the development of resistance. However, such an anti-adhesive approach requires detailed knowledge of how microbes attach to the host and how the adhesive strategies differ among microbes. To provide the essential foundations for this approach and understand how microbes adhere to and interact with the host surfaces, we aim to generate structural knowledge by studying key molecules that establish the initial contacts between the host and microbes. We currently focus on hair-like surface organelles (pili) mediating the initial contact with the host surfaces for colonization and biofilm formation.

Our ongoing structural investigation programme covers beneficial and pathogenic strains to obtain insights into tissue tropism and microbial interaction strategies in health and diseases.

Beneficial strains from gut microbiota

The most conventional probiotics are lactic acid bacteria (LAB) from the genera *Ligilactobacillus*, *Lactococcus*, and *Bifidobacterium*. Pili from LAB play a crucial role in adherence, persistence, and beneficial health effects. We have chosen a few representative LAB strains to understand pilus structures, assembly, and pili-mediated interaction with the host. Our previous work on *L. rhamnosus* GG revealed new insights about pilus shaft formation and pili-mediated lectin-type interaction with mucin, and we have recently purified its pili to visualize the whole architecture.

L. ruminis, an autochthonous member of the indigenous microbiota present in the gut of humans and animals, assembles pilus with three pilins (LrpA, LrpB, and LrpC). The *L. ruminis* pilus binds to various intestinal surface components such as collagen and fibronectin but lacks mucus binding. We have recently determined the crystal structures of *L. ruminis* pilins. Interestingly, the LrpA structure reveals three immunoglobulin(Ig)-like domains in bent conformations different from previously known shaft pilin structures and indicates the possibility of forming a distinct dynamic pilus shaft. The LrpB structure shows two Ig-like domains again in a bent conformation. The LrpC structure consists of seven Ig-like domains. Our ongoing structural analysis will provide more insights into pilus assembly and receptor binding.

L. lactis, the best-characterized and most widely used LAB strain in dairy fermentation and biotechnological applications (e.g., delivery of oral vaccines), uses three pilins to assemble and achors pilus with pilus-specific and housekeeping sortases, respectively. While our previous work on sortases provided insight into substrate recognition, purification of pilins and pili is in progress for their structural characterization. We also purified pilins from a bifidobacterial strain for structural and functional comparison.

Pathogenic strains from the oral cavity

The oral cavity harbours the second most abundant microbiota after the gut. Certain bacteria (primary colonizers) stick to the surfaces of the oral cavity through their pili and provide attachment sites for other bacteria (secondary colonizers) to develop oral biofilms (plaque). The attachment of primary colonizers and their coaggregation promote the growth of plaque, which can lead to many oral diseases (e.g., caries, gingivitis, and periodontitis) and infective endocarditis. Our previous work on the PI-2 heterodimeric pilus from *S. oralis* has revealed insights into pilus assembly and pili-mediated coaggregation in dental plaque formation. We have recently purified and characterized pilus-specific sortase (SrtC) from another primary colonizer, *S. sanguinis*. In contrast to PI-2 pilus, the SrtC catalyzes the

heterotrimeric pilus polymerization with three subunits. Since SrtC catalyzes the pilus polymerization for mediating attachment with the host and other bacteria, inhibiting its activity is a promising approach to control dental plaque and infection (Fig. 1). Our recent SrtC crystal structure showed a compact β-barrel fold consisting of eight β-strands arranged in an anti-parallel manner and flanked by three α-helices (Fig. 2). Residues Cys209, Arg218, and His147 constitute the active site. The SrtC structure revealed an open-lid conformation lacking a conserved DPX motif. We identified the substrate-binding residues essential for pilin recognition and pilus assembly based on molecular docking and structural analysis. We also demonstrated that zinc significantly reduces the activity while SrtC is enzymatically active toward the LPNTG sorting motif peptide of the pilins. We further showed that rutin and α-crocin are potential candidate inhibitors of the SrtC via structure-based virtual screening and inhibition assays.

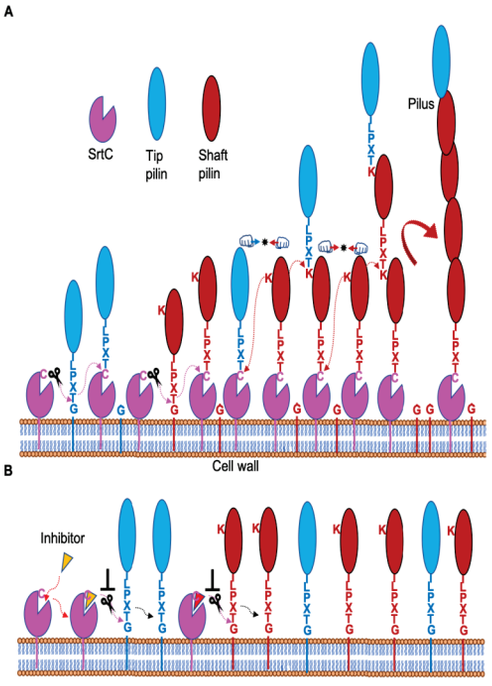

Figure 1: Schematic representation of targeting sortase-mediated pilus assembly. (A) SrtC-mediated pilus polymerization. SrtC cleaves the LPXTG sorting motif of pilins and forms an intermediate. A nucleophilic attack from the amino group of lysine of an adjacent pilin on the intermediate results in an amide bond formation between pilins. Repeated SrtC cleavage and subsequent nucleophilic attacks generate pilus by covalently linking pilins. (B) Inhibiting SrtC activity to prevent pilus assembly.

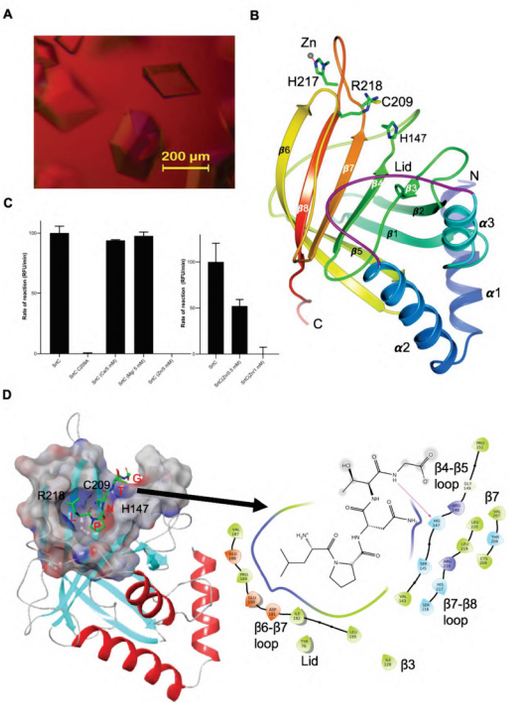

Figure 2: Structure-function analysis of SrtC. (A) SrtC crystal. (B) Crystal structure of SrtC in ribbon diagram with blend through color (blue: N-terminal and red: C-terminal) showing the eight-stranded β barrel and three αhelices. Catalytic triad (sticks), Zn (sphere), and lid (magenta) are shown. (C) The FRET-based assay shows reduced SrtC activity in the presence of Zn. (D) A 2D representation showing interaction of the SrtC active site pocket (electrostatic surface) with the LPNTG (sticks).

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Transcription Regulation: Structure and Mechanism

Pseudomonas aeruginosa, a gram-negative, opportunistic human pathogen, is listed as a "critical" category pathogen in the DBT priority list of antibiotic-resistant bacteria. A significant contribution to the persistence of *P. aeruginosa* is due to its ability to transition from a motile to a biofilm mode of life. This phenotypic transition is regulated at the transcription level, the pivotal regulatory checkpoint for gene expression in bacteria. We employ an integrated approach involving structural tools, biophysical techniques, biochemical methods, and functional *in vivo* assays to investigate the molecular mechanisms of transcription regulation of flagellar and biofilm genes in *P. aeruginosa*. The mechanistic insights obtained are exploited to discover novel therapeutic agents against *P. aeruginosa*.

Structural Insights into Late Flagellar Genes Expression

The pathogenic bacteria *P. aeruginosa* uses external appendages, such as flagella, for motility to move towards favorable environments and away from unfavorable ones. Additionally, adhesion and invasion of the lung epithelial cells by *Pseudomonas aeruginosa* during infection depends on its flagella. Loss of flagella results in a reduction in motility with a consequent decline in adhesion and invasion by this organism. Therefore, understanding the intricate regulatory mechanisms governing bacterial flagellar assembly is pivotal in unraveling the details of bacterial motility and pathogenesis (Fig. 1). The assembly of the bacterial flagella is regulated through a four-tiered transcriptional hierarchy. Central to the regulation of flagellar assembly is the protein FliA, a master regulator of the expression of late flagellar genes. The FliA, also called as the alternate sigma factor, associates with core RNA polymerase to drive the transcription of class four flagellar genes. However, the activity of FliA depends on its interaction with its cognate anti-sigma factor, FlgM, which is an agonist of FliA. Upon assembly of the basal body of the flagella, FlgM is exported out of the bacterial cells, resulting in the activation of FliA and transcription of late flagellar genes. We have obtained high-resolution structural details of the FliA-FlgM complex, which sheds light on the dynamic interaction of FliA with FlgM and RNA polymerase. The structure reveals that the FliA adopts a compact conformation when bound to FlgM such that the promoter binding sites are buried (Fig. 2). The structure also reveals that FliA must undergo large-scale conformational changes in order to interact with RNA polymerase upon release of FlgM.

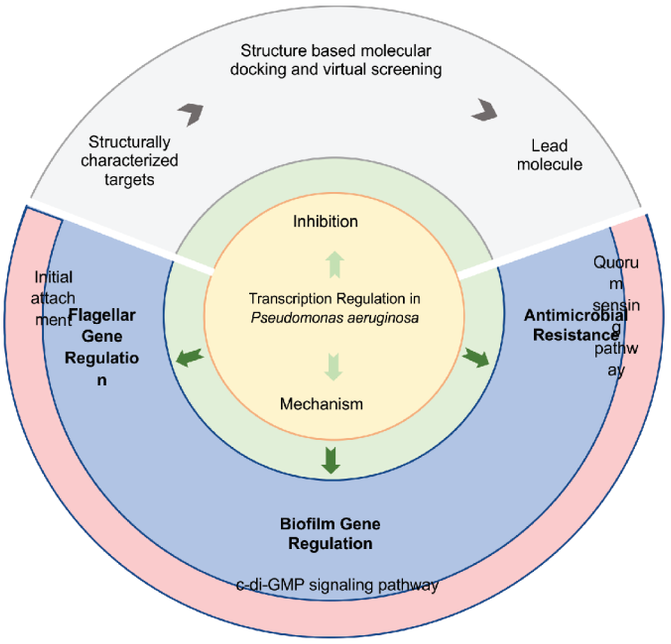

Figure 1: Transcription Regulation: Structure and Mechanism

We have deciphered the molecular mechanisms underpinning the regulation of late flagellar gene expression, paving the way for the development of novel antimicrobial strategies targeting bacterial motility and pathogenesis. The structural data provide atomic details of the conformational changes underlying protein-protein recognition and offer

valuable clues for designing therapeutic interventions targeting bacterial motility and virulence.

Inhibition of Pseudomonas aeruginosa Biofilms

Pseudomonas aeruginosa causes acute and chronic infections that are hard to treat. The persistence of *P. aeruginosa* is due to its ability to develop into biofilms, which are sessile bacterial communities attached to substratum and encapsulated in matrix consisting of layers of self-produced exopolysaccharides. The biofilms provide enhanced protection from the host immune system and resilience towards antibiotics, which poses a challenge for treatment. The current remediation approaches offer some hope for clinical usage. However, the treatment and eradication of pre-formed biofilms is still challenging. Thus, identifying novel targets and understanding the detailed mechanism of biofilm regulation becomes imperative.

We have identified small molecule inhibitors of transcription factor FleQ, a master regulator of biofilm formation in *P. aeruginosa.* We have performed *in-silico* screening of small molecule libraries using the crystal structure of FleQ, which was determined in our lab as the target. Amongst the selected compounds, five molecules have been identified that inhibit the ATPase activity of FleQ and demonstrate better than 50% reduction in biofilm formation. Additionally, we have determined the crystal structure of one of the inhibitors in a complex with the transcription factor. The inhibitors bind to a cavity very close to the ATP binding site, interacting with residues common to ATP binding. Simultaneously, we have also screened commercially available chemical compound libraries of small molecules against FleQ for biofilm inhibition. 8 molecules have been identified that demonstrate 50% reduction in biofilm formation. Further validation of these compounds is in progress. Additionally, in collaboration with Prof. Khare at IITD, we have identified bioactive secondary metabolites produced by rare actinomycetes, *Nocardiopsis lucentensis,* in a halophilic environment. These metabolites were shown to exhibit anti-biofilm properties and eradicate preformed biofilms of *P. aeruginosa*. We established that these compounds target the quorum-sensing cascade in *P. aeruginosa*.

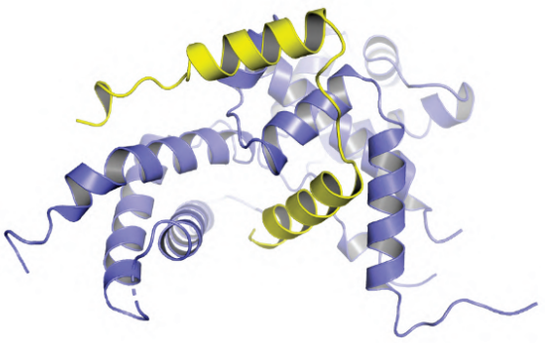

Figure 2: Crystal structure of Sigma (purple)/Anti-Sigma (yellow) complex

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Structural Aspects of Translation Regulation in the Pathogenic Microbes and Drug Design

Translation, the protein synthesis, in which genetic information present in mRNA is decoded into a polypeptide, occurs on the ribosome in all cells. Protein synthesis is one of the most energy-consuming cellular processes, consumes nearly half of the cell's energy, and the ribosome is a target of nearly 40% of known antibiotics. Our research focuses on protein synthesis, and ribosome assembly in pathogenic microbes, mainly *Mycobacterium tuberculosis*, which causes the deadliest disease, tuberculosis, and *Entamoeba histolytic*, which causes bloody diarrhea. We apply structural biology tool; cryo-electron microscopy, with molecular biology and biochemistry techniques to address research questions (Fig. 1), and a structure-based drug design platform for inhibitor design.

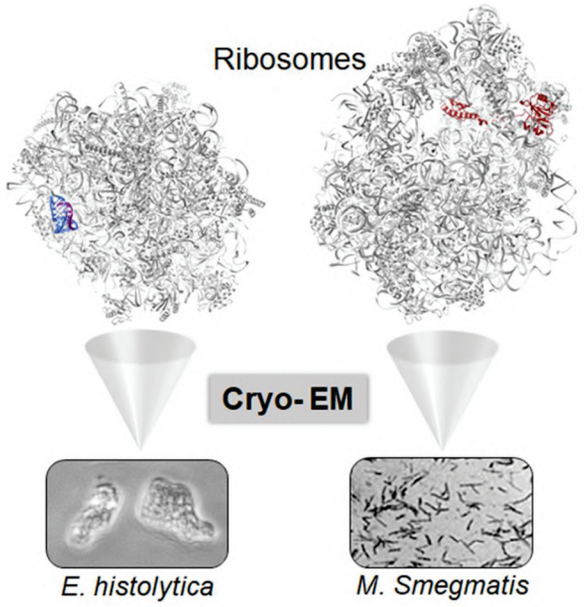

Figure 1: Our laboratory's overall research theme. The Entamoeba histolytica and Mycobacterium smegmatis are shown in grey color, major research tool used is Cryo- EM. (top left) recent cryo- EM structure from E. histolytica ribosome containing rRNA triple helix shown in blue & purple color. (top right) M. smegmatis 70S ribosome with hypoxia induced stress factor, RafH (red) are shown.

Protein synthesis in pathogenic protozoan *Entamoeba histolytica*

Entamoeba histolytica (Eth) is an anaerobic parasite responsible for amebiasis, an intestinal infection that results in bloody diarrhea and liver abscesses. Amoebiasis is more predominant in tropical areas with poor sanitation, including India. Therefore, amoebiasis puts a huge economic burden on our country. One of the first-line drugs used to treat amoebiasis, 'paromomycin,' targets the ribosome. However, these drugs have their own side effects and cell toxicity, and the drug resistance strains of Eth are also emerging. We aim to determine the high-resolution cryo- EM structure of Eth ribosome and identify its protozoan-specific unique features. This project is being carried out in collaboration with Prof. S. Gourinath's laboratory at JNU, New Delhi.

We have reported first Eth ribosome structures isolated from its disease-causing trophozoites stage, determined using single-particle cryo-EM. The 53S ribosome large subunit is resolved overall at 2.8 Å resolution (Fig. 2), and the 75S associated ribosome overall 3.3 Å resolution. The high-resolution maps allowed us to build the atomic structure of the whole Eth ribosome. These structures report several *Entamoeba*-specific features, such as the rRNA triple helix near the peptide exit tunnel on LSU (Fig. 1) and the co-evolution of rRNA expansion segments and extensions in r-proteins. To the best of our knowledge, this structure reports the triple helical motif in ribosomal RNA for the first time (Fig. 1B-E).

This study opens a new avenue to thoroughly investigate protein synthesis in *Entamoeba,* which is vaguely understood, and to design novel amoebicidal drugs. We proposed that the rRNA triple helix might protect the Eth ribosome from RNAase. Further, experimental validation is in progress. We plan to reconstitute the functional complexes to understand Eth protein synthesis better. The bioinformatics analysis showed that Eth possesses fewer translation factors compared to its human counterpart, particularly the initiation factors. Therefore, the initial focus would be on Eth translation initiation complexes.

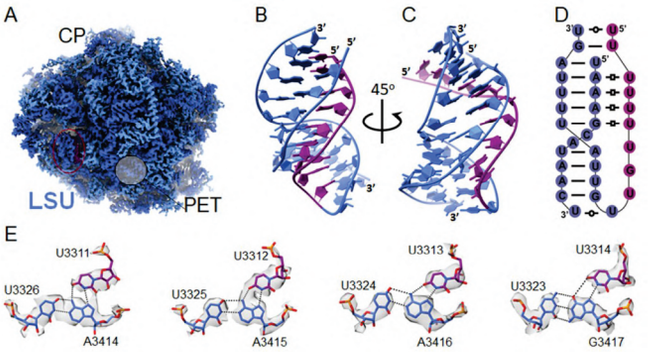

Figure 1: Cryo- EM structure of E. histolytica ribosome large subunit. *(A) The 2.8 Å resolution cryo- EM map of 53S ribosomal large subunit, rRNA (sky blue), r-proteins (royal blue), and third helix of rRNA triple helix (purple) are shown. (B and C) rRNA triple helix, Watson and Crick pairing helices (sky blue), and third helix interacting to the major groove (purple), backbone in ribbon, are shown. (D) A 2D diagram for triple helix color code and labeling is the same as for B and C. (E) four base triples that constitute the triple helix are shown in the sticks, and cryo-EM density is shown on the surface with 85% transparency.*

Understanding the translational strategy Mycobacterium tuberculosis adopts under different stresses.

Mycobacterium tuberculosis (Mtb) is the etiological agent of tuberculosis (TB), one of the most deadly bacterial diseases that remains a major health threat to the human race. The Mtb becomes dormant, non-replicating, and phenotypically drug-resistant while encountering multiple stresses within the host macrophages. This condition is known as latent tuberculosis infection (LTBI) or dormancy. LTBI affects about one-third of the world's population, with ~10% of those infected developing acute TB infection. Therefore, the latent Mtb infection serves as a reservoir for TB spread. Ribosome hibernation is a key survival strategy bacteria adopt under environmental stress, where a protein, hibernation promotion factor (HPF), transitorily inactivates the ribosome and slows its overall protein synthesis.

We reported a 2.8 Å resolution Cryo-EM structure of *M. smegmatis* 70S ribosome in complex with RafH protein. RafH is induced under hypoxia stress. The structure provided ribosome RafH interaction in atomic details, and we proposed that the RafH has a distinct mode of ribosome hibernation, and it inhibits protein synthesis by blocking the crucial sites for translation initiation on the ribosomal small subunit. RafH binding site also overlaps with the binding of the aminoglycoside class of antibiotics, which hints about its role in antibiotic resistance in LTBI. RafH also protects ribosomes from RNase attack.

Now, we have isolated ribosomes from *M. smegmatis* cells grown under hypoxia stress conditions, and astoundingly, we could see RafH bound to the ribosome in cryo- EM maps (manuscript under preparation). Further, we would like to verify our hypothesis by conducting RafH gene genetic knockout studies in collaboration with geneticists.

Besides hypoxia stress, our lab has isolated ribosomes from different stress and nutrition starvation, H_2O_2, low pH, and heat shock, and observed differences in sucrose density gradient fractionation peaks. Our preliminary mass spec studies showed a stress-specific factor binding to the ribosome. Further, we would like to get the atomic details of ribosomes in different stress conditions and understand how ribosomes are protected under different stresses.

Molecular Medicine

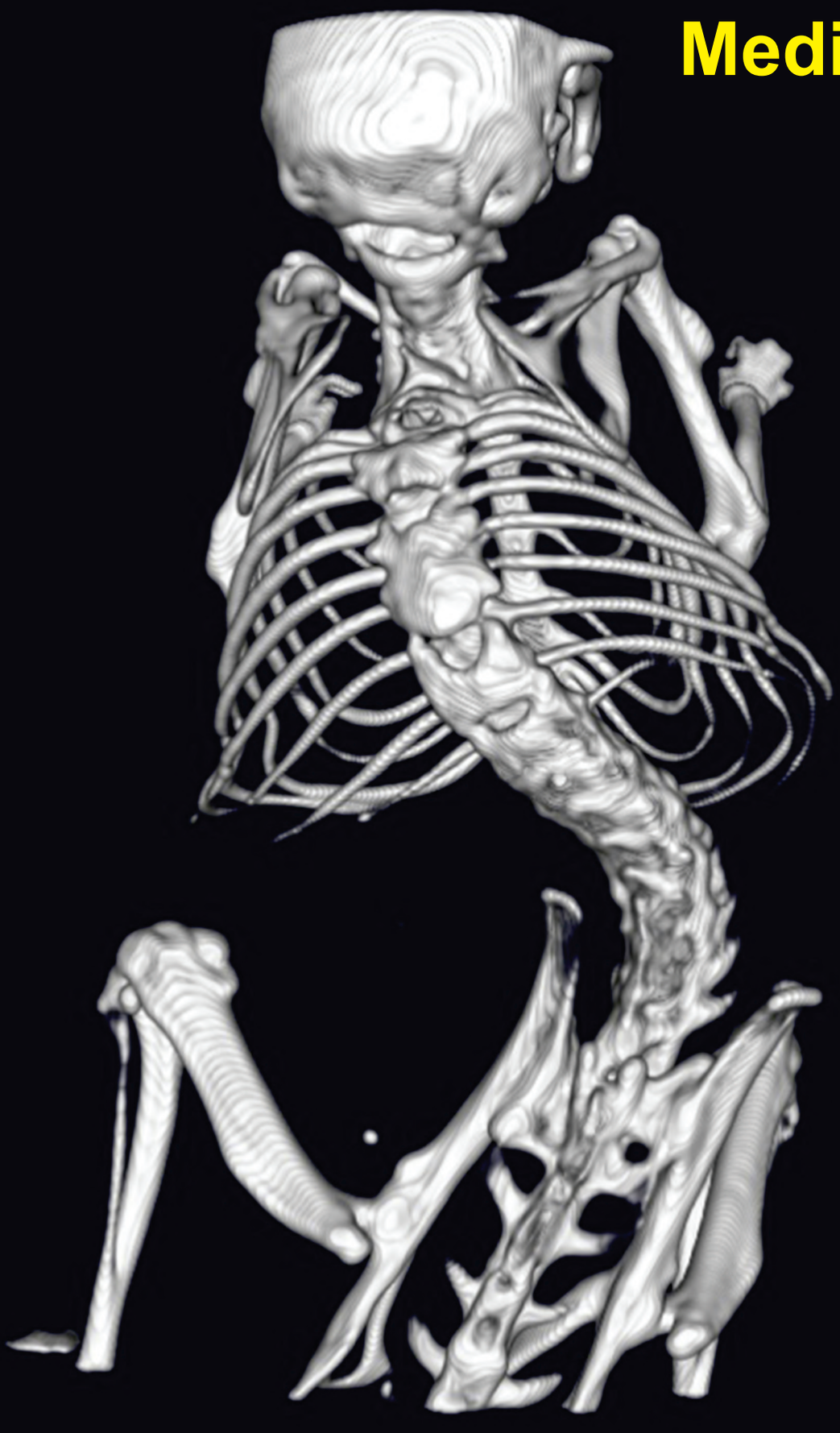

Photo Credit: Sam J Mathew

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Thrombosis, Inflammation and Immune Response in Human Health and Diseases

Major research programme focuses on studying molecular signaling of thrombosis, inflammation, and immune responses in human health and diseases, and identifying biomarkers and molecular targets to develop potential therapeutics.

Dengue and JEV: Recently we reported that platelet factor 4 (PF4), chemokine secreted primarily from activated platelets, is highly elevated in viral infections including Japanese Encephalitis virus (JEV) and dengue virus (DENV). PF4 is pro-viral for both viruses. PF4 inhibits interferons (IFNs) synthesis, in turn helps in viral replication (Ojha *et al*, 2019). PF4 also inhibits autophagosome-lysosomal vacuole formation, in-turn helps in replication of both viruses (Singh *et al*. 2023a,b). We developed a small-molecule antagonist to CXCR3 (receptor of PF4) and described that compound 7D potently rescues mice from DENV2 infection by improving IFNs via PF4-CXCR3 axis; and also by increasing synthesis of DENV2-neutralizing IgM/IgG via Sirt1-STAT3 axis (Gaur *et al*. 2024). 7D turns out to be a promising drug candidate against DENV.

Another investigation focuses on **severity of dengue in case of secondary infection**. Studies have shown that the sub-neutralizing antibodies from the previous infection allows the virus to successfully enter the monocytes by binding to Fc receptors and evade the host antiviral responses. We also found changes in the expression levels of FcγR-IIB (Inhibitory Fc receptor) in T and B cells in secondary dengue infection. We are currently exploring the above mechanism using mice models and patients' sample

COVID-19: We investigated the mechanism of inflammation and clot formation in the lungs of SARS-CoV-2 infected mice/hamsters. We used dietary supplementation with a common metabolite of Krebs cycle, namely α-Ketoglutarate (αKG), to reduce inflammation and viral load in lungs by suppressing HIF1α and P-Akt, and improve animal survivability. Further, we describe the mechanistic insights in the severity of lung inflammation in SARS-CoV-2 infected mice with diabetic background (both type 1 and type 2 diabetes). The dietary supplementation with anti-diabetic drug metformin along with αKG improved IFN synthesis by suppressing HIF1α axis, and decreased SARS-CoV-2 infection in both T1D/T2D mice. Furthermore, patients data showed improved IFN synthesis and lesser COVID-19 severity in T2D patients taking higher doses of metformin (Joshi et al. 2024, in communication). Our study thus suggest the usage of metformin against COVID-19 in diabetic patients.

Besides, we are exploring the therapeutic potential of dietary αKG to alleviate pulmonary inflammation and fibrosis in a murine model of **SARS-CoV-2-induced ARDS**. Our study shows that 1% αKG supplementation till fifteen days post-infection significantly reduced SARS-CoV-2 infection and decreased markers of inflammation and fibrosis, such as surfactant proteins B and C. SARS-CoV-2 triggers epithelial to mesenchymal transition (EMT), a key factor in persistent fibrosis in ARDS. Notably, αKG supplementation effectively counteracts EMT by lowering P-AKT and TGF-β levels, reducing ZEB-1 levels and mesenchymal state. Although our research is ongoing, we believe αKG holds promise as a therapeutic agent against SARS-CoV-2-induced ARDS.

Diabetes: The db/db mice with a chronic T2D phenotype or patients with T2D with recurrent cardiovascular disease (CVD) symptoms displayed an elevated systemic inflammation and increased pro-thrombotic phenotype. The T2D mice displayed chronic lung inflammation, which was further rescued by dietary αKG supplementation, suggesting a potential therapeutic role of αKG against thrombo-inflammation and CVD in T2D (Agarwal et al. 2023a). In another work, using proteome data of T2D/health platelets, we described that N-linked glycosylation of CD36, glycoprotein on platelet surface, responsible for up taking oxidized-LDL from plasma, causing hyperactivation of platelets in T2D. An antagonist to CD36, sulfo-N-succinimidyl oleate, could potentially inhibit the above mechanism, in turn rescue platelet activation, Fig. 1 (Agarwal *et al*. 2023b).

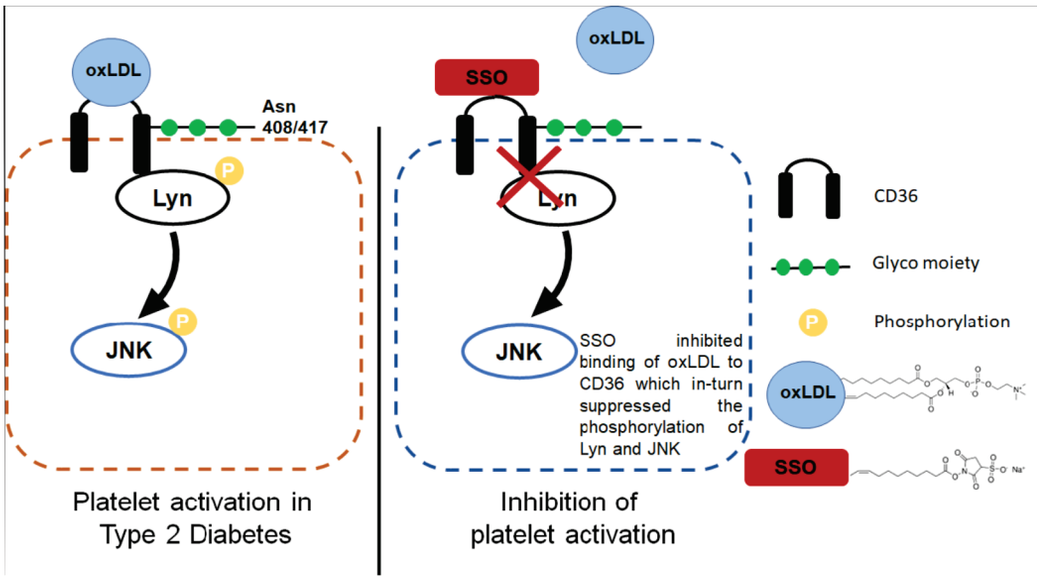

Figure 1: *Schematic describes that the elevated N-linked glycosylation of CD36 at asparagine (Asn)^{408,417} in platelets of T2D patients is a risk factor for platelet activation in diabetes. Oxidized-LDL, which exists in high level in T2D patients' plasma, significantly activated platelets via CD36:Lyn:JNK pathway. An inhibitor to CD36, namely SSO reduced the oxLDL-mediated platelet activation. LDL cholesterol preferably bound glycosylated CD36 at Asn^{417} as compared to non-glycosylated form (Agarwal et al. 2023b).*

High altitude pulmonary edema: Recently, we have shown that the Tibetan specific mutations in prolyl hydroxylase-2 (PHD2, gene EGLN1), known as PHD2D4E/C127S protects these highlanders form hypoxia-triggered inflammatory response and related symptoms like high altitude pulmonary edema (HAPE, Bhattacharya S et al, 2021). Further, our study describes that PHD2D4E;C127S monocytes displayed protection against DENV2 infection by suppressing HIF1α, in-turn promoting IRF-3/7/9 and IFNα/β expression in hypoxia (3% O2). But PHD2WT monocytes elevated HIF1α and suppressed IRFs and IFNα/β, in-turn increased DENV2 infection in hypoxia. Interestingly, under normoxia (21% O2), PHD2D4E;C127S cells increased HIF1α and decreased IRFs/IFNs, in-turn increased DENV2 infection. Infection with SARS-CoV-2 had the similar response pattern to DENV2. Therefore, our study describes a unique crosstalk of PHD2D4E;C127S variant with HIF1α-IFN axis under environmental pO2 in protecting or predisposing Tibetans to viral infections (Ghosh et al. 2024, in communication).

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Investigating Proteomic Biomarkers for early Prediction of Pregnancy Complications

Preterm birth stands as a significant global public health challenge, representing the primary cause of neonatal mortality. India accounts for approximately a quarter of global preterm births and related deaths. From a clinical standpoint, comprehending the molecular mechanisms underlying preterm birth is imperative for its early prediction and prevention. RCB collaborates with THSTI, NIBMG, Gurugram General Hospital, and several other institutions for the Inter-institutional Advanced Research on Birth Outcome-DBT India Initiative (GARBH-Ini), with our team taking the lead in the proteomics component. Moreover, our involvement in the global Multi-Omics for Mothers and Infants (MOMI) Consortium allows us to address diverse inquiries related to pregnancy complications like preterm birth (PTB), Preeclampsia (PE), Gestational diabetes melilites (GDB) (GDM) and stillbirth. At the heart of our endeavors lies the overarching objective of pinpointing biomarkers crucial for the early detection of preterm birth (**Fig 1**).

Identification and verification of plasma proteome signature in spontaneous preterm birth

Preterm birth (PTB) is a significant cause of neonatal mortality and morbidity worldwide, with the Indian subcontinent contributing over 3 million preterm births annually. The GARBH-Ini cohort estimates the incidence of preterm births at approximately 13%. Early prediction of PTB can significantly reduce its incidence and associated burdens. More than 50% of PTB cases are spontaneous, with unknown underlying causes. Various proteomics studies have attempted to identify and validate protein markers in biofluids like plasma and high vaginal fluid, highlighting proteins such as fetal fibronectin, C-reactive protein (CRP), serum amyloid A, interleukins, insulin-like growth factor-binding protein 4 (IBP4), and sex hormone-binding globulin (SHBG). However, these studies are limited by low sensitivity, lack of external validation, small sample sizes, and relevance only to symptomatic pregnancies.

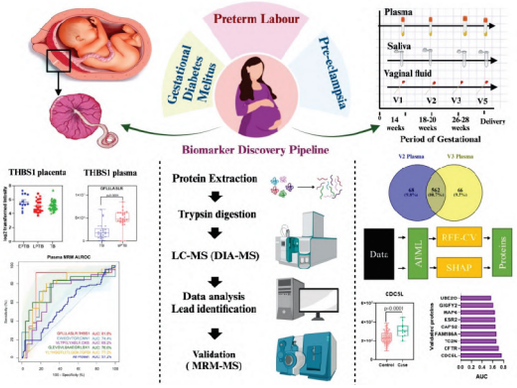


Figure 1: *Schematic diagram of proteomics biomarker discovery pipeline for pregnancy complications*

Our primary objective is to develop a comprehensive model for early (mid-trimester) risk stratification of mothers at risk of spontaneous preterm birth, facilitating timely medical intervention. To achieve this, we conducted a high-throughput comprehensive plasma proteomics study within the GARBH-Ini cohort using a nested case-control design. We selected 54 plasma samples from 27 pregnant women who delivered before 35 weeks of gestation, with plasma collected at 18-20 weeks (V2) and 26-28 weeks (V3) of gestation. Proteomics data were acquired from these samples using SWATH-MS mode. Data analysis was performed with Spectronaut and scikit-learn machine learning algorithms in Python, identifying and quantifying around 650 proteins in both V2 and V3 samples. PCA analysis showed partial separation of preterm and term birth at both time points. Differential expression analysis revealed about 90 upregulated and 23 downregulated proteins at V2, and 80 upregulated and 10 downregulated proteins at V3 (0.66>FC>1.5, p-value <0.05), with 59 differentially expressed proteins (DEPs) shared between the two time points. We used machine learning to identify significant proteins distinguishing case and control samples. Intensity data from V2 and V3 samples were analyzed using six classification models: SVM, DT, LR, KNN, GNB, and RF. Stratified K-fold cross-validation (K=5) ensured randomness, with models evaluated by mean accuracy, Jaccard score, and Matthew's correlation coefficient *(Fig. 2)*

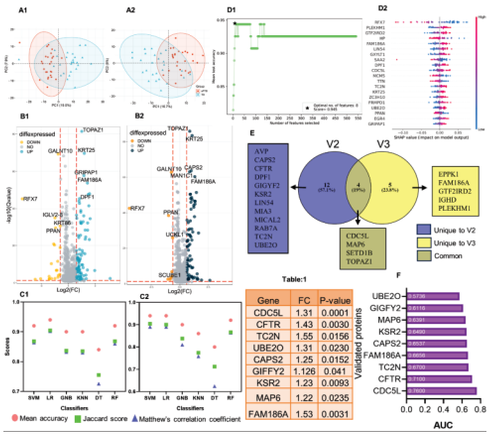
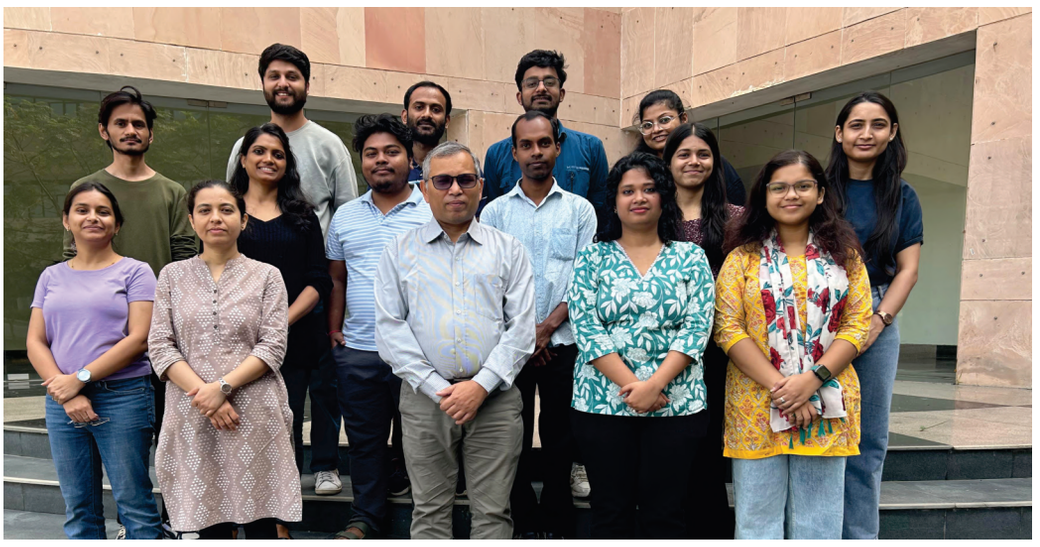


Figure 2: *A: Principal component analysis separating sPTB and TB samples in two partially overlapping clusters at both V2 (A1) and V3 (A2) time points with maximum variation at PC1 and PC2. B: Volcano plot indicating the differentially expressed proteins between sPTB and TB groups in V2 (B1) and V3 (B2) samples. C: Dot plot indicating the scores of different scoring matrices for six different ML based classifiers. D1: Representative mean accuracy plot for RFE-CV extraction algorithm indicating optimal number of features and accuracy score. D2: SHAP plot showing the top 20 extracted features/proteins with their impact on model output and feature value. E: Venny plot reveals the final set of proteins extracted using machine learning and feature extraction algorithms. 12 and 5 proteins were unique to V2 and V3 respectively, whereas 4 proteins were common in both groups. F: Bar plot indicating the ROC-AUC values of validated proteins. Table 1: List of validated proteins with their fold change and p value.*

We selected the top three models SVM, LR, and RF and further analyzed them using two feature extraction algorithms: Recursive Feature Elimination (RFE) and Shapley Additive Explanations (SHAP). In RFE, we extracted 8, 12, and 73 proteins at V2, and 5, 5, and 13 proteins at V3 using SVM, LR, and RF, respectively. With SHAP, we considered the top 20 features from each model at both time points. Overlapping these extracted proteins with the DEPs, we identified 42 and 29 common proteins at V2 and V3, respectively. These proteins were then verified using ^{HR}MRM-based targeted proteomics. The precursor and product ions corresponding to each protein were selected, and collision energy was calculated. The MRM method was optimized with pooled samples, verifying 42 proteins from V2 and 29 proteins from V3. Manual curation and statistical evaluation were conducted for each proteins. We verified eight proteins like CAPS2, EGR4, GXYLT1, PPAN, MIA3, RAB7A, TC2N, and SPT2YD1 in V2, six proteins like GALNT10, IGHD, SPTY2D1, MATK, and MAP6 at V3, and two proteins, PLEKHM1 and SPTYD1, were successfully verified in the targeted mass spectrometry.

Considering 18-20 weeks of pregnancy (V2) as a critical time point, we focused our validation study at V2 to identify potential predictors of PTB. We conducted a validation study of 14 verified plasma proteins using targeted HR-MRM mass spectrometry-based relative quantitative workflow with a case-cohort study design in the GARBH-Ini cohort, with a sample size of 51 cases and 750 controls. Preliminary analysis of 230 samples (15 cases and 215 controls) demonstrated that CDC5L, FAM186A, TC2N, and CFTR could potentially discriminate term and preterm births with moderate AUROC (Fig 2). Our future studies aim to analyze the complete dataset and further develop a decision algorithm combining clinical and ultrasound imaging data.



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Signals that Regulate Skeletal Muscle Structure and Function

The skeletal muscle is the largest tissue in our body, essential for vital functions such as locomotion, support, posture maintenance, and regulation of whole-body metabolism. We are investigating the mechanisms that regulate skeletal muscle formation and controls its function. Skeletal muscle damage or injury occurs in accidents, during physical activity such as sports, or due to congenital diseases such as muscular dystrophy. Muscle stem cells also known as satellite cells, present in the skeletal muscle, help in its repair and regeneration. We are studying how skeletal muscle repair and maintenance occurs, identifying and characterizing genes involved in this process. We are also studying a cancer type called rhabdomyosarcoma, where the tumor cells exhibit properties of muscle cells, to identify signaling pathways that can be targeted for therapies to treat such tumors.

Myosin Heavy Chain-embryonic is required for normal adult muscle homeostasis

Mammalian adult skeletal muscle is crucial for locomotion, posture maintenance, support and metabolic regulation. Multinucleated, contractile myofibers are the major cell type making up the skeletal muscle. The myofibers contain sarcomeres, which are functional contractile units, composed of thin and thick filaments. Myosins are the contractile proteins that constitute the thick filaments, composed of different subunits, of which Myosin heavy chains (MyHCs) are the major subunit. Several MyHC isoforms exist, among which one, MyHC-embryonic encoded by the *Myh*3 gene, is expressed only during muscle development or during muscle injury and associated regeneration. Mutations in *MYH3* lead to human congenital musculoskeletal disorders such as Freeman-Sheldon and Spondylocarpotarsal Synostosis Syndromes. It is therefore vital to understand the functions of MyHC-embryonic using animal models, which will help develop strategies to treat such muscle disorders.

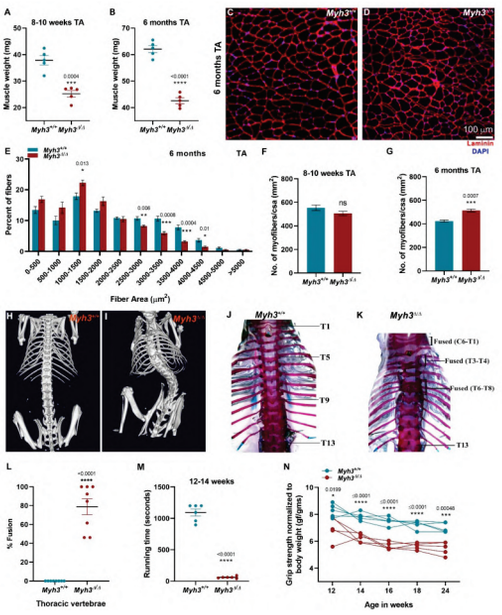


Figure 1: Loss of MyHC-embryonic leads to adult muscle and skeletal defects. *(A-B) Tibialis anterior (TA) muscle weight of control and Myh3 knockout mice. (C-D) Sections through control and Myh3 knockout mice TA stained for Laminin (red) and DAPI (blue). (E-G) Myofibers grouped according to size or normalized to area of control and Myh3 knockout mice. (H-I) MicroCT images of control and Myh3 knockout mice. (J-L) Skeletal preparations of control and Myh3 knockout mice and thoracic vertebral fusion. (M-N) Treadmill exhaustion and grip strength of control and Myh3 knockout mice.*

We generated *Myh3* germline knockout mice (*Myh3*$^{-/-}$) which lacked MyHC-embryonic expression. The individual muscle weight using the tibialis anterior (TA) muscle as a representative muscle, was reduced in the *Myh3*$^{-/-}$ mice at early (8-10 weeks) and late (6 months) adult time points (Fig. 1A-B). At the histological level, *Myh3*$^{-/-}$ mice exhibited an increase in smaller muscle fibers at 6 months of age (Fig. 1C-D). Upon quantification based on myofiber area, the proportion of smaller-sized myofibers were increased and larger sized myofibers decreased in *Myh3*$^{-/-}$ mice (Fig. 1E). The number of myofibers per unit area was unchanged in the 8-10 week old TA whereas it was increased at the 6-month time point in *Myh3*$^{-/-}$ mice (Fig. 1F-G). Scoliosis was observed in all *Myh3*$^{-/-}$ mice by 6-weeks of age, which persisted thereafter (Fig. 1H-I). Vertebral fusion was observed in *Myh3*$^{-/-}$ mice in the cervical, thoracic and lumbar regions, with severe intervertebral disc region reduction observed between fused vertebrae (Fig. 1J-L). At the level of muscle function, *Myh3*$^{-/-}$ mice exhibited significantly reduced treadmill running capability and grip strength (Fig. 1M-N).

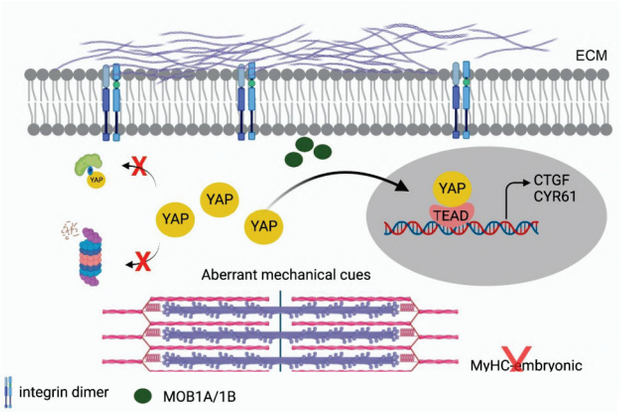


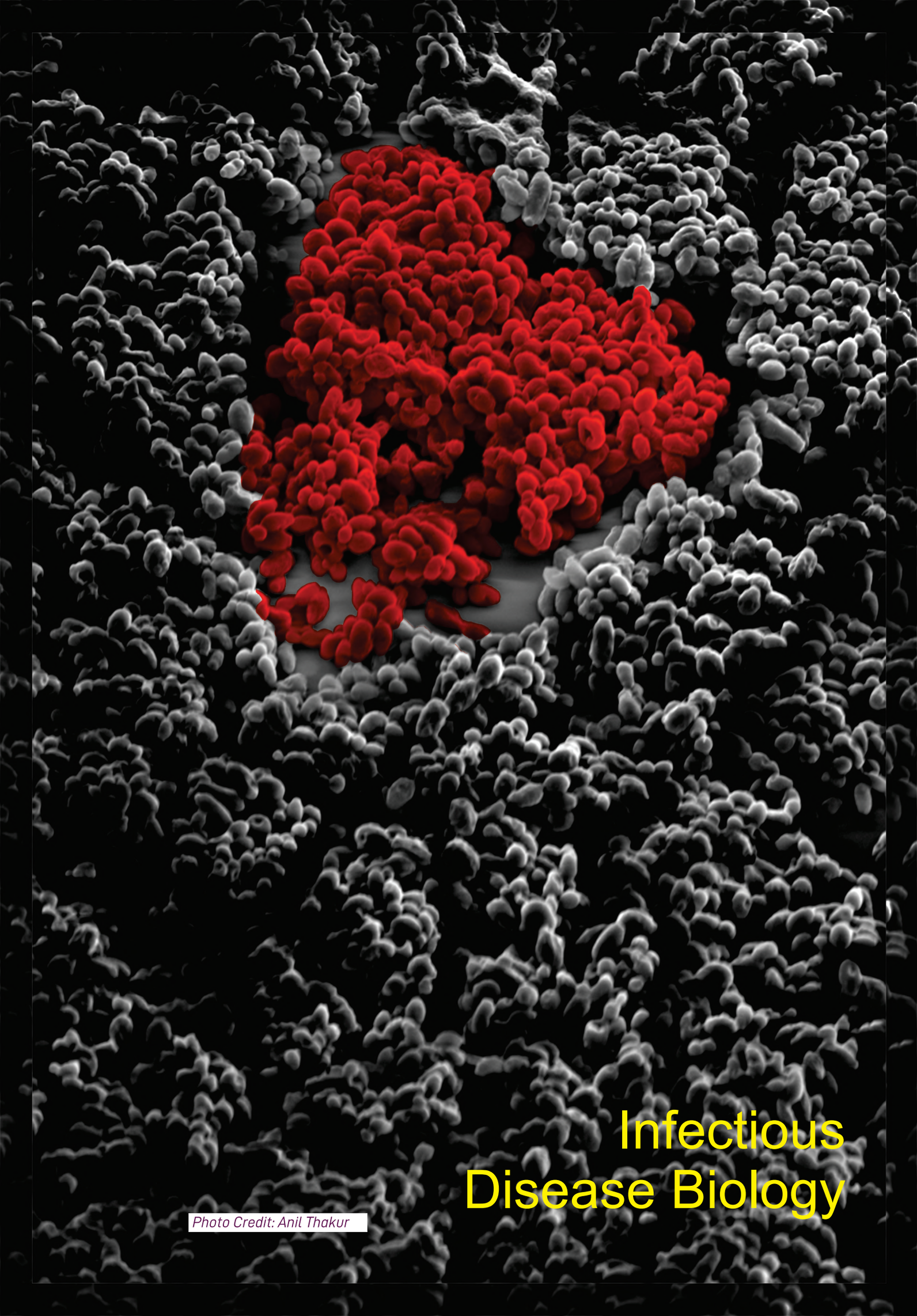
Figure 2: MyHC-embryonic is required for proper contractility and mechanical cues. *Absence of MyHC-embryonic in the sarcomeres leads to aberrant contractility, mechanical cues and integrin signalling, reduction in levels of Hippo pathway adaptors such as MOB1A/B resulting in lack of YAP phosphorylation leading to its stabilization, nuclear entry, binding to TEAD, activation of downstream targets such as CTGF and CYR61 and increased fibrosis.*

Our findings indicate that MyHC-embryonic in the developing skeletal muscle sarcomeres is required for normal contractility, mechanical cues and integrin signaling. This leads to activation of the upstream kinases in the Hippo signaling pathway which phosphorylate Yes-associated protein (YAP) using adaptors such as MOB1A/1B. In *Myh3*$^{-/-}$ mice, loss of MyHC-embryonic leads to aberrant contractility, mechanical cues and integrin signaling. This in turn causes reduction in the levels of MOB1A/1B preventing YAP phosphorylation leading to its stabilization, nuclear entry, binding to TEAD, and activation of downstream targets such as CTGF and CYR61 (Fig. 2).
Our results indicate that inhibiting the YAP signaling pathway using inhibitors such as CA3 normalizes most of the musculoskeletal defects exhibited upon loss of MyHC-embryonic function. Thus, YAP signaling is a crucial therapeutic target in *MYH3*-associated musculoskeletal diseases such as spondylocarpotarsal synostosis.

Research undertaken by India Alliance Early Career Fellow Dr. Masum Saini

Modulation of MET signaling and its role in myogenesis

Cell signaling mediated by receptor tyrosine kinases (RTKs) regulates vital processes such as embryonic development, postnatal tissue homeostasis and regeneration. Consequently, aberrant RTK signaling is often implicated in various diseases including cancer. MET, a proto-oncogenic RTK, is crucial to morphogenesis of different tissues in the embryo, especially to the migration of muscle precursors during skeletal muscle formation (myogenesis). Postnatally, muscle stem cells re-deploy MET signaling to regenerate injured skeletal muscle. Dysregulated MET signaling maintains Rhabdomyosarcoma tumor cells, a pediatric soft-tissue cancer, in an undifferentiated myogenic state. Thus, MET signaling emerges as a shared feature between muscle development, regeneration and disease. Therefore, to understand the role of MET in myogenesis, I use genetically engineered mouse models to ablate its function particularly in the skeletal muscle progenitors. Interestingly, loss of MET function does not impact survival during embryonic stages, but its absence is lethal after birth. I am trying to identify the stage and cause(s) of postnatal lethality and to characterize defects in skeletal muscle formation in the Met knockout animals. This work will provide leads for follow-up studies in multiple contexts where MET signaling axis is used during development, regeneration and disease.



Infectious Disease Biology

Photo Credit: Anil Thakur

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Biology of Medically Important Viruses

Viruses pose an ever-increasing threat to the well-being of the human population at large and this scenario is particularly ominous in the Indian context where epidemics of various viral infections are reported at regular intervals. Understanding the biology of virus infection, replication, and pathogenesis will help in designing novel antivirals for effective therapeutic and prophylactic interventions. We are studying the biology of Chikungunya virus (CHIKV), Dengue virus (DENV), and Japanese encephalitis virus (JEV) to understand their replication and pathogenesis with a view to design novel antiviral strategies. Several projects relating to the goals of the research program is being pursued. Provided below is a summary of some of the key projects under the program.

Identification of novel antivirals

To deal with the ever-increasing incidence of CHIKV, JEV, and DENV, efficacious and affordable antivirals are highly desirable. High throughput assays for testing the antiviral activity of small molecules have been developed in the lab and these are used to screen the medicinal plant extracts and chemical compound libraries. From a library of ~100,000 compounds that includes small druggable molecules, we have identified lead compounds that show inhibition of CHIKV infection in 3 different cell types at micromolar concentration. A mouse model of CHIKV infection has been established where some of these compounds show antiviral activity. Attempts are underway to understand the mechanism of antiviral action of these compounds. These libraries are now being screened for anti-JEV activity as well.

A cellular imaging-based high-content screening of natural compounds identified withaferin A (WFA), a steroidal lactone isolated from the plant *Withania somnifera*, as a potent antiviral against CHIKV. In the ERMS cells, WFA inhibited CHIKV replication early during the life cycle by binding the CHIKV non-structural protein nsP2 and inhibiting its protease activity. WFA mounted the nsP2 protease inhibitory activity through its oxidising property as the reducing agents N-acetylcysteine and Glutathione-monoethyl ester effectively reversed the WFA-mediated protease inhibition *in vitro* and abolished the WFA-mediated antiviral activity in cultured cells. WFA inhibited CHIKV replication in the C57/BL6 mouse model of chikungunya disease, resulting in significantly lower viremia. Importantly, CHIKV-infected mice showed significant joint swelling which was not seen in WFA-treated mice. These data demonstrate the potential of WFA as a novel CHIKV antiviral.

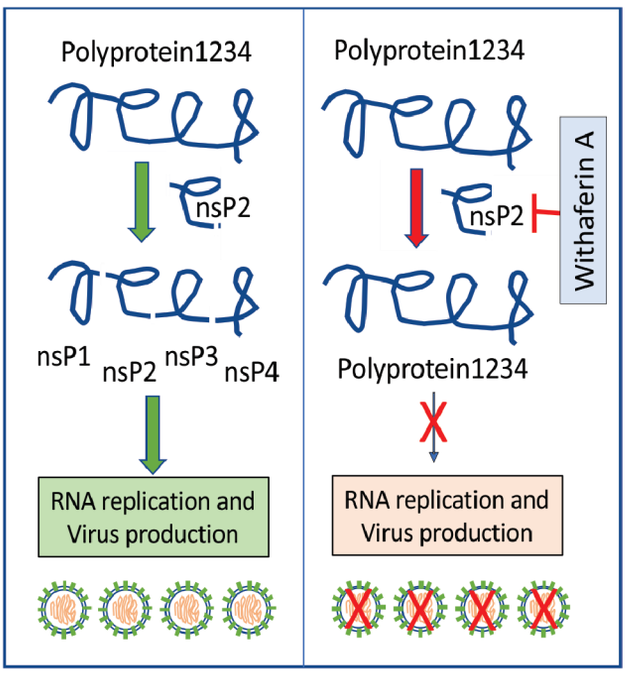

Figure 1: Withaferin A acts as a potent antiviral against CHIKV: *In untreated condition, CHIKV polyprotein1234 is processed into non-structural proteins nsP1, 2, 3, 4, thereby promoting RNA replication and virus production. Withaferin A inhibits CHIKV replication by binding the CHIKV non-structural protein nsP2, thereby preventing RNA replication and virus production*

Identification of Chikungunya virus receptor on mammalian cells

Although CHIKV is not a deadly virus, it causes severe, long-lasting indisposition in a large population each year. The FDA has recently approved a live, attenuated CHIKV vaccine. However, no virus-specific antivirals are available to treat the chikungunya fever. Identification of the CHIKV receptor in mammalian cells will advance our understanding of the virus pathogenesis and aid in developing the virus entry inhibitors as novel antivirals.

Purified CHIKV was used to pull down the virion-binding plasma membrane proteins from Huh7 cells and identified by mass spectrometry. The following proteins were repeatedly identified in different experimental replicates: Junction plakoglobin (JUP), Flaggrin (FLG) Annexin 2 (ANXA2), and Hornerin (HRNR), and 1-Acylglycerol-3-Phosphate O-Acyltransferase 1 (AGPAT1). Of these proteins, antibody to AGPAT1 inhibited CHIKV uptake in Huh7 and BHK-21 cells. AGPAT-1 was found to localize on the cell membrane in Huh7 cells and the protein levels were significantly reduced in the cells infected with CHIKV. Confocal microscopy showed AGPAT1 colocalization with CHIKV on Huh7 cell membrane. The *in silico* studies predicted that CHIKV E1 protein might interact with AGPAT1. Indeed, confocal microscopy showed that CHIKV E1 colocalized with the AGPAT1 protein in Huh7 cells. The CHIKV uptake and replication were significantly reduced in AGPAT1 knock-down or knock-out cells and these were significantly higher in HeLa cells ectopically expressing AGPAT1. These data support the role of AGPAT1 as a CHIKV receptor on Huh7 cells.

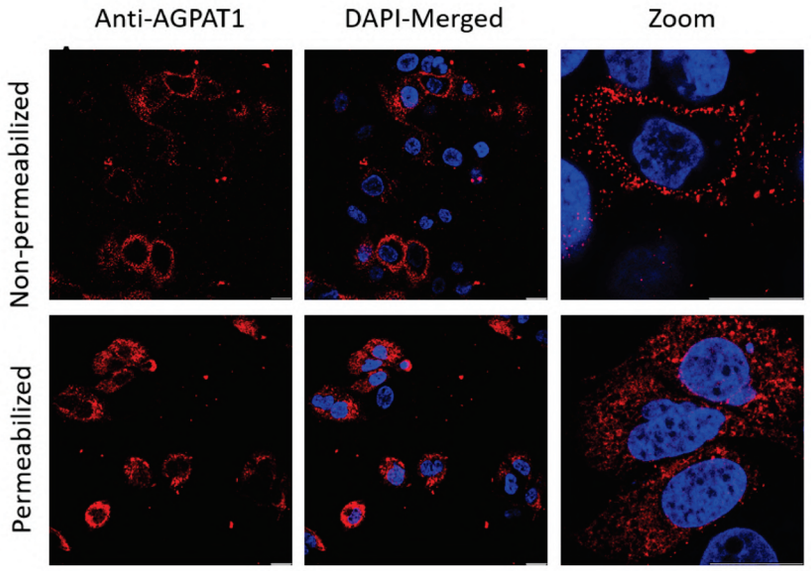

Figure 2: Localization of AGPAT1 on cell membrane: *Heh7 cells were fixed and non-permeabilized or cells permeabilized with Tween 20 were stained with AGPAT1 antibody followed by incubation with Alexa 647 anti-rabbit antibody. The images were taken under a Leica SP8 confocal microscope.*

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Molecular Biology of Infectious and Idiopathic Inflammation of the Gut

Uncontrolled inflammation is a major culprit in a number of gut illnesses including inflammatory bowel disease (IBD). IBD is a group of autoimmune diseases with two major forms- Ulcerative colitis (UC) and Crohn's disease (CD). Both CD and UC are accompanied by chronic inflammation leading to a severely compromised lifestyle. Gut epithelium cross-talks with microbiota, environment and transduce the information to the underlying immune cells. The efforts of the following program is directed towards understanding the molecular mechanisms that mediate this phenomenon. The program also aims to utilise this information to device strategies to combat inflammatory diseases of the gut.

Altered expression of Rab7 protein in goblet cells during colitis

UC mainly affects the inner lining of colon displaying inflammatory markers including epithelial erosions and ulcers. Symptomatically the patients experience vomiting, diarrhoea, loss of appetite, blood in the stool which result in a severely compromised lifestyle. Dysregulated immune response, abnormal epithelial signalling and/or alteration in microbiota composition are factors known to contribute to UC pathogenesis. Often overactive immune response against the resident microbiota is responsible for UC and CD. In healthy individual's composition of microbiota is tightly regulated by the host environment. Furthermore, host epithelium is insulated from coming to direct contact with the microbiota by a impervious mucus layer. In UC patients have a reduced number of goblet cells, specialised cells which secrete the mucins. The mechanisms that govern goblet cell function and mucus layer architecture are not fully understood. In the current work the contribution of a vesicular transport pathway protein, Rab7 was investigated in UC. To understand the possible role of Rab7 a dextran sulphate sodium (DSS) murine model was utilised. After DSS treatment (hereafter DSS mice), the mice displayed discernible signs of inflammation including reduced body weight and various histopathological features. Interestingly, a significant reduction of Rab7 protein was also seen in colon from DSS mice Fig 1A.

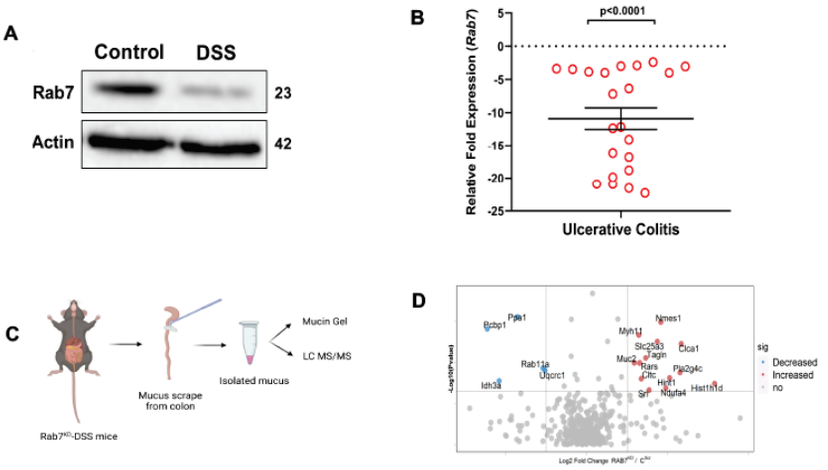

Figure 1: Small GTPase Rab7 shows altered expression during murine and human colitis correlative of disease severity. *(A) Rab7 expression analyzed in whole colon tissue of healthy and DSS-treated mice. Graph represents densitometric analysis showing fold intensity of Rab7 expression calculated by normalizing to loading control (β actin). (B) RT-PCR analysis of relative fold expression of Rab7 gene in human UC patient colonic biopsies (n=22) relative to average control values (n=22). HPRT was used for normalization. (C) Schematic representing steps for mucus isolation from mice colon followed by sample preparation for total mucin measurement through mucin gels and mucus layer composition analysis using mass spectrometry (Created with BioRender.com). (D) Volcano plot of proteome in mucus samples showing differential expression of proteins in Rab7^{KD} mice verses C^{Scr}.*

To investigate if these observations are relevant to Human IBD, biopsy samples of human UC samples were investigated. Expression analysis revealed a ~11 fold downregulation of *Rab7* in UC Fig 1B. Immunofluorescence microscopy revealed Rab7 staining in goblet cells of the epithelium from only healthy subjects but those having UC. Goblet cells have a secretory role and as such involve a vigorous and tightly regulated intracellular vesicle trafficking system. Role of Rab7, a GTPase and regulator of cellular vesicle transport pathway, in goblet cell function in the context of intestinal inflammation was investigated.

Knock-down of Rab7 *in vivo* aggravates DSS-induced colitis in mice

Rab7 knockout mice are embryonic lethal, therefore a transient Rab7 knock-down mice model (hereafter Rab7^{KD}) was developed using an in-house nanogel based oral nucleic acid delivery system Fig 1C. Interestingly, only 4 days of DSS administration was sufficient to generate severe inflammation in Rab7^{KD} mice. The knockdown of Rab7 protein expression in the colon without any off target effect in other organs was confirmed. Interestingly, DSS+Rab7^{KD} group showed exacerbated signs of inflammation compared to DSS mice. Mucus scrapings from the colons of different groups of mice revealed a significant upregulation of TNFα in DSS+Rab7^{KD} mice. These data along with histopathology led us to conclude that downregulation of Rab7 heightens DSS induced colitis in mice.

Rab7 perturbation impacts mucus composition in colon

The details of the alterations in the colonic mucus composition was next investigated. The secreted mucus is composed of a mixture of proteins, including those contributing to mucus gel architecture, antimicrobial peptides and regulatory processes. Alcian blue dye based assay of mucus secretions harvested from mice colon showed no significant change between the groups. For identification of any change in proteins in the secreted mucus, the samples were subjected to high resolution tandem mass spectrometry (mucus proteomics). 522 proteins were detected among different mice groups, of which 288 were common in all along with some unique proteins in each group as is evident through the Venn diagram. Label free quantification identified approximately 500 differentially expressed proteins. Proteins observed to be differentially expressed in Rab7^{KD} mice in comparison to control group are represented in volcano plot (Fig 1D). Chloride channel accessory 1 (CLCA1), a mucin protease, was a major protein seen to be upregulated in Rab7^{KD} mice group through Gene ontology (GO) analysis. Remarkably, CLCA1 (53 kDa) was also found to be highly upregulated in mucus samples of Rab7^{KD} followed by DSS-treated mice compared to controls. Mechanistic studies involving HT29-MTX cells, which are gobletlike cells, revealed CLCA1 to be regulated by Rab7. Overall, our data highlights a crucial role of Rab7 in maintaining gut homeostasis. Rab7 downregulation, as observed during colitis, results in increased CLCA1 in goblet cell and thereby a higher secretion. These changes adversely affect the mucus layer, the composition of microbiota and epithelial barrier function altogether leading to inflammation (Fig 2). CLCA1 could thus be an interesting and probable candidate to justify modifications in mucus layer with its increased secretion in mucus upon Rab7 knock-down in mice.

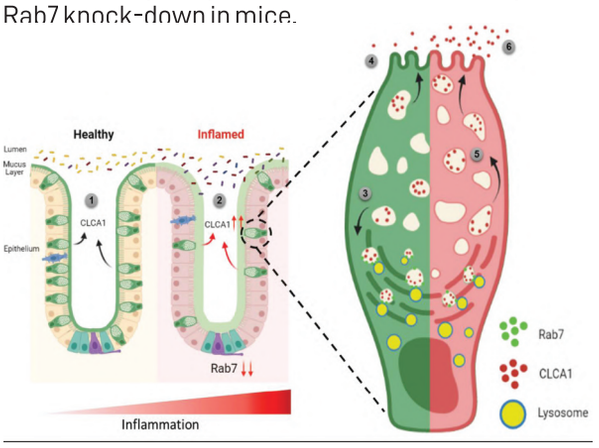

Figure 2: Rab7 maintains mucus layer dynamics in intestine by regulating degradation of CLCA1 protein via lysosomal fusion

Healthy intestine inhabits lumen microbes well separated by mucus layer secreted by goblet cells along with CLCA1 protein in balanced levels (1). During colitis, Rab7 downregulates along with increased expression of CLCA1 resulting in diffused mucus layer penetrable to microbes (2). In a goblet cell, CLCA1 filled vacuoles destined for secretion are rerouted for degradation pathway by Rab7 and fuse with lysosomes (3) leading to a balanced release outside the cell (4). However, during inflammation the loss of Rab7 consequently impedes CLCA1 degradation (5) fostering its increased secretion from the cell (6) (Created with BioRender.com).

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Host-Pathogen Interactions of Flaviviruses

Japanese Encephalitis Virus (JEV), a mosquito-borne flavivirus, is a leading cause of virus induced encephalitis worldwide, characterized by neuronal cell death and neuroinflammation. The burden of this disease is huge with one-third cases showing mortality and one-third developing permanent neurological sequelae. The treatment given to patients is mostly symptomatic, as there is no effective antiviral drug available till date. The virus is endemic mainly in East and South-East Asian countries. In India, epidemics occur every year where many children succumb to the disease. The virus infection leads to acute brain fever (encephalitis). There is an urgent need for the development of antiviral treatment. During virus infection, a constant battle between the host and virus decides the course of the disease. This ranges between two extremes- complete recoveries to death. We are trying to understand how the virus invades the different cells of the human body including the brain and how it exploits the cellular machinery to grow and spread. We are actively engaged in testing FDA-approved drugs for any antiviral potential using the animal model of JEV. We also study how the infected host mounts an immune response and what parameters are essential for inhibiting infection. This gives us clues to design and/or test drugs that can block the infection and/or enhance immunity. We aspire towards identification and development of anti-viral strategies and drugs.

Identification & characterization of FDA-approved antipsychotic drug Methotrimeprazine a neuroprotective antiviral in JEV infection

Our previous studies suggested that upregulation of autophagy, a cellular degradation process that helps remove damaged components and pathogens, can exert antiviral effect on JEV infection. This study aimed to identify drugs that could mitigate the effects of JEV by inducing autophagy. Here we screened 42 such FDA-approved drugs and identified four candidates with promising antiviral effects based on their ability to protect against neuronal cell death, inhibit virus replication and show anti-inflammatory effects in microglial cells. These drugs were, then, tested in a mouse model of Japanese encephalitis for their *in vivo* antiviral efficacy. The antipsychotic phenothiazine drug Methotrimeprazine (MTP) significantly improved JE infected mice survival, reduced neuroinvasion and provided protection against blood-brain barrier breach and neuroinflammation Fig 1. Another widely prescribed antipsychotic phenothiazine, Trifluoperazine (TFP) showed similar antiviral and neuroprotective effects *in vitro* and *in vivo*.

Both the drugs were identified as potent autophagy inducers, independent of mTOR pathway, which is typically involved in autophagy regulation. Mechanistically, MTP caused dysregulation of ER Ca^{2+} homeostasis, and induced a unique adaptive ER stress signature, resulting in upregulation of autophagy flux. Our detailed live cell Ca^{2+} imaging experiments showed that the source of this increase in cytosolic Ca^{2+} is ER Ca^{2+} release. Since Thapsigargin (SERCA inhibitor) and MTP treatment showed a non-additive rise in Ca^{2+} levels, it suggests that they are mobilizing Ca^{2+} from same intracellular pools and most likely they act on same Ca^{2+} handling channel/pump. Further, this rise in intracellular Ca^{2+} concentration can activate adaptive ER stress and autophagy. In future, it would be interesting to investigate precise molecular mechanism through which phenothiazines inhibit SERCA pumps as it would be relevant for several other disorders associated with SERCA hyperactivity. Our data further indicates that MTP induces a unique chronic/adaptive ER stress with gene expression profiles that are qualitatively distinct from those induced by severe stress such as Thapsigargin. We observed that the pharmacological rescue of ER stress completely reversed autophagy induction and antiviral activity of MTP. The antiviral effects of MTP were also found to be autophagy dependent.

Time kinetics assays showed that the antiviral activity of drug is between 6 to 12 hours post infection, during which the virus is rapidly replicated and translated on ER membranes. The polysome profiling showed that MTP treatment does not alter the translation of viral RNA. Instead, the antiviral activity of MTP is through its ability to inhibit the formation of JEV replication complexes, as confirmed by the decrease in the copy no. of a negative strand of the JEV RNA.

Besides its antiviral effects against JEV, MTP holds strong anti-inflammatory effects as shown by decrease in release of pro-inflammatory cytokines and chemokines in *in-vivo, ex-vivo and in-vitro* systems. Also, MTP treatment in infected cells significantly reduced NLRP3 protein levels. However, MTP treatment in autophagy deficient condition failed to reduce JEV-induced inflammation. This indicates that the anti-inflammatory effects of MTP are also autophagy dependent. The combined antiviral and anti-inflammatory effects make MTP a promising therapeutic candidate for Japanese encephalitis.

Phenothiazine drugs are widely used in clinical practice for the treatment of bipolar disorders, psychosis and schizophrenia, and can reach the brain/CNS which is an added advantage for infections such as JE. They are approved for chronic use and have a high therapeutic index with well-tolerated side-effects, and can be administered to pediatric patients. These thus have potential for a paradigm shift in the treatment of JE.

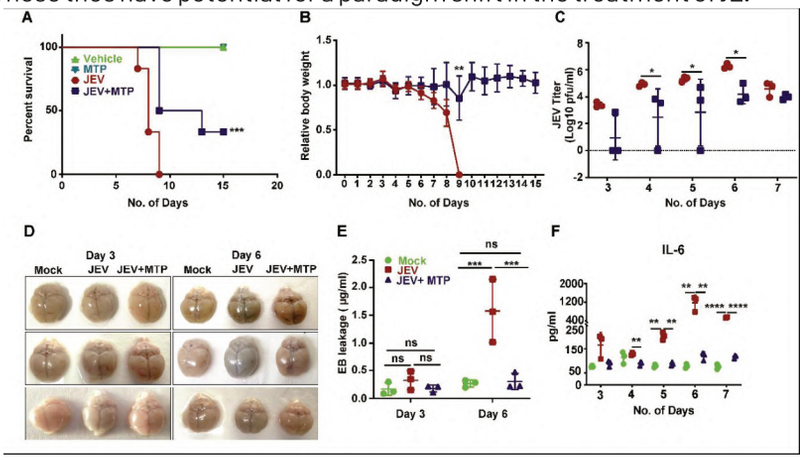

Figure 1: Efficacy of MTP in JEV-mouse model. *3 weeks old C57BL/6 mice were mock/ JEV-S3 (10^7 pfu) infected through an i.p. injection, and at 4 hpi were treated with vehicle control (PEG400) or MTP (2mg/kg) by oral gavage at an interval of 24 h for 15 days. (A) Survival curve of mock (n=4)/MTP (n=4)/JEV (n=6)/JEV+MTP (n=6), (B) Graph representing the change in body weight of vehicle/MTP-treated infected mice group normalized to mock-infected mice group. (C) Virus titre between JEV and JEV+MTP group was compared by unpaired Student t-test. (D) Representative images showing Evans blue dye distribution in the brain. (E) Concentration of Evans blue in brain tissues (F). Cytokine level in brain tissues.*

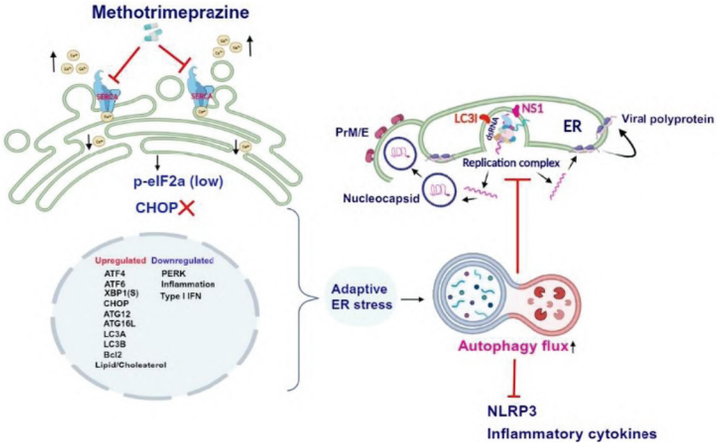

Figure 2: Mechanism of antiviral and anti-inflammatory action of methrotrimeprazine

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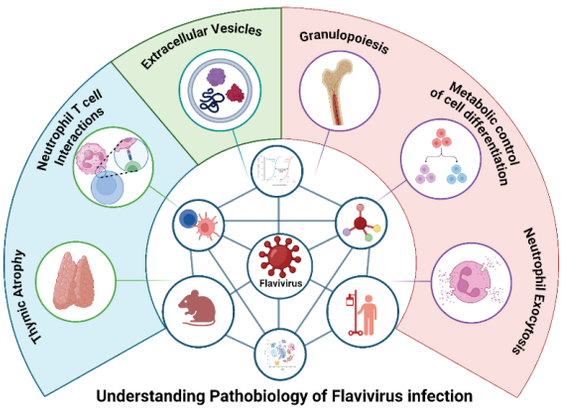
Understanding Pathobiology of Flaviviruses prevalent in India

The outcome of viral infection is primarily driven by immune cells interacting with the viruses and eliciting protective or detrimental immune responses. Our lab's research is broadly directed at understanding the immune pathogenic mechanisms of vector-borne diseases caused by the dengue virus (DV) and the Japanese encephalitis virus (JEV).

Neutrophils are the body's first line of defence against infection and display plasticity, with the ability to adapt themselves in different inflammatory scenarios. Viral infection may significantly impact neutrophil biogenesis and phenotypes. However, it is unclear how these phenotypic changes are related to cell fate decisions in imparting adverse disease outcomes. Understanding mechanisms that fine-tune neutrophil biogenesis and responses is critical for disease intervention.

In our lab, we aim to understand how neutrophil heterogeneity arises during viral infection and use these insights to develop neutrophils-targeting therapies to control inflammation in viral infections. Our lab is also interested in using extracellular vesicles to understand disease biology and identify novel interventions for viral infections.



Dengue virus infection affected the specific progenitor lineages in the bone marrow of AG129 Mice.

Infection with dengue virus (DV) is known to be associated with transient suppression of haematopoiesis. However, it is unknown whether DV infection causes impairment in a specific set of progenitor populations. Therefore, we studied the impact of DV on the expansion of progenitor cells in the bone marrow (BM). So, we performed a colony formation assay, which allows the measurement of single haematopoietic stem and progenitor cells' proliferation and differentiation ability in a methylcellulose media in the presence of cytokines and growth factors. The single cells give rise to individual colonies that can be characterised based on the morphology of the colonies obtained after 14 days of incubation (Fig. 1A). Colony formation assay was performed after 3 and 6 days post-infection (pi). It was observed that the CFU-G (Colony forming Unit - Granulocyte) was increased at day 3 pi, but it significantly decreased at day 6 pi. (Fig. 2). Also, the number of all CFU-M (Colony forming unit - Megakaryocytes) colonies substantially reduced at day 6 pi. in the dengue virus serotype 2 (DV-2) infected mice (Fig. 2). We also performed the BrdU assay to study the proliferation of the BM cells in the mice. We found that the proliferation of BM cells, as represented by the levels of $BrdU^{+}$ cells, was significantly increased in the BM of DV-2-infected mice compared to the mock mice on day 3 pi and significantly reduced by day 6 pi. (Fig. 1C, D), suggesting proliferation occurred in progenitor cells during an early stage of DV infection. Together, our data showed that DV-2 infection induces the expansion of progenitor cells in the bone marrow.

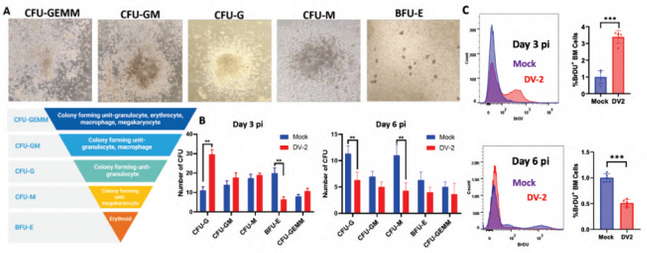


Figure 1: Colony formation assay of bone marrow cells - *(A) Representative images showing the colonies obtained from the bone marrow cells after 14 days of incubation. (B) Bar graph showing the number of colonies from different progenitor cells on day 3 and day 6 post-infection from the mock and DV-2 infected mice. (C) Histogram and Bar graph showing the increased levels of BrdU$^+$ cells in the bone marrow of DV-2 infected mice after 3 days post-infection. The statistical analysis was performed using the Brown-Forsythe and Welch ANOVA tests (*p<0.01; **p<0.001; ***p≤0.0001).*

Effect of neutrophil modulation on disease progression in dengue infected mice model

Our previous year's study reported that DV-2 infection induced the expansion of the immature CD11b+Ly6C^{int}Ly6G^{low} neutrophil population in the bone marrow. However, the impact of these immature neutrophils on the modulation of the immune response remains unexplored.

Here, we have assessed the impact of immature CD11b$^+$Ly6C^{int}Ly6G^{low} neutrophil population on immune response and disease outcome. We performed functional studies with Ly6G^{low} cells and found that the Ly6G^{low} population has T-cell suppressive activity. Further, we depleted neutrophils in DV-2-infected mice. We observed a decrease in the survival of mice, along with augmented plasma leakage in DV-2-infected neutrophil-depleted mice, suggesting neutrophils play protective roles during dengue infection. Next, we modulated neutrophil functions by treating mice with myeloperoxidase inhibitor, a heme-containing peroxidase mainly found in neutrophils. Interestingly, we observed a significant reduction in plasma leakage, suggesting that neutrophil-derived products can enhance disease severity. Our findings suggest that neutrophils have both protective and detrimental roles in the pathogenesis of dengue infection in mice models, and they can be potentially targeted to combat the complications associated with dengue severity.

Neutrophil-derived extracellular vesicles (N-EVs) and their impact on endothelial cells in dengue virus infection

Extracellular vesicles (EV) are small membrane structures (size range up to 30 – 200 nm) produced by most cells, including neutrophils. Neutrophils have been implicated in the endothelial dysfunction. However, there is less clarity on how EVs influence endothelial cells' proliferation activation and functions during DV-2 infection. In the current study, we purified the EV isolated from dengue-activated neutrophils (DV-N-EV) and studied their role in endothelial cell (EC) damage. We noted that DV-N-EV treatment significantly delays endothelial cell migration and affects wound healing. Further study confirms that miR-122-5p levels were enriched in EC post-DV-N-EVs treatment. To understand the role of miR-122-5p in EC, we overexpressed or inhibited miR-122-5p in EC by transfecting mimic or inhibitor. We observed that overexpression or inhibition of miR-122-5p had little effect on apoptosis and proliferation of EC but significantly impacted the wound healing ability in endothelial cells. miR-122-5p overexpression also induces actin cytoskeletal changes and increased NFkB p65 expression. Further studies are underway in primary endothelial cells to understand the mechanistic insights.

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Translational Control of Gene Expression in Yeast and Fungal Pathogens

Candida species present a growing concern due to their increasing drug resistance, making fungal infections challenging to treat. These pathogens infect millions worldwide, particularly immunocompromised individuals, with high mortality rates, emphasizing the urgency of developing effective antifungal strategies.

To address this, we are understanding the intricate world of protein translation within *Candida* species, a fundamental cellular process crucial for fungal growth, development and virulence. Translational regulation that fine-tunes the translation of mRNA subgroups of pathogens required for host adaptation for virulence needs to be thoroughly investigated. Therefore, our broad objective is to unveil the molecular mechanisms that govern the synthesis of virulence factors, increasing the growth fitness of the fungus. By targeting key components of the translation machinery of the fungus, we aim to disrupt its growth and survival within hosts. This approach could potentially lead to the development of new antifungal agents that overcome the current limitations in treatment options.

Translation regulation of proline catabolism determines the pathogenesis in Candida glabrata.

Candida species are opportunistic fungal pathogens of humans, with *Candida glabrata* being the second most common cause of infection among candida species. *C. glabrata* infections are challenging to treat, due to intrinsic resistance to antifungal drugs. The mechanisms of pathogenicity of *C. glabrata* are not yet fully understood. *C. glabrata* can survive in macrophages and even replicate within a phagosome, despite deficiencies in nutrients and trace elements. However, *C. glabrata* exhibits high resistance to oxidative killing compared to *Candida albicans* and *Saccharomyces cerevisiae*. Genome wide studies have revealed altered expression profiles of stress-protective molecules of the pathogens inside macrophages and neutrophils. This is achieved through complex regulatory mechanisms, including global inhibition of protein translation. We have found this translation inhibition mainly depends on the kinase Gcn2, which phosphorylates the alpha subunit of eIF2, binding with initiator methionyl-tRNA (Met-tRNAi) in a ternary complex (TC) during scanning of the start codon for translation initiation. Phosphorylation of eIF2α reduces global protein synthesis, inducing expression of stress-responsive genes, and assists the mRNA decay pathway in degrading accumulated mRNAs. One of the key stress-responsive factors is Gcn4, a master transcriptional regulator, studied for its roles during amino acid starvation and oxidative stress. We found that the *gcn4* mutant is defective in the utilisation of proline as a nitrogen source. In eukaryotes, cytoplasmic proline is transported into the mitochondria, which convert it back to P5C by proline oxidase (*PUT1*). Mitochondrial P5C is then converted to glutamate by PUT*2,* which is further converted to α-ketoglutarate *via* Gdh2 to enter the citric acid cycle. We found that the utilization of proline as a nitrogen source represses the global translation and activates the Gcn2 kinase to regulate the expression of transcription factor Gcn4. Intriguingly, Gcn4 further regulates the expression of transcription factor *PUT3,* which transcribes proline catabolic pathway genes *PUT1 and PUT2* (Fig 1A). The *put3* strain is defective in forming efficient biofilms and reduces survival in the host cells. The fungal burden was significantly reduced in the kidney, spleen, and liver of *put3* infected mice. Thereby, through this study, we have concluded that proline catabolism is crucial for the pathogenesis and survival strategies of *C. glabrata* (Fig 1b). It suggests that the ability of *C. glabrata* to freely obtain proline from the host system as a nitrogen and carbon source may help it thrive as a commensal and opportunistic pathogen.

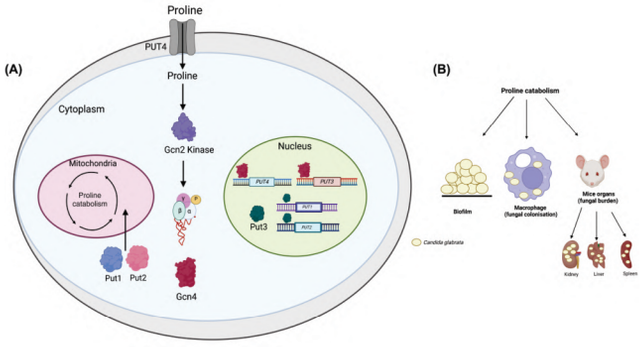


Figure 1: Proline catabolism facilitates C. glabrata pathogenicity by repressing global *translation: A) Proline utilization activate the Gcn2 kinase to express the GCN4. GCN4, in turn, regulates the expression of PUT3 to transcribe PUT1 and PUT2 to utilize proline as a nitrogen and carbon source. B) The proline catabolism of C. glabrata plays a crucial role in forming efficient biofilms, aiding survival within macrophages and maintaining the fungal load in the organs of infected animal.*

Ribosomal protein Rps14 controls the accuracy of start codon selection by translation pre-initiation complex

The eukaryotic 43S pre-initiation complex, containing Met-tRNA$_i^{Met}$ in a ternary complex (TC), scans the mRNA leader for an AUG start codon in favorable context. Recognition of AUG evokes rearrangement of the PIC from an open (P_{OUT}), scanning to a closed (P_{IN}), arrested conformation.

Recent Cryo-EM structures have revealed interactions between RPS14 with the rRNA and mRNA, including the -3 nucleotide of the "Kozak" context enhancing AUG selection. We found that substitutions at interacting residues of RPS14- L137 with rRNA and mRNA, increased recognition of a UUG start codon at *HIS4* reporter and L137E reduced dissociation of the eIF2·GTP·Met-tRNA$_i$ ternary complex (TC) with a UUG start codon *in vitro,* indicating destabilization of the open complex. L137R substitution also increased usage of poor-context AUGs in *SUI1* mRNAs *in vivo*. In contrast, R135 and R136 interact with the rRNA backbone only in the closed complex. The R135E substitution reduced initiation at UUG codon and poor-context AUGs, while increasing TC dissociation at UUG codons *in vitro*, indicating destabilization of the closed complex. Thus, distinct interactions of RPS14 with mRNA or rRNA stabilize first the open and then closed conformation of the PIC to influence the accuracy of initiation (Fig. 2). Currently, we are also identifying the roles of additional ribosomal proteins of small 40S subunit to determine the high-fidelity selection of AUG initiation codons.

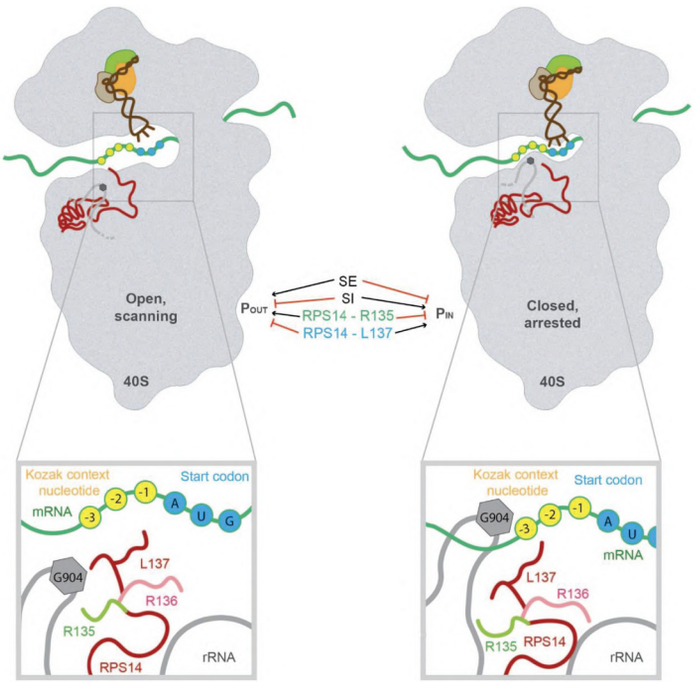
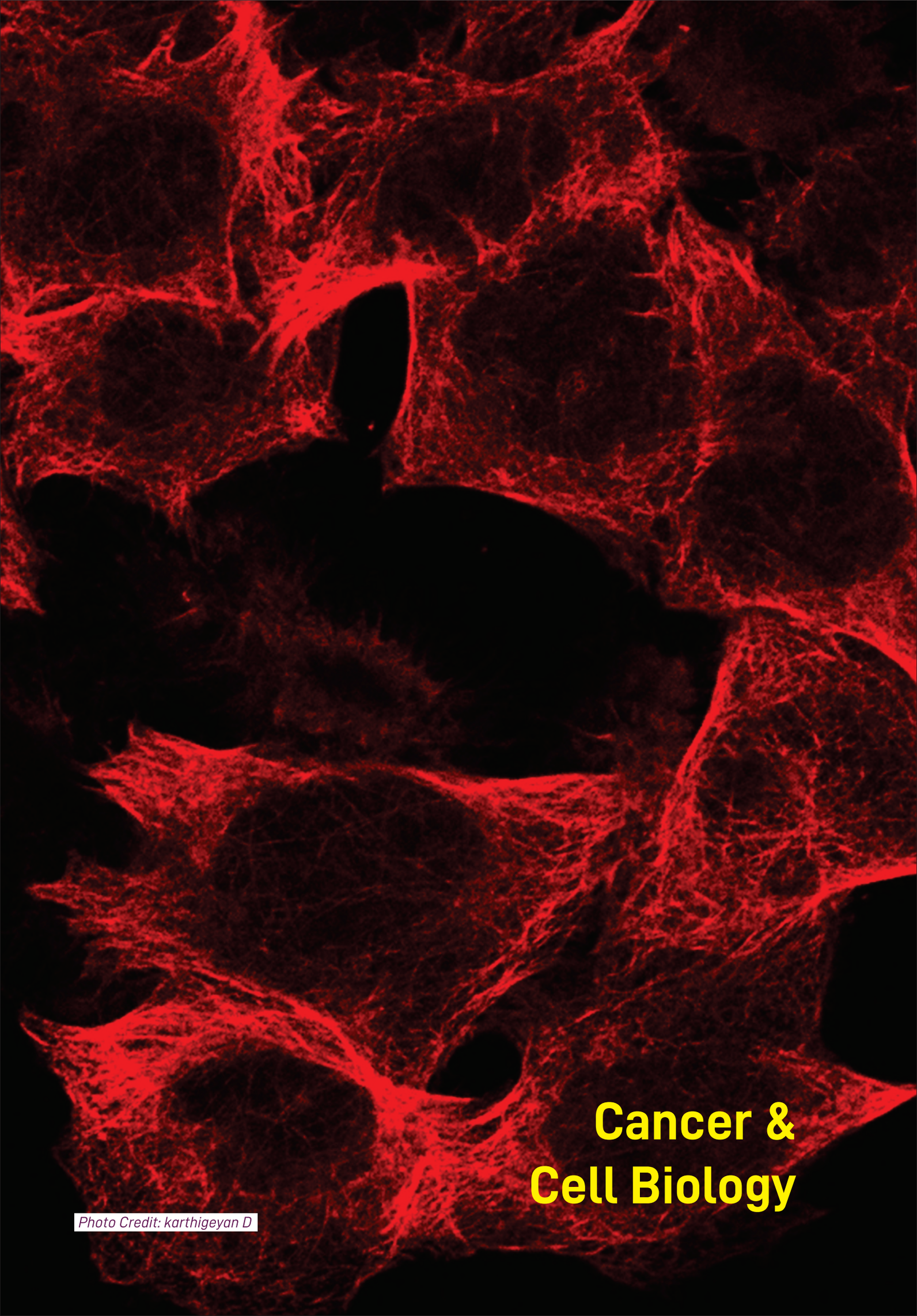


Figure 2: The role of Rps14 in conformational switch in the PIC between the open scanning, and closed conformations upon start-codon recognition. *Residues L137 promote the open scanning conformation by anchoring the rRNA -G904 in open conformation. Closed complex engaging rRNA-G904 with mRNA context nucleotides and L137 interacts with backbone of mRNA. The interactions of R135 and R136 with rRNA, help to fix the mRNA in the exit channel and stabilize the closed/P_{IN} state at the start codon*



Cancer & Cell Biology

Photo Credit: karthigeyan D

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Engineering of Nanomaterials for Biomedical Applications

We use interdisciplinary approaches, such as synthetic chemistry, cell biology, cancer biology, nanotechnology, microbiology, lipidomics, genomics, and bioinformatics, to address challenges in cancer biology and infectious diseases and develop nanomaterials for effective therapeutics.

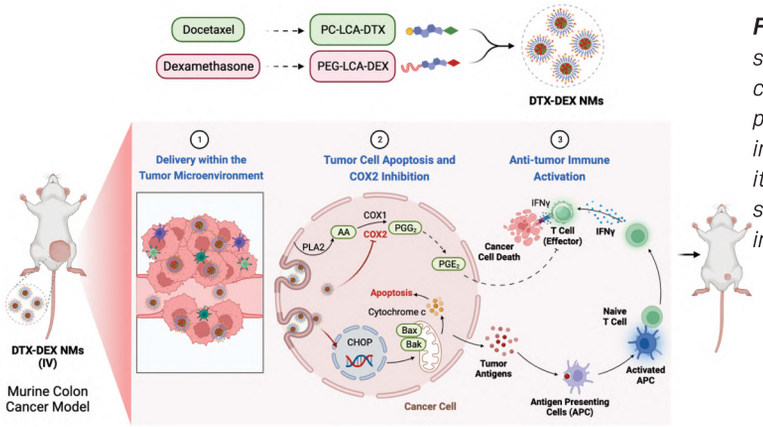

Figure 1: *A schematic showing the engineering of chimeric NMs targeting proliferation and inflammation in the TME and its impact on prostaglandin synthesis and immunosuppression.*

We synthesised phosphocholine derivative of lithocholic acid-docetaxel conjugate (PC-LCA-DTX) where docetaxel was conjugated at the 24' COOH and phosphocholine was conjugated at 3' OH of lithocholic acid (Fig. 2A). To target tumour associated inflammation, we synthesised PEGylated lipid-drug conjugate (PEG-LCA-DEX) where anti-inflammatory drug, dexamethasone was conjugated with polyethylene glycol-derived lithocholic acid (Fig. 2A). After purification, we engineered sub-100 nm DTX-DEX NMs upon using a mixture of PC-LCA-DTX and PEG-LCA-DEX using nanoprecipitation method, and also prepared DTX-NMs using a combination of PC-LCA-DTX and a PEGylated lipid and DEX-NMs using only PEG-LCA-DEX (Fig. 2B). We found that DTX-DEX NMs were safe and did not cause any major change in cytokine levels including IL-1α, IL-1β, IL-6, TNF-α, GM-CSF, IL-23, IFN-γ, IL-17α, IL-12p70, MCP-1, IFN-β and IL-10 compared to healthy mice (Fig. 2C). Biodistribution studies showed a > 5-fold higher accumulation of DTX (Fig. 2D) and a >3-fold higher accumulation of DEX (Fig. 2E) in tumour tissues on treatment with DTX-DEX NMs as compared to treatment with solution of combination of DT and DEX. Subcutaneous syngeneic (CT26) and xenograft (HCT116) colon cancer model was used to study the anticancer activity. In both models, animal studies showed that DTX-DEX NMs are more effective than individual-drug-loaded NMs in tumour growth inhibition (Fig. 2F, 2G). Immunoblot studies showed an increase in pro-apoptotic proteins, Bak, Bax and Chop. Flow cytometry analysis showed an increase in the % apoptotic cells in treated tissues along with a decrease in the proangiogenic marker VEGFR with the treatment of DTX-DEX NMs.

DTX-DEX NMs treatment demonstrated a >2-fold decrease in myeloid-derived suppressor cells (MDSCs) compared to DTX NMs, DEX NMs, and untreated tumours. Treatment with only PEG-LCA showed an increase in the accumulation of MDSCs in tumour tissues, but this effect is nullified on treatment with drug-conjugated NMs. Further, we quantified the expression of iNOS (for M1 macrophages) and ARG1 (arginase 1) (for M2 macrophages) expression after gating for $CD11b^{+}F4/80^{+}$ cells and witnessed a ~ 1.5-fold decrease in iNOS expression in CT26 tumours treated with DTX-DEX NMs compared to untreated tumours. Interestingly, we also observed a ~2-fold increase in ARG1 expression on treatment with DTX-DEX NMs. Quantification of $CD8^{+}$ T cells showed a >3-fold increase on treatment with DTX-DEX NMs with increase in Granzyme $B^{+}CD8^{+}$ cytotoxic T cells. In contrast, treatment with only DEX NMs depleted the $CD8^{+}$ T cells from tumour tissues. Therefore, flow cytometry analysis confirmed that DTX-DEX NMs deplete MDSCs, polarise macrophages, and activate Cytotoxic $CD8^{+}$ T cells in the TME. ELISA analysis demonstrated inhibition of pro-inflammatory and pro-tumorigenic cytokines like IL-6, IL-1α, IL-1β, TNF-α, GM-CSF, and IFN-β and activation of anti-tumorigenic cytokines like IL-23 and IFN-γ.

Bioactive lipids, especially prostaglandins, are one of the key metabolites responsible for immunosuppressive TME. Quantification of different prostaglandin levels using LC-MS/MS demonstrated the overall decrease in PGE_2 (and its metabolites), PGD_2, 6-keto-PGF1α (a metabolite of PGI_2) and $PGF_{2\alpha}$ in CT26 tumours on treatment with DTX-DEX NMs. Immunoblot showed a decrease in COX2 protein expression on treatment with DTX NMs, DEX NMs and DTX-DEX NMs treatment compared to untreated tumours. In contrast, there is no noticeable change in COX1 expression. To validate the contribution of PGE_2 inhibition in TME upon treatment with DTX-DEX NMs, we investigated the effect of exogenous administration of PGE_2 on the anticancer effect of DTX-DEX NMs. There was a 2-fold increase in tumour volume on PGE_2 administration in DTX-DEX NMs treated mice compared to only DTX-DEX NMs treated mice. Interestingly, we observed a >2.5-fold reduction in Granzyme B^+CD8^+ T cells in DTX-DEX NMs treated tumour tissues upon PGE2 administration.

These results demonstrated that DTX-DEX NMs allow the delivery of a combination of anti-proliferating and anti-inflammatory drugs that modulate prostaglandin synthesis and alter the immunosuppressive TME in favor of tumour regression.

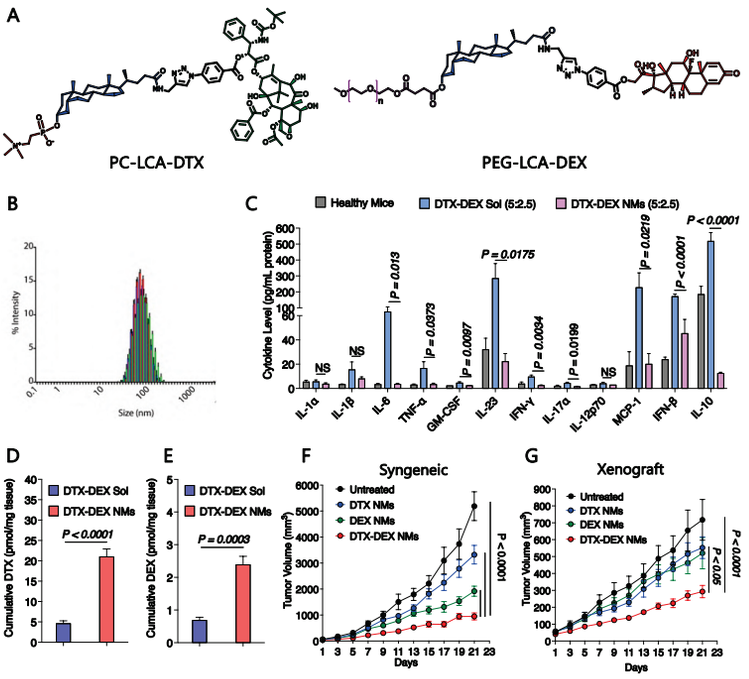

Figure 2: *(A) Structure of phosphocholine derivative of lithocholic acid-docetaxel conjugate (PC-LCA-DTX) and PEGylated lithocholic acid-dexamethasone conjugate (PEG-LCA-DEX). (B) Hydrodynamic diameter of DTX-DEX NMs. (C) Change in release (pg/mL) (mean± SEM, n = 4) of different cytokines in serum on intravenous administration of DTX-DEX Sol (combination of DTX (5 mg/kg) and DEX (2.5 mg/kg)) or DTX-DEX NMs (DTX equivalent of 5 mg/kg and DEX equivalent of 2.5 mg/kg). (D, E) Quantification of DTX (D) and DEX (E) in tumour tissues. (F, G) Antitumor efficacy of nanomicelles in subcutaneous syngeneic (CT26) (F) and xenograft (HCT116) (G) colorectal cancer models.*

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Molecular Mechanisms of Cell Division, Intercellular Communication and Cellular Dynamics

We study the molecular regulation of cell division and intercellular communication, two vital and dynamic cellular processes essential for cell survival and organism development. These processes are subverted in both infectious and non-infectious diseases, underscoring the relevance for future therapeutic exploitation. Under this broad objective, we aim to elucidate the mechanisms of formation of novel modes of cell-cell communication, currently focusing on enigmatic structures called tunneling nanotubes, and aim to understand the host cell biology of pathogenic microorganisms. We also wish to understand the regulation of cell division by the intracellular motor dynein and the mechanisms of cytokinesis, the final step of cell division. The broad objective is to obtain a holistic understanding of the molecular mechanisms that govern these processes through multi-disciplinary approaches. Knowledge gained from these studies could be exploited towards strategies for the amelioration of disease conditions.

Intercellular communication is essential for the harmonious development of organisms. Tunneling Nanotubes (TNTs) are thin, long and hollow plasma membrane tubes known to connect distant cells (fig. 1), carry diverse cellular contents for their direct intercellular transfer and are supported either by a backbone of filamentous actin (F-actin) alone (thin TNTs), or additionally supported by microtubules or intermediate filaments (thick TNTs). TNTs are usually fragile and dynamic structures that shear easily, and can range in diameter from 50 nm to 1500 nm and in length from a few µm to as long as 100 µm. Different signals and specific conditions such as stresses promote the induction of TNTs in various cell types. TNTs and TNT-like structures have been shown in various in vivo contexts, indicating the fundamental importance of these structures across biology.

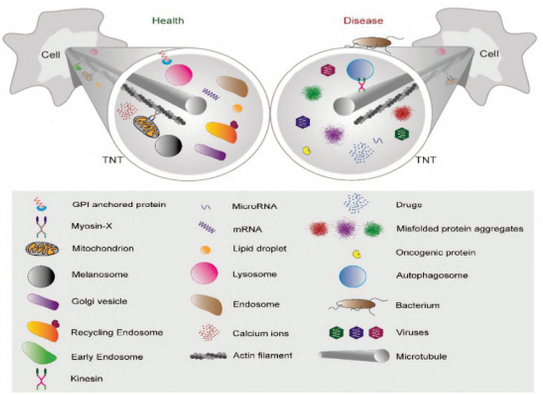

Figure. 1: *Tunneling nanotubes are long, thin, hollow, plasma membrane-enclosed channels that connect distantly located animal cells. Various cargoes are transported through tunneling nanotubes in health and disease.*

Regardless of their varied functions in human physiology and maintaining cellular homeostasis, there is an absence of a deep mechanistic understanding of their biogenesis and functions. TNT biogenesis requires localized actin remodulation, membrane bending and membrane addition at the cortex. MSec is an important protein for TNT formation in several cell types. The microtubule-based motors, dyneins and kinesins, which also have cortically enriched pools, have not been implicated in TNT formation. Our present efforts are focused on understanding these molecules' involvement to address some of the molecular mechanisms underlying TNT formation.

Cytoplasmic dynein is required for TNT formation

We showed that dynein, a microtubule-based motor, is required for TNT formation since siRNA-mediated depletion of the heavy chain (HC) of dynein leads to a reduction in TNT numbers in multiple cell types. (fig. 2A) A similar effect was observed on TNT numbers by using two specific dynein inhibitors followed by confocal imaging and analysis (fig. 2B, 2C). Out of two subpopulations of dynein, i.e. LIC1-dynein and LIC2-dynein, our experiments revealed that LIC2 dynein is required for TNT formation. By overexpressing tagged LIC1 and LIC2 dynein, it was found that LIC2-dynein induced more TNTs than the expression of the LIC1-dynein or the tag alone in mammalian cells. We also observed that MSec interacts with

LIC2 dynein in immunoprecipitation experiments. Further, co-depletion experiments suggested that LIC2-dynein and MSec may work as part of a single biochemical pathway to induce TNT formation.

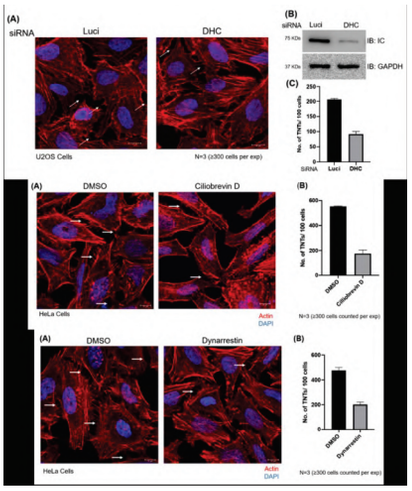

Figure 2: *Dynein HC depletion reduces TNT numbers in U2OS cells. Dynein's ATPase activity inhibition reduces TNT numbers. Inhibiting Dynein-microtubule interaction reduces TNT numbers.*

We treated U2OS cells with 1 µM nocodazole (an anti-mitotic agent that disrupts microtubule polymerization), or a DMSO (solvent) negative control for 2 hours at 37 C. Depolymerization of microtubules led to a visibly drastic loss in TNT numbers, confirming that intact microtubules are required for TNT formation. siRNA-mediated knockdown of dynein's cofactors p150 (the projecting arm of dynactin) and LIS1 in U2OS cells over three independent experiments revealed a significant reduction in TNT numbers upon both p150 and LIS1 knockdown, with no change observed upon the negative control (anti-luciferase siRNA). These results suggested that active dynein, is required for TNT formation in U2OS cells.

We observed that MSec and dynein may function in the same biochemical pathway, and proceeded to examine their order of function. LIC2 overexpression was not able to rescue the reduction in TNT numbers upon MSec depletion, suggesting that MSec could be the latter determinant of TNT formation in this pathway, with LIC2-dynein playing a role upstream. Indeed, MSec overexpression was able to rescue the reduction in TNT numbers upon LIC2 depletion (fig. 6), suggesting that MSec could be the key determinant to induce TNTs in this pathway, and confirms a specific upstream function for LIC2-dynein in TNT formation.

We next quantified cortical MSec levels upon depleting LIC2-dynein from the cells by immunostaining for phalloidin and DAPI and imaged by confocal microscopy. Quantification revealed that cortical enrichment of MSec-MTAP was significantly reduced after LIC2-dynein depletion, but the protein levels were unchanged, suggesting that MSec could be the critical player for TNT induction, but LIC2-dynein is vital for the proper cortical enrichment of MSec. We examined whether Par3 has any role in TNT formation and may operate along with LIC2 dynein to induce TNT formation. Co-depletion of LIC2 with Par3 significantly reduced TNT numbers to a level similar to the depletion of either Par3 or LIC2 alone, suggesting that LIC2 and Par3 might be working in the same pathway to induce TNT formation. In order to validate whether MSec, LIC2-dynein, and Par3 operated through the same pathway to induce TNT formation, we performed rescue experiments. We first depleted Par3 from the cells and complemented it with LIC1/LIC2 or MSec overexpression. Upon image analysis, it was found that upon Par3 knockdown, TNT numbers were drastically reduced, but were not rescued by either LIC2 or MSec overexpression, suggesting that Par3 could be the latter determinant of TNT formation in this pathway, with LIC2-dynein and MSec playing roles upstream.

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Understanding Role of Calcium Signaling in Human Health and Diseases

Ca^{2+} signaling regulates plethora of cellular functions and thereby plays a critical role in maintaining tissue homeostasis and health. Perturbation in Ca^{2+} dynamics causes impairment of cellular physiology eventually leading to diseases. The focus of our group is to understand the role of Ca^{2+} signaling in Skin pigmentation, Tumorigenesis and Cancer metastasis. We are aiming to: 1) Delineate the role of organellar Ca^{2+} dynamics in these pathophysiological conditions; 2) Elucidate detailed molecular mechanisms connecting dysregulated Ca^{2+} signaling to Cancers and Pigmentary disorders; 3) Eventually, we aim to utilize this knowledge for devising strategies for better management and treatment of these pathophysiological conditions.

Calciomics of skin pigmentation

Skin pigmentation plays a vital role in protection against UV-induced cancers. Perturbations in pigmentation pathways result in pigmentary disorders like solar lentigo, melasma, and vitiligo. These disorders are considered as social stigma; impart long-term psychological trauma and are huge economic burdens. The current therapeutic regimes are not efficient in alleviating pigmentation defects. Therefore, it is critical to identify the novel molecular players regulating pigmentation and devise strategies for targeting them. For identifying novel regulators of pigmentation, we performed microarrays on hyperpigmented and hypopigmented human melanocytes. Interestingly, we observed significant deviations in the Ca^{2+} homeostasis in these cells. Although the role of plasma membrane Ca^{2+} handling proteins are reported in pigmentation, the significance of organellar Ca^{2+} signaling and the functional relevance of intracellular Ca^{2+} handling proteins remains unappreciated. Therefore, this program is focused on understanding the role of inter-organellar crosstalk, via Ca^{2+} dynamics, especially ER-Mitochondrial and Mitochondrial-Melanosome communication in regulating pigmentation.

We had earlier reported mitofusin2 (MFN2) regulates pigmentation by modulating mitochondrial ROS levels. Further, we recently revealed that mitochondrial Ca^{2+} uptake is a critical determinant of vertebrate pigmentation (Tanwar *et al.* bioRxiv, 2023). We demonstrate that pigmentation requires mitochondrial Ca^{2+} uptake. In vitro gain and loss of function studies show that Mitochondrial Ca2+ Uniporter (MCU) is crucial for melanogenesis while MCU rheostat, MCUb negatively control melanogenesis. Zebrafish, $MCU^{+/-}$ and $MCUb^{-/-}$ mice models show that MCU complex drives pigmentation in vivo. Mechanistically, MCU silencing activates transcription factor NFAT2 to induce the expression of keratin (5, 7 and 8) filaments. Interestingly, keratin5 in turn augments mitochondrial Ca^{2+} uptake and potentiates melanogenesis by regulating melanosome biogenesis and maturation (Fig. 1). Hence this signaling module acts as a negative feedback loop that fine-tunes both mitochondrial Ca^{2+} signaling and pigmentation. Notably, mitoxantrone, an FDA-approved drug that inhibits MCU, reduces pigmentation thereby highlighting the therapeutic potential of targeting mitochondrial Ca^{2+} uptake for clinical management of pigmentary disorders. This work is currently under revision for a reputed journal.

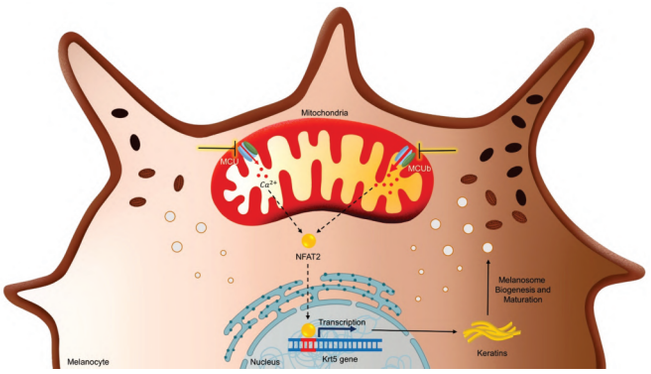

Figure 1: Mitochondrial Ca2+ uptake is a novel positive regulator of pigmentation. *MCU-NFAT2- Keratin5 signaling module drives pigmentation by augmenting melanosome biogenesis and maturation. Importantly, we have validated MCU's role in vivo in zebrafish and transgenic mice models. Moreover, mitoxantrone, an FDA approved MCU inhibitor decreases physiological pigmentation.* Figure adopted from *Tanwar et al., bioRxiv 2023.*

Targeting calcium signaling for curtailing tumor growth and metastasis:

Pancreatic Cancer (PC) is one of the deadliest cancers that accounts for lakhs of deaths annually and has a mean survival time of less than 5 years. Most of the PC deaths are associated with late diagnosis, secondary metastasis and chemoresistance. For developing effective treatment strategies, it is necessary to understand the molecular mechanisms that drive PC metastasis and chemoresistance. Ca^{2+} signaling plays a critical role in tumorigenesis by regulating the hallmarks of cancer progression such as cellular proliferation, invasion and metastasis. Cancer progression is often associated with altered cellular Ca^{2+} levels and dysregulated functioning of Ca^{2+} channels. In non-excitable cells including pancreatic cells, Store Operated Ca^{2+} Entry (SOCE) mediated by Orai channels is the most important Ca^{2+} influx pathway that regulates cellular physiology. Mammals consist of three distinct Orai proteins (Orai1, 2 and 3). Orai1 is ubiquitously expressed and contributes towards "classical" SOCE in most of the non-excitable cell types. Interestingly, recent findings implicate that instead of Orai1, Orai3 is the major contributor of SOCE in estrogen receptor-expressing (ER+) breast cancer cells and in non-small cell lung cancer (NSCLC).

We earlier reported that Orai3 forms a functional SOCE channel in PC cells and regulates PC metastasis *in vivo*. Further, we reported that Orai3 is overexpressed in PC tissue samples and higher Orai3 levels are associated with metastasis thereby leading to poor prognosis. However, the molecular mechanisms working downstream of Orai3 to drive PC metastasis remain completely unappreciated. Partial Epithelial to Mesenchymal Transition (pEMT) is an emerging paradigm wherein metastatic cancerous cells stay in a hybrid state with both epithelial and mesenchymal characteristics. The pEMT phenotype contributes to higher metastatic capabilities and thereby it is associated with poor prognosis. Although elevation in cytosolic Ca^{2+} concentration was demonstrated to drive pEMT in PC, the channel responsible for the rise in cytosolic Ca^{2+} remains unknown. Based on the literature survey, unbiased analysis of pEMT transcriptomics data and our pilot studies (Fig. 2), we hypothesize that Orai3 contributes to pEMT and associated poor clinical outcomes. Therefore, we are currently elucidating the role of Orai3 in PC pEMT.

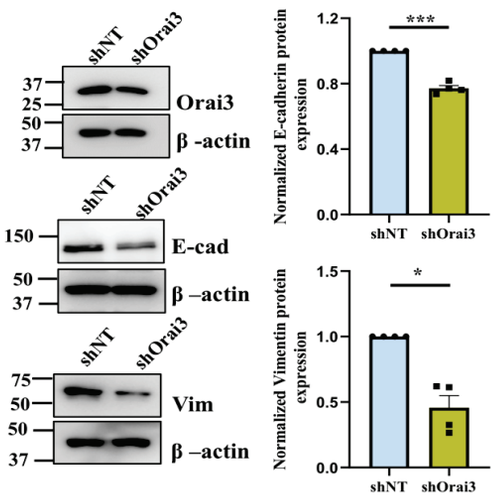

Figure 2: Orai3 concomitantly regulates epithelial and mesenchymal markers. *Western blot analysis of control (shNT) and Orai3 silenced (shOrai3) CFPAC1 cells for expression of (A) Orai3, (B,D) E-cadherin and (C,E) Vimentin (N=4).*

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Understanding the Structure and Function of Centriole Based Organelles

Centrosomes are microtubule-based membrane-less organelles that have been studied for more than a century but their significance has been limited to cell division and the associated pathogenesis in aneuploidy and cancer until the recent developments in cell biology. Today we understand the biogenesis of centrosomes and cilia largely yet we fail to connect all possible events from nucleation to faithful segregation. This is partly due to the lack of tools and the dearth of focused research involving centrosomes in physiological contexts. Our lab is majorly motivated towards understanding the centrosome and ciliary functional aspects regulating physiological and pathological events. We are interested in studying the structural composition as well as the regulatory aspects controlling the genesis and maintenance of centriolar structures especially while facing challenges like cancer, viral infection and neurodegeneration. Beyond this, our group is also actively involved in understanding the centrosome signalling components operating in response to cellular cues. We majorly rely upon high-resolution imaging, biochemical, proteomic and electron microscopy-based assays to gain an in-depth mechanistic understanding of the centriolar role across various diseases.

Impact of flaviviral proteins on centrosomes

The centrosome is a multifunctional organelle that consists of a pair of centrioles embedded in the pericentriolar matrix (PCM). They are involved in multiple cellular processes and moreover, numerous structural and numerical defects in these organelles have been documented in human diseases widely, ranging from congenital defects, cancers to neurodegeneration and various infectious diseases. Several instances have shown the centriolar structure subversion during viral infections. Yet the underlying mechanisms are least addressed and not completely understood. Our screening of the RNA viral nonstructural proteins reveals multiple instances of such centriolar involvement. The focus of our group is to understand the overall impact on the host centriole-based organelles during infection and its consequences in establishing the disease pathobiology.

Flaviviruses including Zika Virus (ZIKV), Dengue Virus (DENV), Japanese Encephalitis virus (JEV), etc. are majorly mosquito-borne and highly pathogenic ss RNA viruses causing severe illness in humans. Among these, DENV replicase, ZIKV helicase and ZIKV replicase were already known to localize over the centrosomes. These viruses are also known to induce centrosome structural and functional defects, thereby regulating cell division, differentiation and death. Centrosomal amplification is a very dominant phenotype post-viral infection in a few of the instances documented to date. Interestingly, for the first time, we have documented the JEV-infected host cells with a centrosomal involvement having significant implications for both the host and virus. Appreciating this interesting connection between the viral proteins and centrosomes we neither understand their role in viral propagation nor the host cell response comprehensively at this juncture.

So far we have identified some of the common centrosome targeting features (Fig. 1A) of the flaviviral proteins using the SNAP-tagged viral free protein expression system. Choosing JEV helicase as a case study we further characterized multiple phenotypes including the centriolar (Fig. 1 B) and pericentriolar (Fig. 1 C) defects. At present, we are trying to understand the mechanistic details of this localization and consequently its functional impact on viral pathobiology. These understandings would be important mileposts in identifying novel targets to intervene JEV infection in future.

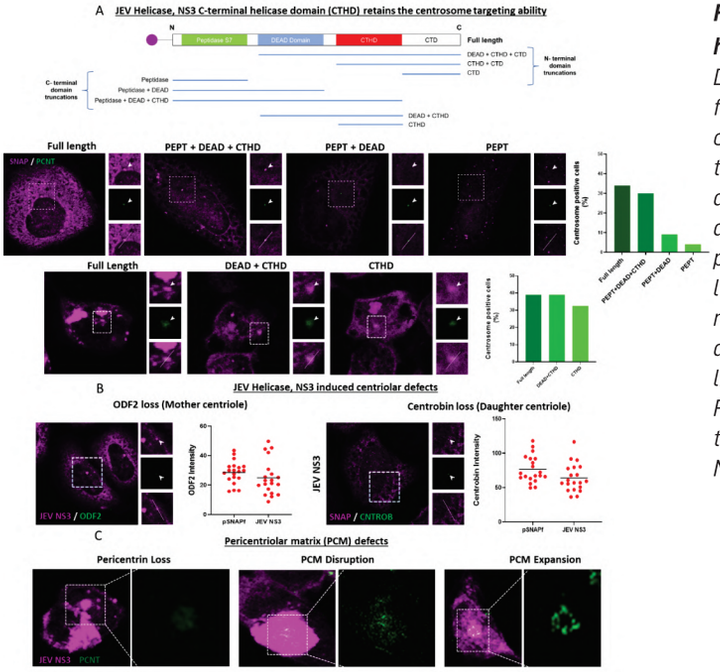


Figure 1: JEV infection involves host cell centrosome. *(A) Domain mapping of the minimal fragment targeted towards centrosome in HeLa cell. Various truncations of JEV helicase (NS3) and their localization are shown along with the quantification for percent centrosome positive localization. (B) Confocal micrographs of JEV NS3 associated centriolar defects like ODF2 and Centrobin loss. (C) Representative images showing the PCM-related defects in JEV NS3 expressing HEK293T cells.*

CHIKV-infected host cell biology

Chikungunya virus (CHIKV) which is also a mosquito-borne alphavirus causes debilitating musculoskeletal disorders in infected humans. Understanding the molecular interactions between the virus and host cell is necessary in identifying more promising viral and/or host-directed therapeutic targets. Till today the effect of CHIKV infection over the centriole base structures is not well documented. Hence, exploring their involvement at the subcellular level upon infection in the cell line models we have visualized various interesting centriolar phenotypes. So far we have seen perturbations like the appearance of supernumerary centrosomes (Fig. 2A), ciliary shortening (Fig. 2B) and centriolar satellite redistribution (Fig. 2C) in the CHIKV-infected cells. Our work provides new insights that would allow us to look at these subcellular structures like centrosomes and cilia during the viral pathogenesis with better understanding in future.

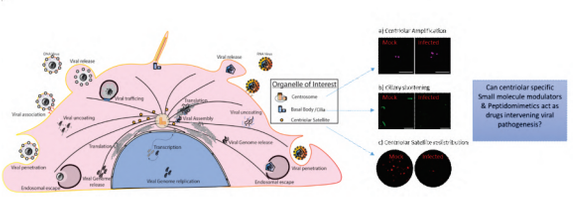
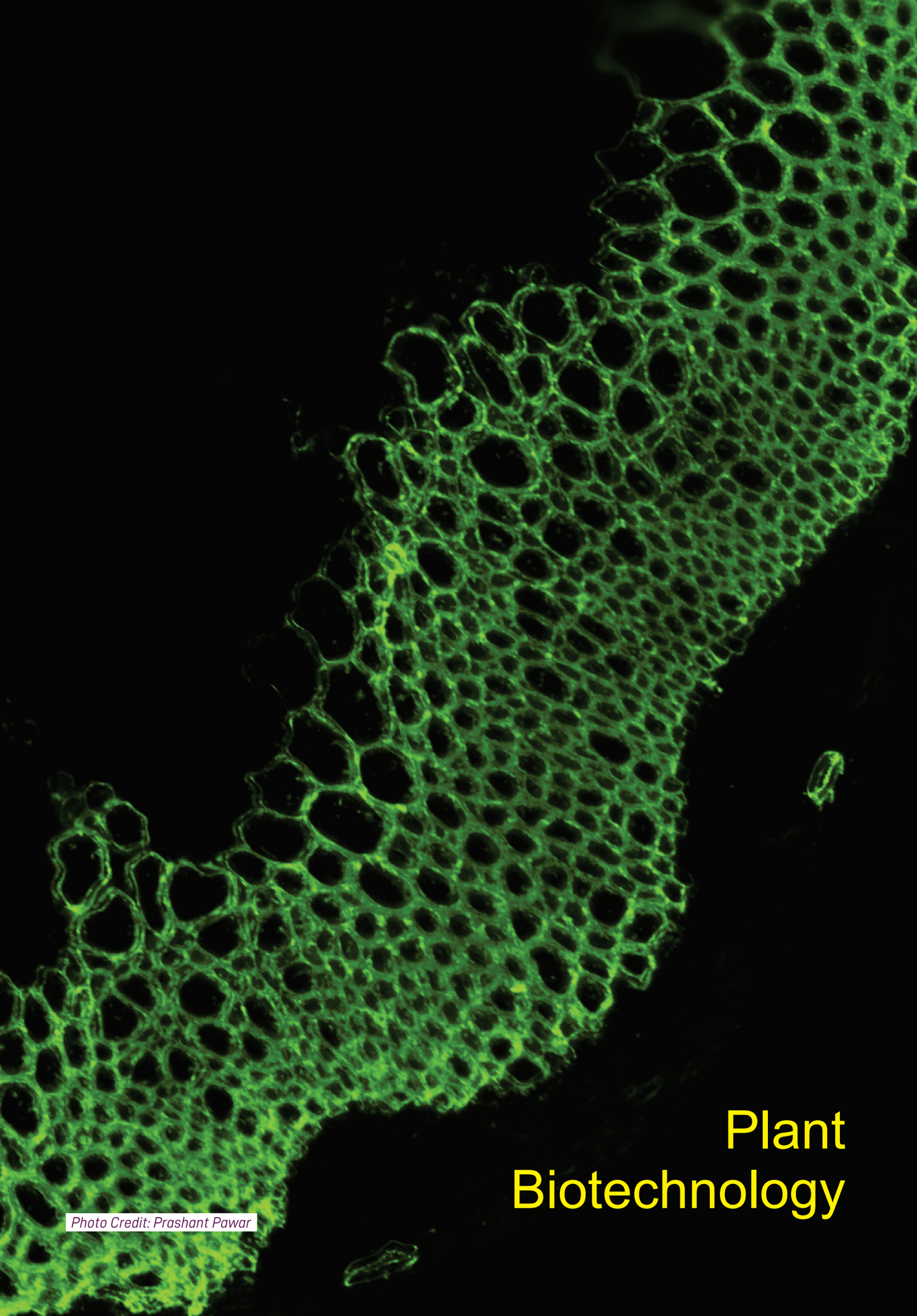


Figure 2: Centriolar targets during viral propagation. *Left panel depicts the cartoon showing the organelles of interest in the backdrop of viral life cycle. Right panel (A) CHIKV induces centrosome amplification in HeLa cells visualized by pericentrin (magenta). Scale bar-5 µm. (b) CHIKV in RPE-1 cells leads to the ciliary length shortening measured by using the axonemal marker Arl13B (green). Sale bar-10 µm. (c) CHIKV infection alters the centriolar satellite distribution in HeLa cell shown by PCM1(red) staining.*

Put together we are interested in identifying the common host centrosome-related phenotypes associated across various RNA viruses and delving more using appropriate animal models in future studies. Ultimately, we are trying to understand the mechanism utilized by viruses to subvert these centriolar structures. Likewise, equal interest lies in deciphering the contributions of these organelles towards the host cell response for all the viruses involved in our current research.



Plant Biotechnology

Photo Credit: Prashant Pawar

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Molecular Mechanisms of Signal Transduction in Innate Immune Responses of Plants

Intricate and interconnected signaling networks orchestrate both regulation and elicitation of immunity in plants (Fig. 1). Defensive signals originate extracellularly at the site of perception of a pathogen attack (PAMP-triggered immunity; PTI), or intracellularly via the sensing of pathogen-derived effectors by the plant immune arsenal (effector-triggered immunity, ETI). These signals are then transduced by downstream partners/mediators that include both metabolites and proteins. Pathogen effectors constantly evolve to evade this detection via multiple mechanisms. We are characterizing the virulence activities and immune-evasion strategies of a class of rapidly evolving effectors from *Pseudomonas syringae* (*Ps*). Further, we are surveying how the molecular functions of a key plant immune signaling hub are disrupted by various unrelated pathogen effectors. In a parallel effort, we are also elucidating the role of various inositol phosphates (InsPs), a class of versatile signaling metabolites, and the respective InsP-kinases in the maintenance of growth-defense balance in plants.

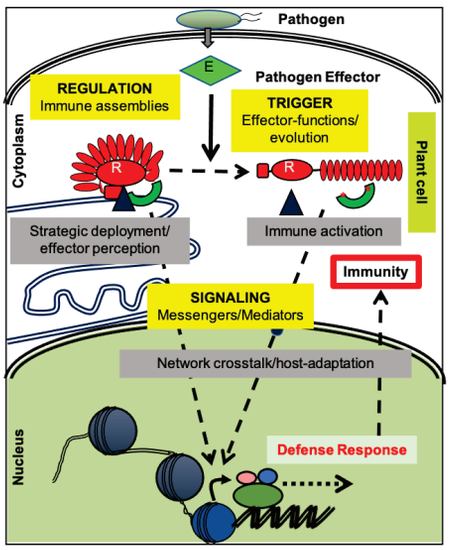

Figure 1: Schematic representation of immune regulatory and signaling networks in a plant cell. *Strategic deployment of defense modulators including resistance (R) proteins intercept effector activities to trigger immunity. Signaling messengers/mediators orchestrate key steps of immune regulation to modulate elicitation and amplitude of immune responses.*

Arabidopsis InsP kinases IPK1 and ITPK1 affect CSN composition

The versatile functions of soluble inositol polyphosphates (InsPs) have been linked to various cellular processes including phytohormone perception and plant immunity. The fully phosphorylated *myo*-inositol derivative, $InsP_6$ (*myo*-inositol-1,2,3,4,5,6-hexakisphosphate, also known as phytic acid), is produced by INOSITOL PENTAKISPHSPHATE 2-KINASE 1 (IPK1) and is sequentially (pyro)-phosphorylated by INOSITOL 1,3,4-TRISPHOSPHATE 5/6-KINASES (ITPK1/2) and then by DIPHOSPHOINOSITOL PENTAKISPHOSPHATE KINASES (VIH1/2) to generate the energy-rich phosphoanhydride bond-containing inositol pyrophosphates, $InsP_7$ and $InsP_8$, respectively. $InsP_7$, promotes auxin-receptor complex formation that may eventually drive the degradation of AUX/IAA repressors, whereas $InsP_8$ may similarly facilitate the targeting of JASMONATE ZIM-DOMAIN (JAZ) repressors. Decreased $InsP_8$ levels during Pi-starvation are also shown to promote ubiquitylation of at least two SPX proteins. Thus, selective InsPs are biochemical regulators of stimulus-dependent substrate stabilities.

In a typical eukaryotic cell, ~20% of targeted protein degradations are mediated by Cullin RING ubiquitin ligases (CRLs), the largest subfamily among the E3 ubiquitin ligase family. In the absence of cognate substrates, CRLs become vulnerable to self-ubiquitylation and are protected by the Constitutive photomorphogenesis 9 signalosome (CSN), an evolutionarily conserved eight-subunit (CSN1-8) macromolecular complex. Mammalian IP5K and IP6K1 provide $InsP_6$ and $InsP_7$, respectively to strengthen and loosen CRL-CSN associations. Whether the cognate Arabidopsis InsP-kinases perform similar activities has not been shown so far.

We identify that, in Arabidopsis, the metabolically-linked pair IPK1-ITPK1 interact with multiple CSN subunits, and moderates the CUL1-deneddylation efficiency of the holo-complex. In these mutants, the basal ratio of neddylated: unneddylated CUL1 ($CUL1^{Nedd8}$: CUL1) is skewed towards higher $CUL1^{Nedd8}$ levels than in Col-0, implying deneddylation deficiencies. Selective subunits such as CSN4/5, but not CSN1, undergo dynamic association/dissociation cycles to/from the CSN and form smaller sub-complexes. In the context of CSN5, its association/dissociation cycles have a direct impact on the equilibrium of the CSN holo-complex deneddylase activity. CSN5 and CSN4 profiles from *ipk1-1* and *itpk1-2* show comparatively reduced or almost negligible presence, respectively of these subunits as monomers, in comparison to Col-0. These differences in CSN5 partitioning noted in the mutants, are abolished in the respective complemented lines, indicating that the alterations were indeed associated with IPK1 and ITPK1 deficiencies. Thus, a steady-state equilibrium of CSN holo-complex composition is likely perturbed in *ipk1-1* or *itpk1-2* plants, especially affecting association/dissociation cycles of components such as CSN4 or CSN5 subunits that directly modulate the deneddylation efficiency. Indeed, *in-lysate* deneddylation assays showed decreased efficiencies of CUL1-deneddylation in extracts from *ipk1-1* and *itpk1-2* plants (Fig. 2A).

IPK1 and ITPK1 affect CSN-mediated deneddylation efficiencies on CUL1

To test whether $InsP_6$ directly affects the deneddylation activity of a plant CSN holo-complex, we first subjected Col-0 extracts through size-exclusion chromatography and pooled fractions that contained the CSN holo-complex. Using Nedd8-conjugated to aminoluciferin (Nedd8-AML) as a substrate, we then tested for *in vitro* deneddylation rates by the pooled CSN holo-complex. The pooled CSN holo-complex proteins displayed a dose-dependent increment in deneddylating Nedd8-AML. Remarkably, $InsP_6$ addition enhanced, in a dose-dependent manner, the deneddylation rate of Col-0 CSN holo-complex on the Nedd8-AML substrate (Fig. 2B). Overall, our data implied that $InsP_6$ is a likely co-factor that promotes the deneddylation activity of the Arabidopsis CSN holo-complex. To reaffirm the deneddylation deficiencies in *ipk1-1* or *itpk1*-2 extracts noted earlier, fractions corresponding to the CSN holo-complex pools were first collected from these mutants, as done above for Col-0. At similar total protein concentrations, *ipk1-1* or *itpk1-2* CSN holo-complex displayed significantly lower basal and reduced deneddylase kinetics on Nedd8-AML, in comparison to Col-0 (Fig. 2C). These results validated our earlier findings of deneddylation deficiencies in *ipk1-1* or *itpk1-2* mutants. Taken together, our results unravel novel activities of the plant IPK1-ITPK1 InsP-kinase pair in regulating functions of the CSN in maintenance of neddylated: unneddylated CUL1 ($CUL1^{Nedd8}$: CUL1) homeostasis, and likely CRL functions.

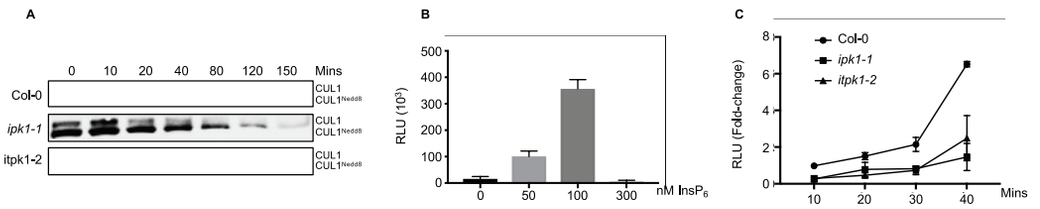

Figure 2: InsP-kinase mutants ipk1-1 and itpk1-2 display Cullin1-deneddylation deficiencies. *(A) In lysate deneddylation assay of Col-0 (wild-type), ipk1-1, and itpk1-2 plant. The lysates were probed with the anti-CUL1 antibodies. The migration position of neddylated- ($CUL1^{Nedd8}$) and unneddylated- (CUL1) Cullin 1 are marked. (B) InP_6 potentiates Cullin1-deneddylation by the CSN holo-complex in vitro. (C) Endogenous CSN holo-complex from ipk1-1 or itpk1-2 plants are deneddylation-deficient.*

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Investigations into the Molecular Mechanisms Underlying Legume-Powdery Mildew Interactions

Powdery mildews (PM) are biotrophic fungal pathogens that cause substantial yield losses in grain and forage legumes, such as pea, lentil, and Medicago. Our research program aims to identify molecular targets for powdery mildew disease management in legume crops. Specifically, we study the molecular interplay between the pea powdery mildew pathogen *Erysiphe pisi (Ep)* and two legume hosts, *Medicago truncatula* and *Pisum sativum* (pea), to identify host resistance/susceptibility factors and pathogen virulence determinants that significantly impact disease development.

Unraveling the role of a secreted ribonuclease effector in powdery mildew pathogenesis

To successfully colonize host plants, pathogens secrete a diverse battery of effectors whose primary role is to interfere with host metabolism and immune signaling. Among these, the ribonuclease family of secreted effectors, present in many fungal species and significantly expanded in obligate biotrophic pathogens such as the barley powdery mildew and rust fungi, are known to mediate complex interactions between fungi and their ecological niches. While some of these RNase effectors are similar to fungal ribotoxins that specifically cleave a single phosphodiester bond within the sarcin-ricin loop of ribosomal RNA, inhibiting protein synthesis and inducing cell death, others are similar to non-toxic T1/F1 fungal RNases.

Studies have reported that RNase-like effectors secreted by the barley powdery mildew are pseudoenzymes but play pivotal roles in virulence and avirulence. We previously showed that RNase-like effectors are also present in the pea powdery mildew *Erysiphe pisi* (Sharma, Aminedi et al., 2019). Comparative genomics analysis of RNase-like effectors from monocot and dicot-adapted powdery mildews revealed that the expansion of this effector family is restricted to a few species. Further, unlike previously reported for the barley powdery mildew, we (in collaboration with Deepti Jain's group at RCB) have identified a pea powdery mildew RNase effector with a catalytically active ribonuclease domain. It is one of the highest expressed effectors and is present at all stages of infection. Foliar application of double-stranded RNA (dsRNA) designed to target this RNase effector silenced the target gene through RNA interference and reduced powdery mildew growth on pea leaves (Fig. 1). Further, by tagging this effector with a fluorescent reporter, we have shown that it localizes to the nucleus of the host plant. Based on our findings, we predict that this RNase effector must play a crucial role in pea powdery mildew pathogenesis, possibly by interfering with host immunity. We are currently trying to identify the host interactors (protein/RNA) of this effector to gain insights into its mechanism of action.

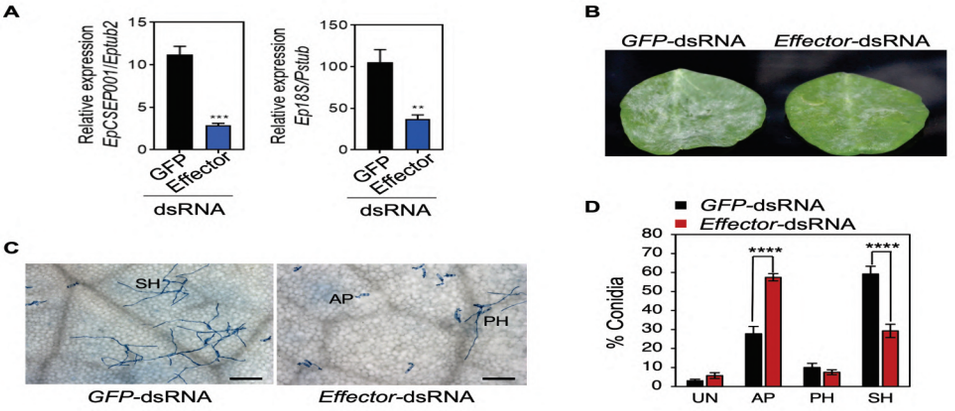

Figure 1: dsRNA-mediated silencing of Ep effector *(A) Effector and Ep18s rRNA transcript levels in pea leaves infiltrated with Effector- or GFP-dsRNA at 72 hpi; ***p<0.001 based on non-parametric Wilcoxon matched-pairs signed-rank test; **p<0.005 based on paired t-test (C) PM symptoms at 72 hpi. Bar, 1 cm (D) Ep growth visualized by trypan blue staining at 48 hpi. Bar, 50 µm (D) The percent of Ep conidia at different growth stages at 48 hpi (****p < 0.0001 based on unpaired t-test). UN, ungerminated; AP, appressorium; PH, primary hypha; SH, secondary hyphae; hpi, hours post inoculation.*

An RNA-based biofungicide for crop protection against pea powdery mildew

In collaboration with nanotechnologists at Thapar Institute of Engineering and Technology, we are now developing a dsRNA-based biofungicide that can be sprayed on plants for crop protection against powdery mildew (Fig. 2). This technology uses non-toxic and degradable layered double hydroxide (LDH) nanoparticles to deliver pathogen-specific dsRNA as a topical spray. By providing the dsRNA through nanocarriers, we can overcome the ephemeral nature of 'naked' RNA and facilitate its slow and sustained release for prolonged protection.

We have found that LDH nanoparticles enhance dsRNA stability and uptake into plant and fungal cells. Spray application of pathogen-specific-dsRNA-LDH on pea plants efficiently silences the target gene and reduces fungal growth at early infection time points similar to that previously observed with naked dsRNA. In addition, at the concentration tested, the dsRNA alone does not trigger canonical stress responses in the plant. We are currently testing whether dsRNA delivered through nanoparticles can enhance the window of protection. To our knowledge, our study is the first to use a dsRNA-LDH-based spray to control the obligate biotrophic PM pathogen. Such RNA-based biofungicides are emerging as eco-friendly, transgene-free alternatives to conventional chemical pesticides or GMOs for crop protection. Developing a microbial-based dsRNA production system can improve the scalability of RNA-based crop protection programs under field conditions.

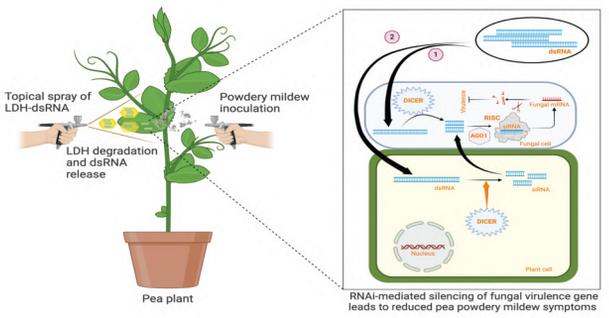

Figure 2: Schematic model representing the eco-friendly RNA-based biofungicide developed for pea crop protection against powdery mildew. *LDH-dsRNA, designed to target a pathogen virulence gene, is sprayed on pea plants, followed by powdery mildew inoculation. The topical application of this composite induces RNA interference (RNAi) in the plant and/or fungal cells, leading to target gene silencing and reduced development of powdery mildew disease symptoms. Created with Biorender.*

Elucidating the metabolic signatures delineating symbiotic and pathogenic legume-microbe interactions

One of the top unanswered questions in plant-microbe interactions is how plants selectively engage with beneficial microbes while effectively restricting pathogens. Legumes are particularly suitable for investigating this phenomenon, as they form symbiotic relationships with beneficial rhizospheric microorganisms and are colonized by pathogenic microorganisms. Using the model legume *M. truncatula*, we aim to decipher the molecular and metabolic changes that occur during symbiosis and pathogenesis, both individually (bipartite) and in combination (tripartite), and at local and systemic levels. Immune response activated by symbionts is known as induced systemic resistance (ISR), while pathogens cause activation of systemic acquired resistance (SAR). ISR and SAR are intricately regulated through gene expression, plant secondary metabolites, and phytohormone signaling. So far, we have initiated transcriptomics and metabolomics studies on the bipartite interaction between *M. truncatula* and the fungal plant pathogen *Erysiphe pisi*. Additionally, we are standardizing the interaction between *M. truncatula* and symbiotic Arbuscular mycorrhizal fungi.

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Translation Mechanisms Contributing to Plant Development and Drought Stress Adaptation

Drought stress tolerance is multigenic in nature. Protein synthesis is affected under drought stress, which, in turn, influences cellular metabolic activities required for optimum functioning. Ribosomes are responsible for protein synthesis. However, ribosome biogenesis is a highly orchestrated mechanism involving many proteins for the translation activity of cells. The emphasis is to study the influence of drought stress on plant ribosomes using different functional biology tools and decipher their role in translational mechanisms. The candidate genes may be engineered to enhance the translation efficiency under drought stress scenarios.

Effect of drought stress on protein synthesis machinery in contrasting rice genotypes to identify candidate Ribosomal proteins.

Plants evolved several acquired tolerance traits for drought stress adaptation to maintain cellular homeostasis. Drought stress at the anthesis stage in rice affects productivity due to the inefficiency of protein synthesis machinery (Fig. 1).

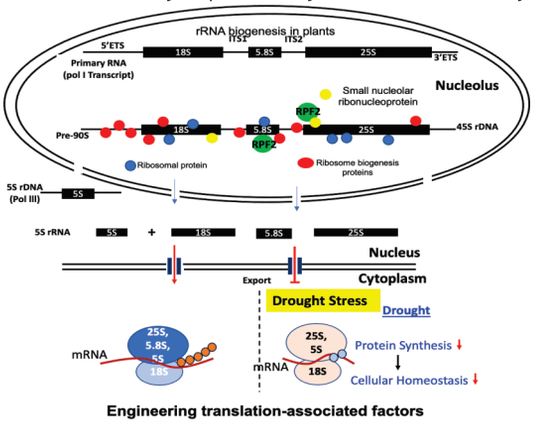

Figure 1: Scheme showing the rRNA processing and ribosome biogenesis. *Drought stress affect protein synthesis and maintaining cellular homeostasis is crucial to improve stress adaptation of plants.*

To understand the impact of drought stress on translational responses in contrasting rice genotypes, polysome profiling at the anthesis stage was adopted, and polysome-bound mRNAs were identified. The drought-tolerant APO maintained higher relative water content, yield, spikelet fertility and biomass (Fig. 2A, B, C). Apo had a higher ratio of large ribosomal subunits to small subunits under 50% FC. APO maintained higher polysome levels than IR64 (Fig. 2D, E), due to its higher RWC. IR64 has lower protein levels under stress, due to defective translation machinery and reduced water potential (Fig. 2F, G). Many polysome-bound long non-coding RNAs (lncRNA) were identified in both genotypes under drought, in IR64 more number may influence translation.

The mRNAs, before translation, undergo N^6-methyladenosine (m6A) modifications with writer, reader and eraser complex proteins. The m6A mRNA modifications regulate RNA fate, splicing, stability, export and processing in the eukaryotes. Apo under stress maintained higher M6A levels and also showed a higher accumulation of transcript of CPSF30(reader), METTL3 (writers) and ALKBH9 (erasers) that contributed to sustained translation in APO (Fig.2H). The reduced spikelet fertility and yield in IR64 under drought stress is attributed to the lower accumulation of these genes affecting m^6A RNA modifications.

The increased ribosomal activity contributes to maintaining protein synthesis under drought, as evidenced by higher protein levels of PSII, NPQ4, FNR, RBCS, RAF2 (Fig. 2I) in Apo, which maintains photochemical quenching and net photosynthesis, Iron homeostasis and increased biomass. Apo's higher protein synthesis under drought stress may be attributed to ribosome biogenesis factors, including factors involved in rRNA and tRNA processing. The differential expression of ribosomal protein genes such as RPL5, RPL18, RPL23 and RPL10A in Apo and IR64 suggests a potential role of ribosome-associated factors under stress (Fig.2J, K, L, M). The phytohormone signalling and transcriptional responses were severely affected in IR64. Apo's higher translation ability favours the maintenance of photosynthesis and physiological responses required for drought stress adaptation.

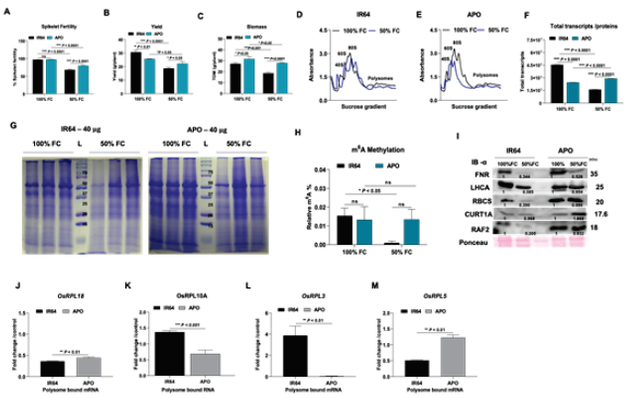

Figure 2. Response of rice contrasting genotypes to drought stress. *The 85-day-old rice plants at the anthesis stage were gradually exposed to a reduction in moisture stress of 50% field capacity. (A) spikelet fertility, (B) yield, and (C) biomass in Apo and IR64. (D & E) Polysome profiling from control and 50% FC in IR64 and APO genotypes. (F) Total transcripts bound in polysomes. (G) The differential accumulation of total proteins in IR64 and APO. (H) m^6A levels in total RNA of IR64 and APO. (I) Levels of different proteins involved in photosynthesis in IR64 and APO under 50% FC and 100% FC. Expression analysis of (J) RPL18, (K) RPL10A, (L) RPL3, (M) RPL5 in IR64 and APO from polysome bound mRNAs.*

Transcription factors controlling the expression of oxidative stress associated genes in rice (Oryza sativa L.)

Reactive oxygen species (ROS) increase under stress and damage cellular processes, leading to a decrease in productivity. Many antioxidant, scavenging and detoxifying genes are reported to be involved in mitigating oxidative stress. However, it requires the coordinated expression of several genes simultaneously to maintain cellular homeostasis. To identify the transcriptional regulators that improve oxidative stress tolerance, an oxidative stress screening of 108 rice germplasm lines at the seedling stage identified rice contrasting genotypes. The response of contrasting rice genotypes under abiotic stresses like temperature induction response, high temperature, moisture and oxidative stress. The stress tolerance of AC39020 to diverse abiotic stresses was higher than BPT5204 genotype.

From the transcriptome data of rice contrasting genotypes AC39020 and BPT5204 for oxidative stress, we identified 52 differentially regulated transcription factors. The promoters of these TFs are enriched with reactive oxygen species binding elements (ROSE). Several genes are differentially regulated by these TFs in the resistant genotype compared to the sensitive genotype. The transcript levels of TFs correlate with the expression levels of stress-responsive genes coding for various pathways, such as a polyol, ABA, JA biosynthesis, and signalling. The transcript levels of *bZIP12, bZIP23, NFX-1, HSFB2B, WRKY23, DREB2a*, and *OSH15* were significantly higher in AC39020 while the transcript levels of *OSH6* and *HOX33* were higher in BPT5204 under oxidative stress. Multiple gene networks are identified to be regulated by specific TFs.

Functional validation of *HSF-C1a* using virus-induced gene silencing (VIGS), showed reduced expression of its target genes. The expression of the target genes of HSF-C1a i.e., *HSP70, HSP101 and HSP 18.1* under MV-induced oxidative stress were reduced in VIGS plants compared to the mock-treated plants. The silenced plants were hypersensitive to oxidative stress indicating that HSF-C1a is a key regulator of oxidative stress tolerance in rice. Our study demonstrates that identified TFs could act as major transcriptional regulators of oxidative stress tolerance and may be used as markers to improve stress tolerance in plants.

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Unravelling the Plant Cell Wall Biosynthesis and Architecture for Bioenergy Applications

Plant cell wall is the outermost layer of the cell, which has a complex and dynamic structure composed of energy-rich sugars and polymers. In our group, we are studying plant cell wall biosynthesis and finetuning its structure for efficient degradation of lignocellulosic biomass to produce biofuel. The focus of our research is represented in the schematic (Fig. 1).

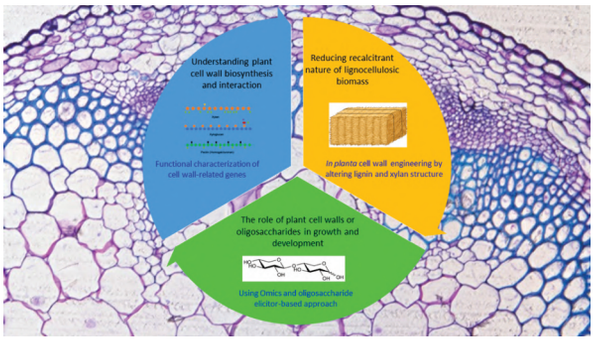


Figure 1: Schematic representing the focus of research. *Three main areas include understanding plant cell wall – (A) synthesis (B) modification, and (C) role in growth and development.*

Xylobiose treatment triggers a defence-related response and alters cell wall composition

The plant cell wall-derived oligosaccharides (OS) may be generated during plant development because of apoplast localized cell wall degrading enzymes such as xylanases, esterase, endoglucanases and other hydrolytic enzymes. Moreover, these OS can play cell wall remodelling and recycling. However, a handful of these OS are identified, and their perception mechanism is unknown. Thus, this project aims to identify and characterize the role OS in different plant cell processes.

Oligosaccharide treatment in seedlings induces pattern-triggered immunity (PTI) responses and to understand whether similar responses are observed upon CB and XB-treatment in Arabidopsis rosette leaf, we treated the commercially available disaccharides with 100 M concertation and after 30 minutes of treatment, the rosette leaf did not show any visible symptoms of hypersensitive response and appeared healthy. Reactive oxygen species (ROS) accumulated in higher amounts in disaccharides-treated than mock-treated leaves. A higher accumulation of ROS in XB-treated plants suggested it as a potential elicitor. The DAB accumulation was more than 1.4-fold after 30 min, 3 h, and 6 h of treatment and reduced in 12 h and 24 h treated leaves compared to earlier time points (Fig. 2A).

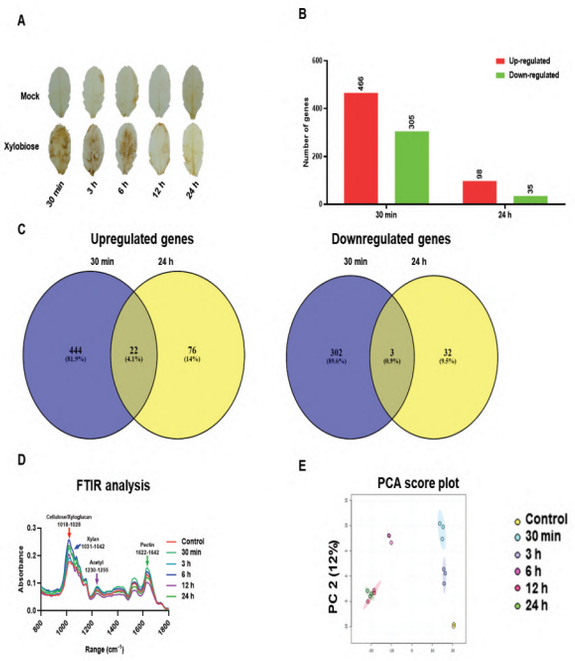


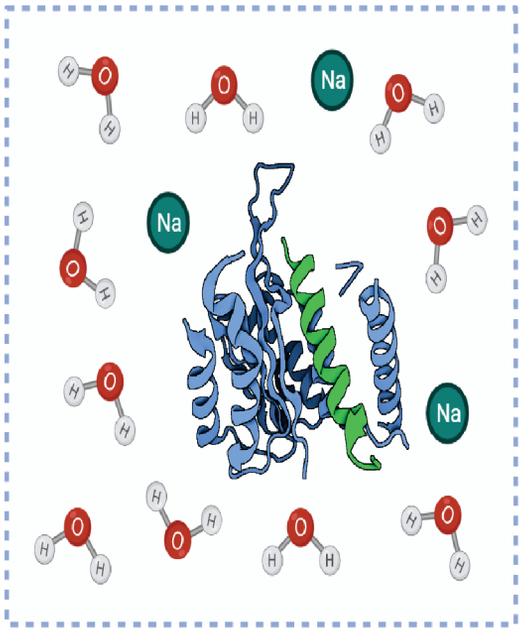
Figure 2: RNA sequencing and cell wall analysis of xylobiose infiltrated leaves. *Four-week-old Arabidopsis rosette leaves were treated with xylobiose and mock (water) (A) represent H2O2 accumulation by DAB staining (B) Bar diagrams represent upregulated and downregulated differentially expressed genes. (C) Venn diagrams represent the overlapping up and down-regulated genes). (D) Cell wall composition was determined by FT-IR analysis. Represents FT-IR spectra from wavenumber 800 cm^{-1} to 1800 cm^{-1}. (E) Principal Component Analysis (PCA).*

The oligosaccharides treatment can be perceived as DAMP, further re-programs the global transcriptome machinery after CB and XOS treatment in seedlings. To further understand the effect on gene expression upon XB treatment, we performed transcriptomic analysis on 30 min and 24 h XB-treated Arabidopsis leaves by RNA sequencing approach. We found that 771 genes were differentially regulated upon 30 min treatment (Fig. 2B). Out of those, 466 genes were upregulated, and 305 genes were downregulated after 30 min of XB treatment. Only 133 genes were differentially regulated after 24 h; out of those, 98 genes were upregulated, and only 35 genes were downregulated. Only 25 genes were commonly regulated between 30 min and 24 h XB treated leaves (Fig. 2C). We checked the expression of cell wall biosynthetic and remodelling genes, and the analysis revealed 35 cell wall remodelling genes were differentially regulated at 30 min. The primary cell wall-related transcription factor, xyloglucan modifying and cell wall degrading genes were upregulated after 30 min and 24 h as compared to mock-treated leaves. Overall, this transcriptomic analysis of 30 min and 24 h XB-treatment revealed that both PTI and cell wall remodelling genes were significantly affected. Transcriptomic data revealed that many cell wall remodelling genes were differentially regulated in XB-treated leaf tissue; we analyzed cell wall composition by FT-IR. Principal component analysis (PCA) was applied to the data generated from the range 800-1800 cm^{-1} wavenumber, which typically represents linkages in the cell wall (Fig. 2D and Fig. 2E). PC1 separated control and XB-treated leaves at 6 h, 12 h, and 24 h. PC2 separated 30 min and 6 h treated samples in relation to the control. Partial least squares-discriminant analysis (PLS-DA) similar clusters as PCA analysis, the important Q-square value was highly significant, suggesting the difference between treated and control samples was significant. To further understand the difference between control and XB-treated leaves in specific cell wall components, we subjected specific wavenumber regions to PLS-DA analysis. Xylan, cellulose, and pectin regions were clustered separately for XB-treated and control leaves, whereas a homogeneous cluster was observed for acetylated polysaccharides. Xylan/O-acetyl and cellulose/xylan ratio was increased. Overall, this data suggested that xylobiose is a potential elicitor that can induce ROS response and alter cell wall structure.

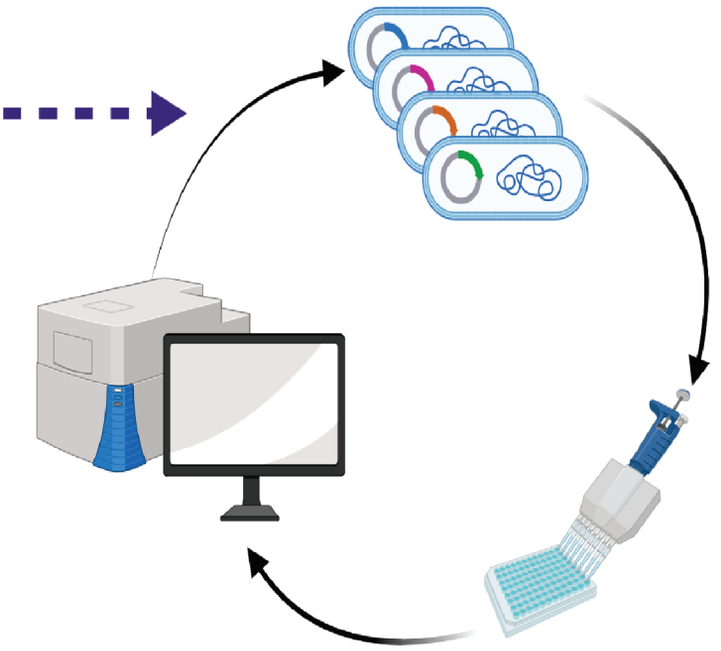
An integrated molecular genomic approach to unveil genomic and epigenetic complexity of adaptive traits, like flowering time, seed size and plant cell wall trait in mungbean

Mungbean is one of the most highly cultivated legume crops in India, and its seeds are nutritious and have high protein and fiber content. Therefore, we have performed a genome-wide association study (GWAS) for seed weight/size trait in an association panel of 144 mungbean accessions. We identified allelic variation linked with *Mungbean 1 (MB1)* gene. For the functional characterization of MB1, we expressed mungbean *MB1* in Arabidopsis under the control of the constitutive promoter and generated independent transgenic lines. The phenotypic analysis revealed that transgenic lines expressing MB1 showed bigger rosette leaves, elongated pods, and increased seed size and seed weight than wild-type plants. Moreover, the leaf and seed of transgenic lines contain more starch than wild types. In conclusion, using GWAS and molecular characterization, we identified novel MB1 that can be used in mungbean breeding programmes to improve yield and biomass-related traits.

Systems and Synthetic Biology



Molecular Dynamics



Screening

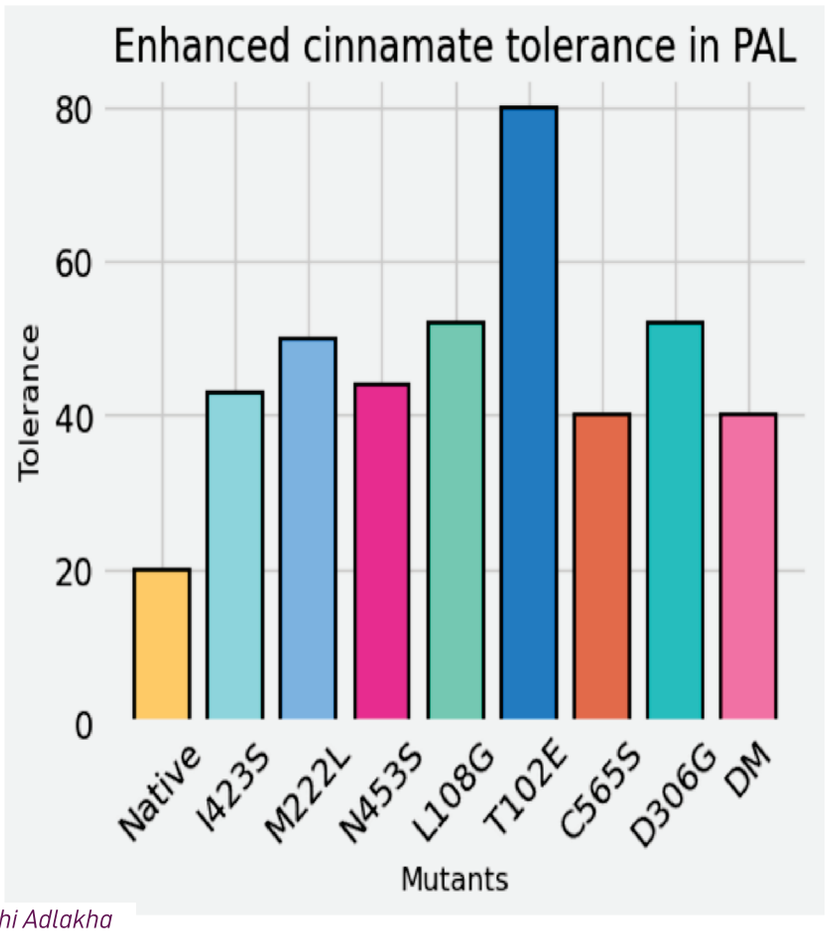


Photo Credit: Nidhi Adlakha

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Peptide Ligation and Protein Semisynthesis

We exploit the protein-peptide ligation propensity of transpeptidase sortase to create synergy in protein engineering. The fusion of recombinant expression with chemical synthesis and enzymatic peptide ligation enables the precise introduction of chemical moieties in a protein of interest. We also study the structure of sortases with a view to evolve enzymes with altered specificity and catalytic efficiency to expand the sortase toolkit for newer protein engineering applications. The delineation of structure and specificity of a housekeeping sortase from *Thermobifida fusca* (TfSrtE) and the engineering of specific chemical marks in histones form the major focus of our current work (Fig. 1).

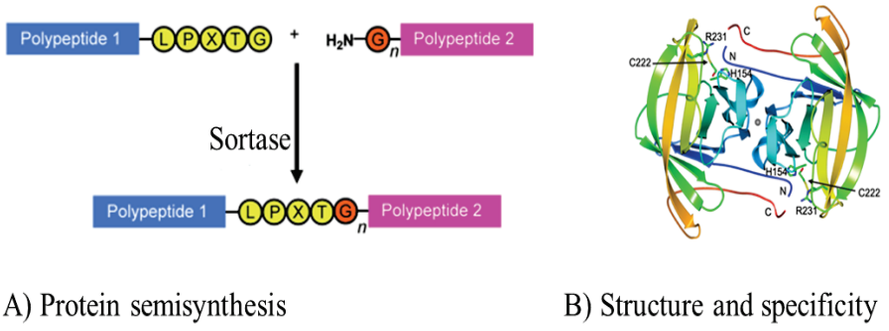


Figure 1. *(A) Schematic diagram showing protein semisynthesis with sortase. (B) Crystal structure of TfSrtE with dimeric form in ribbon representation. Catalytic triad Arg-Cys-His (sticks) of two SrtE molecules and a metal ion (sphere) are shown.*

Recently, we employed sortase-mediated peptide ligation combined with recombinant expression to engineer acetyl marks on specific Lysine residues of histones. The assembled designer nucleosomes embedded with a well-defined acetyl mark in H2B enabled the identification of specific eraser among the 18 human HDACs.

We have previously solved the crystal structure of TfSrtE at a high resolution [Fig. 1B]. The TfSrtE recognizes a non-canonical LAXTG sorting signal instead of the common LPXTG motif processed by class A housekeeping sortases. We observed two molecules in the crystal structure, where the N-and C-termini of one molecule pointed toward the active site cleft of another molecule. The dimeric interface is also stabilized by a metal ion (sodium) coordinated by Asp128, Ser114, and a water molecule. Each molecule in the dimer contains an active site formed by cysteine (Cys222), histidine (His 154), and arginine (Arg231).

Structural analysis indicated the presence of a tripeptide (Pro92-Leu93-Pro94) from the N-terminal region of another molecule at the active site of each molecule (Fig. 2). A closer look at the tripeptide PLP in the active site revealed that residue Pro92 points away from the active site while Leu93 and Pro94 point toward the active site. The side chain of Leu93 contacts hydrophobic residues Val191, Ala195, Ile196, Val198, Ile199, and Ile233, Pro94 engages in hydrophobic interactions with Ala152, Val116, and Ile121. The PLP tripeptide shows two possible enzyme-peptide hydrogen bonds; the active site Arg231 side chain forms a hydrogen bond with the backbone carbonyl oxygens of Pro92 and Leu93, respectively. In the vicinity of hydroxyl oxygen of the side chain from Tyr128, the main chain carbonyl of Leu93 makes water-mediated contact with the side chains Cys222 and Thr220. A conserved Tyr128 residue, specific to Class E sortase, recognizes Ala from the substrate instead of Pro residue. The hydrogen bond between Tyr128 and Ala residue may preferentially stabilize the binding of alanine-containing peptides since the nitrogen atom from a proline residue cannot act as a hydrogen bond donor. Interestingly, the active site arginine residue (Arg231) in the SrtE crystal structure holds carbonyl oxygen from Pro92 and Leu93 of PLP tripeptide, which likely mimics the sorting motif. We also solved the crystal structure of a mutant $TfSrtE_{P94A}$, where Pro94 is substituted with Ala residue.

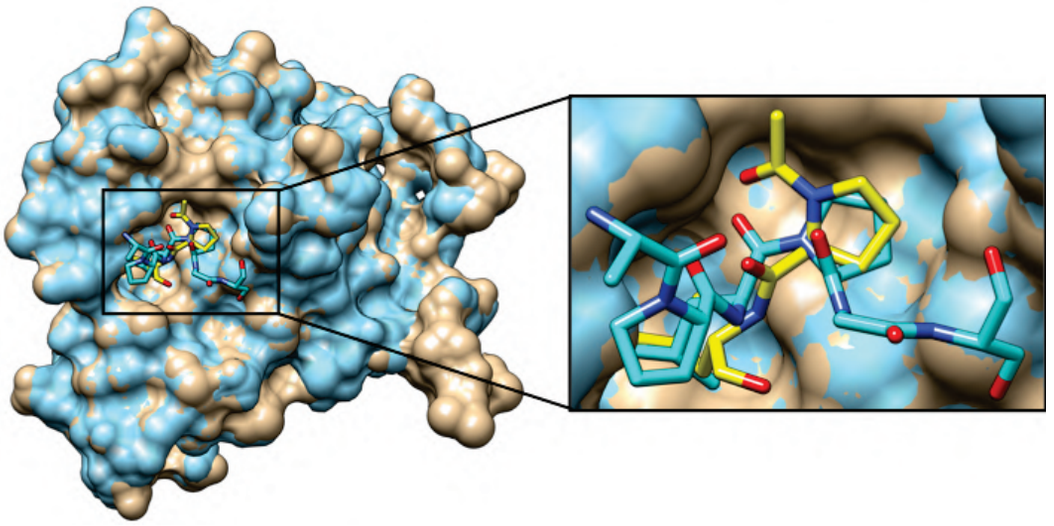
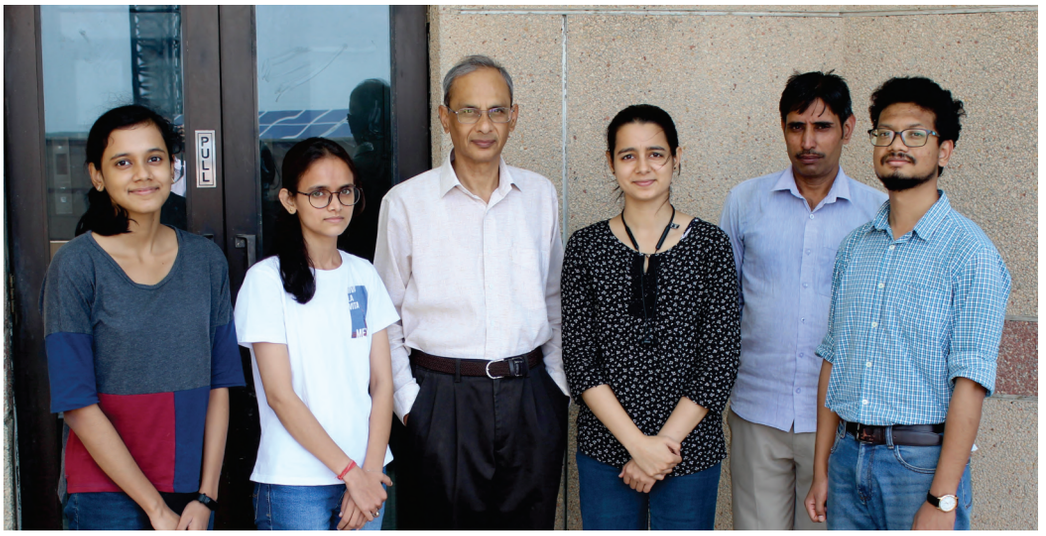


Figure 2. *Surface representation of structural superimposition of TfuSrtE wildtype (Brown) with EPLPGS peptide (cyan) over $TfSrtE_{P94A}$ (Blue) with EPL peptide(yellow). Shift in the active site cleft peptides is shown in the enlarged view*

The shift in the active site cleft peptides is visible in the structural comparison of TfSrtE and $TfSrtE_{P94A}$. In the $TfSrtE_{P94A}$, the N-terminal peptide ($E_{91}P_{92}L_{93}A_{94}$) breaks at the mutation site; P_{92} occupies the position of $P_{94,}$ facilitating snuggle fitting of the EPL peptide into the active site cleft. Interestingly, $L_{93}P_{92}E_{91}$ fit mimics the LPTA peptide observed in the substrate-enzyme complex structure of SpySrtA (PDB:7S51). The overall results provide a framework for modulating the substrate specificity of TfSrtE.



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Molecular Engineering of Functional Nucleic Acids for Biomedical and Biotechnological Applications

Our research focuses on harnessing the nucleic acids structure-mediated gene regulation in humans and bacteria for biomedical applications. The propensity of nucleic acids to control cellular processes, not only relies on their base-pair identities but also on the inherent ability to form tertiary structures such as triplexes, G-quadruplexes, pseudoknots, riboswitches etc. These structures are diverse and are involved in a remarkably broad spectrum of biological processes, from gene expression to genome maintenance. Thus, these structures gained attention as a therapeutic target. Besides this, the modular nature of nucleic acid structures makes it a promising synthetic biology tool. We are developing synthetic riboswitches for conditional and spatiotemporal gene regulation for diverse applications. We also aim to design and synthesize novel synthetic molecules to target functionally important conformations for therapeutic applications.

Rational development of FMN-based orthogonal riboswitches for precise control of gene expression and its applications

Synthetic riboswitches are regulatory RNA elements that are gaining importance across a range of applications, including biosensing, metabolic engineering, and synthetic biology. Drawing inspiration from the functional mechanism of natural riboswitches, researchers have developed numerous synthetic riboswitches. Synthetic riboswitches have the potential to reprogram bacteria and human cellular functions for therapeutic and synthetic biology applications. Like their natural counterparts, the synthetic riboswitches are triggered in response to a specific inducer molecule. The key features of synthetic riboswitches are their ligand concentration-dependent function and are thus useful for diverse biomedical applications. The aptamer domain that recognizes the specific ligand is indispensable for the function of both natural as well as synthetic riboswitches.

The biggest challenge while using these synthetic riboswitches for *in vivo* applications is the unsuitability of the existing aptamer domains and their regulatory ligands. Majorly, RNA aptamers have been selected *in vitro* using an iterative process called systematic evolution of ligands by exponential enrichment (SELEX). Although the SELEX method generates aptamer domains with high binding affinity for the chosen ligand, these aptamers have some limitations when used to construct synthetic riboswitches. To date several aptamers have been selected by SELEX, however only three aptamers i.e. theophylline, neomycin and tetracycline aptamers are mostly used for *in vitro* applications but these were also found unsuitable for *in vivo* applications due to their toxicity and poor cell permeability.

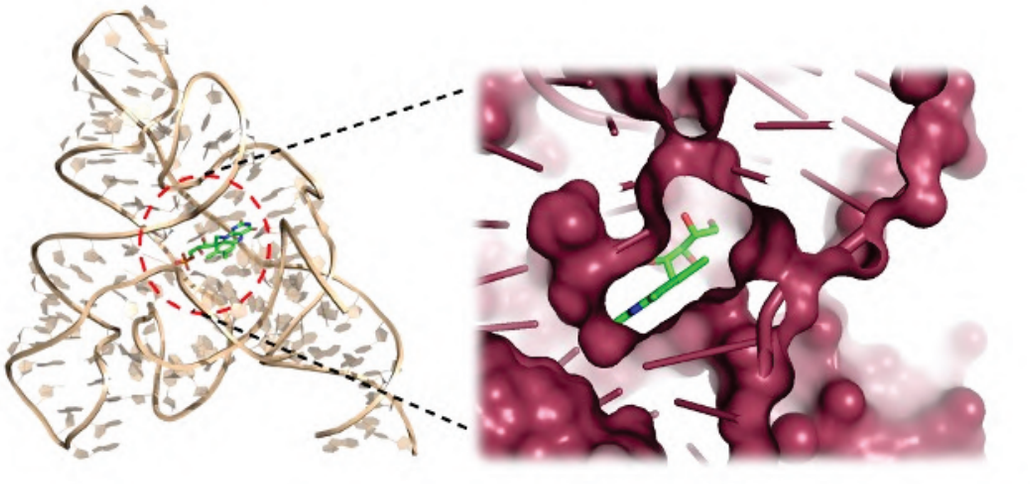

Figure 1: *Most favored binding pose of the developed synthetic ligand with reengineered orthogonal riboswitch aptamer domain.*

An alternative approach for creating synthetic riboswitches involves utilizing naturally occurring riboswitches. Presently, there are over 55 different classes of riboswitches, with thousands more predicted to exist. However, the presence of their regulatory cognate ligand within cells disrupts the intended artificial regulation. To overcome these limitations, in this project, we aim to develop new orthogonal riboswitches through further genetic engineering and by developing new and more effective synthetic ligands that will allow more precise and dynamic control of gene expression. We used a structure-based molecule design strategy to design novel molecules that can bind to selected riboswitches similar to their cognate ligands. Based on the computational docking results, we have selected the compounds with good docking scores (Fig. 1) for chemical synthesis. We have synthesized a series of synthetic analogues, purified and then characterized them by using Nuclear Magnetic Resonance (NMR) and MALDI-TOF analysis.

To investigate the riboswitch aptamer-ligand interaction and affinity, we have used biophysical techniques such as Isothermal titration calorimetry (Fig. 2A), and to validate the functions of reengineered riboswitches we have performed reporter gene assays (Fig. 2B) and western blot experiments (Fig. 2C). We have constructed novel synthetic riboswitches by developing more effective aptamer ligands that allow more precise and dynamic control of gene expression. To validate the riboswitches function, the red fluorescent protein (mRFP) was expressed under the control of constructed riboswitches in *E. coli*. The riboswitch-mediated suppression in mRFP levels was ligand concentration-dependent (Fig 2B). Next, we have used developed riboswitches for balanced gene expression in multienzyme pathways which are crucial for engineering metabolic pathways to improve the yield of biosynthesis of product. We observed a significant increase in biosynthetic product yield in the presence of inducers that we have developed.

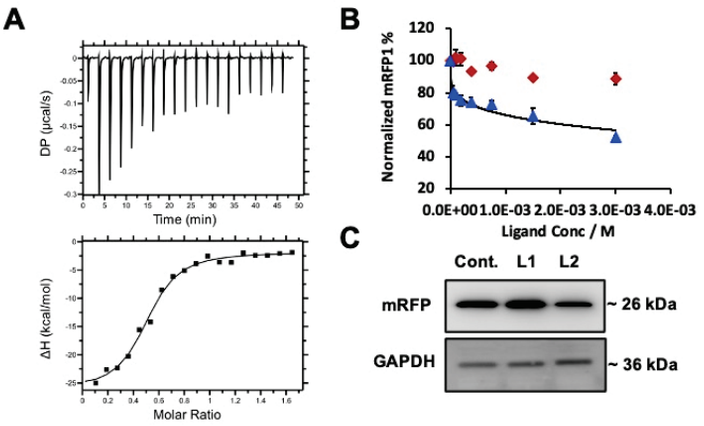

Figure 2: *(A) ITC thermograms showing the interaction of orthogonal riboswitch aptamer with the synthetic ligand; (B) The effect of inducer ligand concentration on riboswitch-mediated induction in mRFP expression in E.coli. The red diamonds and the blue triangle represent the control riboswitch and the orthogonal riboswitch, respectively; (C) A representative Western blot showing the riboswitch-mediated suppression of mRFP levels in E. coli.*

In summary, this work expands the current repertoire of orthogonal riboswitches and suggests that it is possible to rationally re-engineer the aptamer domains of natural riboswitches with minimum modifications. Our approach might serve as a basis for the re-engineering of natural riboswitch classes. Such orthogonal tools can be very useful for regulating genes involved in biosynthetic pathways, gene functional analysis, and various purposes where differential control of multiple genes is required simultaneously.

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Synthetic Biology to Understand and Improve the Production of Value-added Products

Our research focuses on the development of biocatalysts for industrial and biomedical applications using systems and synthetic biology approaches. The lab aims at optimizing the existing microbial cell factories and concentrate on improving the cost economics of enzymes or bioproducts synthesis. Another goal of our group is to understand the underlying mechanism that biocatalysts employ, with the aim to augment the yield and productivity of value-added products from engineered microbes. Our initial efforts will be directed at the following projects.

Continuous preparation of low-phenylalanine formulations by treatment of edible protein with immobilized phenylalanine ammonia-lyase

An estimated 1 in 10,000 newborns is born with phenylketonuria (PKU), a rare autosomal recessive inborn defect of phenylalanine metabolism. Excess Phe might cross the blood-brain barrier and impair neural growth and development. Available treatments aim to decrease the blood Phe concentration. Nevertheless, early-treated PKU patients with well-controlled Phe levels show normal development and average intelligence quotient (IQ) levels.

Currently available treatments include enzyme substitution therapy and diet therapy. Although the enzyme substitution therapy using PAL, Palynziq is an effective FDA-approved solution, its implementation has been constrained by its invasiveness and high cost. Thus, diet therapy is still considered a mainstay treatment for PKU disease.

However, the production of purified diets for PKU involves labour-intensive chemical extraction processes, leading to increased product prices and a huge import dependency. Thus, there is a need to develop strategies to formulate an economically feasible and sustainable low-Phe protein hydrolysate for PKU patients using an enzyme-based approach. For this, the current objectives of our laboratory include:

Scrutiny and engineering of Phenylalanine ammonia lyase.

Phenylalanine ammonia-lyase (PAL) catalyzes non-oxidative deamination of Phe to t-CA and ammonium ion. Diverse strains, including fungi, yeast, and a few cyanobacteria, are known to harbor PAL genes in their genome. We compared PALs from different origins to select an enzyme with the highest stability and specificity rationally. Of the screened PALs, the *Anabaena variabilis* PAL (AvPAL) was found to be highly specific for L-Phe substrate and thus was selected as a candidate enzyme for pre-treatment of proteinaceous substrate and the nutritional management of PKU. The enzyme was engineered for reduced feedback inhibition from its substrate, cinnamate. Further, we have proposed a process for continuous deamination of phenylalanine in protein hydrolysate using immobilized engineered AvPAL, which showed >98% depletion in Phenylalanine levels in protein hydrolysate (Fig. 1).

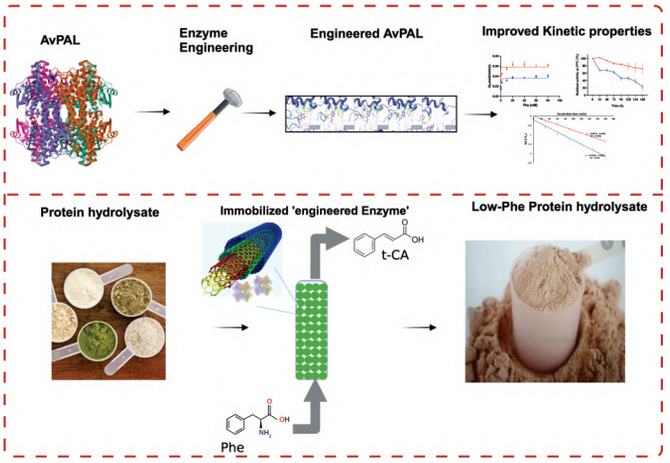


Figure 1: Schematic to represent the enzyme-based process underlying the generation of low-Phe protein hydrolysate.

Immobilization of AvPAL for sustainable development of low-Phe protein hydrolysate.

To develop a sustainable platform for the preparation of low-phenylalanine formulation, we immobilized the engineered AvPAL using chitosan, hydroxyapatite, MwCNTs and MNPs. MwCNTs demonstrated the highest immobilization efficiency because of its inherent properties, such as minimum diffusional limitation, maximum surface area per unit mass, and high tensile strength. The enzyme's binding on functionalized nanoparticles was analyzed using scanning electron microscopy (SEM) and FT-IR spectroscopy. Interestingly, the immobilization of AvPAL increased the affinity and the catalytic efficiency of the enzyme for Phe by almost ~3-fold (Fig. 2A). The most apparent advantage of immobilized enzymes over free enzymes is their repeated use. Therefore, we evaluated the reusability of the MwCNT-AvPAL enzyme and observed that the immobilized AvPAL retained more than 50% activity even after ten consecutive uses (Fig. 2B). We evaluated and compared the operational stability of MwCNT-AvPAL for seven days at its optimum temperature. It was observed that free AvPAL's activity dropped to 50% in just 96 hours, MwCNT-AvPAL retained more than 75% of its enzyme activity after 168 hours of incubation at 37°C (Fig. 2C, D). Finally, we compared the deamination efficiency of MwCNT-AvPAL bioconjugate with that of free AvPAL enzyme. The deamination of 5% acid-hydrolysed soya peptone was performed in a batch mode with 2.5 IU/ml of bioconjugate and free PAL, which indicated complete depletion of Phe content. However, with a further increase in the substrate concentration to 10%, we observed an approximately 80% decline in Phe concentration with bioconjugate; in contrast, the free enzyme treatment showed merely a 40% reduction (Fig. 2E, F).

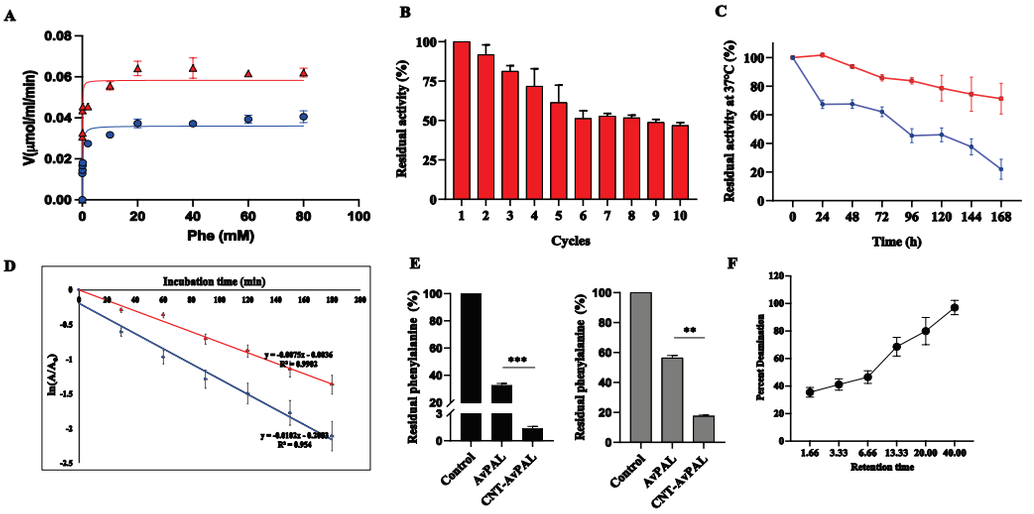


Figure 2: Biochemical characterisation and comparison of immobilized AvPAL with free enzyme. *(A) Michaelis Menten plot of free and bio-nanoconjugates. (B) The reusability of CNT bound AvPAL was evaluated for 10 consecutive cycles. (C) Stability of free and immobilized enzyme was evaluated at its optimum temperature, 37°C for 7days. (D) Thermal stability at 70°C of CNT-immobilized AvPAL was compared with free AvPAL. (E) Biotransformation of Phenylalanine in complex protein hydrolysate and Pure substrate. (F) Relation between percent deamination of protein hydrolysate and retention time.*

SARS-CoV-2 related Research and Development

Dr Prem S Kaushal

Our laboratory is trying to find novel small-molecule inhibitors of SARC-COV2 Nsp1 protein. Nsp1 selectively recruits viral mRNA over host mRNA for translation initiation. We observed that Cholecalciferol (vitamin D3) binds to the C- terminal domain of the Nsp1 and has a binding affinity of 6.4 Kcal/mol. More importantly, it interacts with the crucial residues, Y154 and F157 of Nsp1. Earlier studies have shown that a Nap1 double-mutant Y154A and F157A lose their binding capability to the human ribosomal small subunit. Five phytochemical compounds, Chrysanthemin, Limonin, Hesperidin, Baicalin, and Cryptotanshinone, also showed high affinity. Further screening of the large library is in progress.

Prof Prasenjit Guchhait

1. We investigated that "Inflated SARS-CoV-2 infection in diabetes was rescued by increased IFN synthesis in mice supplemented with metformin and dietary-αKG, and patients taking metformin, via HIF1α axis" (Joshi *et al*, 2024, manuscript is in preparation).
2. Further, we are investigating the mechanism of ARDS and Pulmonary Fibrosis in SARS-CoV-2 infected animals.

Dr. Ambadas B Rode

1. Targeted G-quadruplex in SARS-CoV-2 genome with Tetraphenylethene derivatives for antiviral therapy. In this study, we have developed an RNA G4 stabilizing Tetraphenylethene (TPE) ligand library. We found that TPE derivatives suppressed SARS-CoV-2 replication in A549 cells. Taken together, our results suggest that TPE-mediated stabilization of RNA G4s in the SARS-CoV-2 genome inhibits viral infection *via* nucleocapsid gene suppression, highlighting the therapeutic potential of G4-ligands.

PUBLICATIONS & PATENTS

1. Arora A, Singh M, Saini V, Mehta D, Safwan SM, Pandey N, Verma V, Bajaj A. Cholic Acid-Derived Gemini Amphiphile Can Eradicate Interkingdom Polymicrobial Biofilms and Wound Infections. ACS Infect Dis. 2023 Dec 26. doi: 10.1021/acsinfecdis.3c00369. Online ahead of print. PMID: 38146853

2. Kumar C, Mylavarapu SVS. Nucleolin is required for multiple centrosome-associated functions in early vertebrate mitosis. Chromosoma. 2023 132(4):305-315. doi: 10.1007/s00412-023-00808-4.

3. Kumar V, Meidinna HN, Kaul SC, Gupta D, Ishida Y, Terao K, Vrati S, Sundar D, Wadhwa R. Molecular insights to the anti-COVID-19 potential of α-, β- and γ-cyclodextrins. J Biomol Struct Dyn. 2023 20:1-11. doi: 10.1080/07391102.2023.2294385. Online ahead of print. PMID: 38116950

4. Dewangan BP, Gupta A, Sah RK, Das S, Kumar S, Bhattacharjee S, Pawar PA. Xylobiose treatment triggers a defense-related response and alters cell wall composition. Plant Mol Biol. 2023 Dec;113(6):383-400. doi: 10.1007/s11103-023-01391-z. PMID: 37991689

5. Kesarwani P, Vora DS, Sundar D. Improved Machine Learning-Based Model for the Classification of Off-Targets in the CRISPR/Cpf1 System. ACS Omega. 2023 (48):45578-45588. doi: 10.1021/acsomega.3c05691.

6. Tyagi N, Roy S, Vengadesan K, Gupta D. Multi-omics approach for identifying CNV-associated lncRNA signatures with prognostic value in prostate cancer. Noncoding RNA Res. 2023 Oct (1):66-75. doi: 10.1016/j.ncrna.2023.10.001.

7. Jangid VK, Muthappa S-K, Chandran D, Sinharoy S Callus induction and efficient in vitro plant regeneration protocol for Chickpea. Plant Cell, Tissue and Organ Culture (PCTOC) 2023 156:21

8. Sahoo PK, Sheenu, Jain D. REC domain stabilizes the active heptamer of σ54-dependent transcription factor, FleR from Pseudomonas aeruginosa. iScience. 2023 Nov 4;26(12):108397. doi: 10.1016/j.isci.2023.108397. PMID: 38058307

9. Shakeel M, Kaushik S, Tanimura T, Brockmann A, Kain P. Tracking Sugar-Elicited Local Searching Behavior in Drosophila. J Vis Exp. 2023 (201). doi: 10.3791/65955. PMID: 38047573

10. Singh A, Ghosh R, Asuru TR, Prajapat SK, Joshi G, Gaur KK, Shrimali NM, Ojha A, Vikram NK, Poncz M, Kalia M, Guchhait P. Inhibition of cellular activation induced by platelet factor 4 via the CXCR3 pathway ameliorates Japanese encephalitis and dengue viral infections. J Thromb Haemost. 2023 S1538-7836(23)00853-X. doi: 10.1016/j.jtha.2023.11.015. PMID: 38029855

11. Subramani C, Sharma G, Chaira T, Barman TK. High content screening strategies for large-scale compound libraries with a focus on high-containment viruses. Antiviral Res. 2023:105764. doi: 10.1016/j.antiviral.2023.105764. Online ahead of print. PMID: 38008193

12. Kumar R, Singh R, das Chagas Almeida A, da Trindade Granato J, de Oliveira Lemos AS, Kumar K, Patil MT, da Silva AD, Rode AB, Coimbra ES, Salunke DB. Imidazo[1,2-a]pyrimidine as a New Antileishmanial Pharmacophore against Leishmania amazonensis Promastigotes and Amastigotes. ACS Omega. 2023 (43):40613-40621. doi: 10.1021/acsomega.3c05441. eCollection 2023 Oct 31. PMID: 37929127

13. Rawat S, Kumar S, Duggal S, Banerjee A. Phenotypic alteration by dengue virus serotype-2 delays neutrophil apoptosis and stimulates the release of prosurvival secretome with immunomodulatory functions. J Leukoc Biol. 2023 Oct 27:qiad133. doi: 10.1093/jleuko/qiad133. Online ahead of print. PMID: 37890093

14. Pavale S, Dalei SK, Sokhal P, Biswas B, Meena K, Adlakha N. Engineering phenylalanine ammonia lyase to limit feedback inhibition by cinnamate and enhance biotransformation. Biotechnol J. 2023 e2300275. doi: 10.1002/biot.202300275. Online ahead of print. PMID: 37861236

15. Agarwal S, Saha S, Ghosh R, Sarmadhikari D, Asthana S, Maiti TK, Khadgawat R, Guchhait P. Elevated glycosylation of CD36 in platelets is a risk factor for oxLDL mediated platelet activation in type 2 diabetes. FEBS J. 2023. doi: 10.1111/febs.16976. Online ahead of print. PMID: 37845743

16. Tyagi S, Yadav RK, Krishnan V. Determination of the Crystal Structure of the Cell Wall-Anchored Proteins and Pilins. Methods Mol Biol. 2024;2727:159-191. doi: 10.1007/978-1-0716-3491-2_14. PMID: 37815717

17. Singh A, Ghosh R, Guchhait P. CXCR3 antagonist rescues ER stress and reduces inflammation and JEV infection in mice brain. Cytokine. 2023 172:156380. doi: 10.1016/j.cyto.2023.156380. Online ahead of print. PMID: 37812996

18. Chandrasekhar H, Mohapatra G, Kajal K, Singh M, Walia K, Rana S, Kaur N, Sharma S, Tuli A, Das P, Srikanth CV. SifA SUMOylation governs Salmonella Typhimurium intracellular survival via modulation of lysosomal function. PLoS Pathog. 2023 19(9):e1011686. doi: 10.1371/journal.ppat.1011686. Online ahead of print. PMID: 37773952

19. Ghosh M, Raghav S, Ghosh P, Maity S, Mohela K, Jain D. Structural analysis of novel drug targets for mitigation of Pseudomonas aeruginosa biofilms. FEMS Microbiol Rev. 2023 fuad054. doi: 10.1093/femsre/fuad054. Online ahead of print. PMID: 37771093

20. Joon HK, Thalor A, Gupta D. Machine learning analysis of lung squamous cell carcinoma gene expression datasets reveals novel prognostic signatures. Comput Biol Med. 2023 Oct;165:107430. doi: 10.1016/j.compbiomed.2023.107430. Epub 2023. PMID: 37703712

21. Mehta D, Saini V, Bajaj A. Recent developments in membrane targeting antifungal agents to mitigate antifungal resistance. RSC Med Chem. 2023 J14(9):1603-1628. doi: 10.1039/d3md00151b. eCollection 2023 Sep 19. PMID: 37731690

22. Lekshmy V. S, Preethi V, Karthik N, Arpitha G D, Chaitanya P M, Sathishraj R, Dhananjay Shindhe, Vemanna R S, Xinyou Yin, Paul C. Struik, Sheshshayee Sreeman (2023). Phenotyping and metabolome analysis reveal the role of AdoMetDC and Di19 genes in determining acquired tolerance to drought in rice. Physiologia plantarum. 175, 5:e13992

23. Ruhal R, Ghosh M, Kumar V, Jain D. Mutation of putative glycosyl transferases PslC and PslI confers susceptibility to antibiotics and leads to drastic reduction in biofilm formation in Pseudomonas aeruginosa. Microbiology (Reading). 2023 169(9). doi: 10.1099/mic.0.001392. PMID: 37702709

24. Trivedi A, Kardam V, Inampudi KK, Vrati S, Gupta D, Singh A, Kayampeta SR, Appaiahgari MB, Sehgal D. Identification of a novel inhibitor of SARS-CoV-2 main protease: an in silico, biochemical, and cell-based approach. FEBS J. 2023. doi: 10.1111/febs.16947. Online ahead of print. PMID: 37657928.

25. Duggal S, Rawat S, Siddqui G, Vishwakarma P, Samal S, Banerjee A, Vrati S. Dengue Virus Infection In Mice Induces Bone Marrow Myeloid Cell Differentiation And Generates Ly6glow Immature Neutrophils With Modulated Functions. J Leukoc Biol. 2023 Aug 30:qiad099. doi: 10.1093/jleuko/qiad099. Online ahead of print. PMID: 37648666.

26. Chhabra S, Kalia M. Guanylate-binding proteins in virus infection. Biochem Soc Trans. 2023 Aug 31;51(4):1621-1633. doi: 10.1042/BST20221500. PMID: 37534998.

27. Bhatnagar A, Burman N, Sharma E, Tyagi A, Khurana P, Khurana JP. Two splice forms of OsbZIP1, a homolog of AtHY5, function to regulate skotomorphogenesis and photomorphogenesis in rice. Plant Physiol. 2023 Aug 31;193(1):426-447. doi: 10.1093/plphys/kiad334. PMID: 37300540.

28. Kumar C, Mylavarapu SVS. Nucleolin is required for multiple centrosome-associated functions in early vertebrate mitosis. Chromosoma. 2023 Aug 24. doi: 10.1007/s00412-023-00808-4. Online ahead of print. PMID: 37615728

29. Halayal RY, Bagewadi ZK, Maliger RB, Al Jadidi S, Deshpande SH. Network pharmacology based anti-diabetic attributes of bioactive compounds from Ocimum gratissimum L. through computational approach. Saudi J Biol Sci. 2023 Sep;30(9):103766. doi: 10.1016/j.sjbs.2023.103766. Epub 2023 Aug 6. PMID: 37588570

30. Mehrotra T, Konar D, Pragasam AK, Kumar S, Jana P, Babele P, Paul D, Purohit A, Tanwar S, Bakshi S, Das S, Verma J, Talukdar D, Narendrakumar L, Kothidar A, Karmakar SP, Chaudhuri S, Pal S, Jain K, Srikanth CV, Sankar MJ, Atmakuri K, Agarwal R, Gaind R, Ballal M, Kammili N, Bhadra RK, Ramamurthy T, Nair GB, Das B. Antimicrobial resistance heterogeneity among multidrug-resistant Gram-negative pathogens: Phenotypic, genotypic, and proteomic analysis. Proc Natl Acad Sci U S A. 2023 Aug 15;120(33):e2305465120. doi: 10.1073/pnas.2305465120. Epub 2023 Aug 7. PMID: 37549252

31. Raheja H, George B, Tripathi SK, Saha S, Maiti TK, Das S. Hepatitis C virus non-structural proteins modulate cellular kinases for increased cytoplasmic abundance of host factor HuR and facilitate viral replication. PLoS Pathog. 2023 Aug 4;19(8):e1011552. doi: 10.1371/journal.ppat.1011552. Online ahead of print. PMID: 37540723

32. Kumar S, Verma R, Saha S, Agrahari AK, Shukla S, Singh ON, Berry U, Anurag, Maiti TK, Asthana S, Ranjith-Kumar CT, Surjit M. RNA-Protein Interactome at the Hepatitis E Virus Internal Ribosome Entry Site. Microbiol Spectr. 2023 Aug 17;11(4):e0282722. doi: 10.1128/spectrum.02827-22. Epub 2023 Jun 29. PMID: 37382527 Free PMC article.

33. Agarwal S, Ghosh R, Verma G, Khadgawat R, Guchhait P. Alpha-ketoglutarate supplementation reduces inflammation and thrombosis in type 2 diabetes by suppressing leukocyte and platelet activation. Clin Exp Immunol. 2023 Jul 27:uxad086. doi: 10.1093/cei/uxad086. Online ahead of print. PMID: 37498307

34. Bharadwaj A, Sharma J, Singh J, Kumari M, Dargar T, Kalita B, Mathew SJ. Musculoskeletal defects associated with myosin heavy chain-embryonic loss of function are mediated by the YAP signaling pathway. EMBO Mol Med. 2023 Jul 26:e17187. doi: 10.15252/emmm.202217187. Online ahead of print. PMID: 37492882

35. Bhattacharjee E, Thiruvengadam R, Ayushi, Das C; GARBH-Ini Team; Wadhwa N, Natchu UCM, Kshetrapal P, Bhatnagar S, Majumder PP, Maitra A. Genetic variants associated with spontaneous preterm birth in women from India: a prospective cohort study. Lancet Reg Health Southeast Asia. 2023 14:100190. doi: 10.1016/j.lansea.2023.100190. eCollection . PMID: 37492417

36. Sahu A, Pradhan D, Veer B, Kumar S, Singh R, Raza K, Rizvi MA, Jain AK, Verma S. In silico screening, synthesis, characterization and biological evaluation of novel anticancer agents as potential COX-2 inhibitors.Daru. 2023. doi: 10.1007/s40199-023-00467-x. Online ahead of print. PMID: 37454036

37. Biswas B, Rana A, Gupta N, Gupta I, Puria R, Thakur A. A Novel Robust Method Mimicking Human Substratum To Dissect the Heterogeneity of Candida auris Biofilm Formation.Microbiol Spectr. 2023: e0089223. doi: 10.1128/spectrum.00892-23. Online ahead of print. PMID: 37439683

38. Pal P, Khan MY, Sharma S, Kumar Y, Mangla N, Kaushal PS, Agarwal N. ResR/McdR-regulated protein translation machinery contributes to drug resilience in Mycobacterium tuberculosis. Commun Biol. 2023 6(1):708. doi: 10.1038/s42003-023-05059-8. PMID: 37433855

39. Kar A, Jain D, Kumar S, Rajput K, Pal S, Rana K, Kar R, Jha SK, Medatwal N, Yavvari PS, Pandey N, Mehta D, Sharma H, Bhattacharya D, Pradhan MK, Sharma RD, Srivastava A, Agrawal U, Mukhopadhyay A, Sengupta S, Patil VS, Bajaj A, Dasgupta U. A localized hydrogel-mediated chemotherapy causes immunogenic cell death via activation of ceramide-mediated unfolded protein response. Sci Adv. 2023;9(26):eadf2746. doi: 10.1126/sciadv.adf2746. PMID: 37390205

40. Mirgane HA, More KS, Rode AB, Puyad AL, Bhosale SV. Molecular nanoarchitectonics of proton triggered tetraphenylethylene-based detector: colorimetric, reversible, and intracellular pH. Anal Methods. 2023. doi: 10.1039/d3ay00663h. Online ahead of print. PMID: 37404009

41. Yadav S, Parijat P, Krishnan V. Crystal structure of the pilus-specific sortase from early colonizing oral Streptococcus sanguinis captures an active open-lid conformation. Int J Biol Macromol. 2023;243:125183. doi: 10.1016/j.ijbiomac.2023.125183. PMID: 37276901

42. Madni ZK, Kumar A, Kumar U, Jaiswal D, Salunke DM. Dynamics of lipid displacement inside the hydrophobic cavity of a nonspecific lipid transfer protein from Solanum melongena. J Biomol Struct Dyn. 2023;41(12):5839-5849. doi: 10.1080/07391102.2022.2097956. PMID: 35838149

43. Kumar P, Zehra A, Saini M, Mathew SJ. Zeb1 and Tle3 are trans-factors that differentially regulate the expression of myosin heavy chain-embryonic and skeletal muscle differentiation. FASEB J. 2023 37(8):e23074. doi: 10.1096/fj.202201698RR. PMID: 37392376

44. Pant A, Maiti TK, Mahajan D, Das B.Human Gut Microbiota and Drug Metabolism. Microb Ecol. 2023 86(1):97-111. doi: 10.1007/s00248-022-02081-x. PMID: 35869999 .

45. Bhatnagar A, Burman N, Sharma E, Tyagi A, Khurana P, Khurana JP. Two splice forms of OsbZIP1, a homolog of AtHY5, function to regulate skoto- and photo-morphogenesis in rice.Plant Physiol. 2023 kiad334. doi: 10.1093/plphys/kiad334. Online ahead of print. PMID: 37300540

46. Kalakoti Y, Peter SC, Gawande S, Sundar D.Modulation of DNA-protein Interactions by Proximal Genetic Elements as Uncovered by Interpretable Deep Learning. J Mol Biol. 2023 435(13):168121. doi: 10.1016/j.jmb.2023.168121. PMID: 37100167

47. Ragini, Sakshi, Mani I, Singh V. Applications of bioinformatics in epigenetics. Prog Mol Biol Transl Sci. 2023;198:1-13. doi: 10.1016/bs.pmbts. PMID: 37225316

48. Markandey M, Bajaj A, Verma M, Virmani S, Singh MK, Gaur P, Das P, Srikanth CV, Makharia G, Kedia S, Ahuja V. Fecal microbiota transplantation refurbishes the crypt-

associated microbiota in ulcerative colitis. iScience. 2023 26(5):106738. doi: 10.1016/j.isci.2023.106738. PMID: 37216124 .

49. Yadav K, Arora D, Jatain I, Dubey KK, Dhaka N, Kaur I, Adlakha N. Combining in silico and in vitro approaches to understand the involvement of MEP and shikimate pathway in Agrobacterium tumefaciens for enhanced CoQ10 production. J Appl Microbiol. 2023. doi: 10.1093/jambio/lxad097. Online ahead of print. PMID: 37160352

50. Satange R, Jin P, Hou MH, Rode AB. Editorial: Non-canonical nucleic acid structures, functions and their applications for understanding human genetic diseases. Front Genet. 2023 14:1188978. doi: 10.3389/fgene.2023.1188978. eCollection 2023. PMID: 37091795

51. Sharma A, Zehra A, Mathew SJ. Myosin heavy chain-perinatal regulates skeletal muscle differentiation, oxidative phenotype and regeneration. FEBS J. 2024 1(13):2836-2848. doi: 10.1111/febs.17085. PMID: 38358038

52. Chaudhary M, Kumar A, Bala Sharma K, Vrati S, Sehgal D.In silico identification of chikungunya virus replication inhibitor validated using biochemical and cell-based approaches. FEBS J. 2024 291(12):2656-2673. doi: 10.1111/febs.17066. PMID: 38303163

53. Kumar V, Sari AN, Gupta D, Ishida Y, Terao K, Kaul SC, Vrati S, Sundar D, Wadhwa R. Anti-COVID-19 Potential of Withaferin-A and Caffeic Acid Phenethyl Ester. Curr Top Med Chem. 2024;24(9):830-842. doi: 10.2174/0115680266280720231221100004. PMID: 38279743

54. Sarkar R, Chhabra S, Tanwar M, Agarwal N, Kalia M.Japanese encephalitis virus hijacks ER-associated degradation regulators for its replication. J Gen Virol. 2024 105(5). doi: 10.1099/jgv.0.001995. PMID: 38787366

55. Dawane A, Deshpande S, Vijayaraghavreddy P, Vemanna RS. Polysome-bound mRNAs and translational mechanisms regulate drought tolerance in rice. Plant Physiol Biochem. 2024 208:108513. doi: 10.1016/j.plaphy.2024.108513. Online ahead of print. PMID: 38513519

56. Chauhan M, Arshi SA, Narayanan N, Arfin HU, Sharma A. mechanistic insight on how Compromised Hydrolysis of Triacylglycerol 7 (CHT7) restrains the involvement of it's CXC domain from quiescence repression. Int J Biol Macromol. 2024 130844. doi: 10.1016/j.ijbiomac.2024.130844. Online ahead of print. PMID: 38484809

57. Thakral V, Raturi G, Sudhakaran S, Mandlik R, Sharma Y, Shivaraj SM, Tripathi DK, Sonah H, Deshmukh R. Silicon, a quasi-essential element: Availability in soil, fertilizer regime, optimum dosage, and uptake in plants. Plant Physiol Biochem. 2024 208:108459. doi: 10.1016/j.plaphy.2024.108459. Online ahead of print. PMID: 38484684

58. Yadav P, Rana K, Nardini V, Khan A, Pani T, Kar A, Jain D, Chakraborty R, Singh R, Jha SK, Mehta D, Sharma H, Sharma RD, Deo SVS, Sengupta S, Patil VS, Faccioli LH, Dasgupta U, Bajaj A. Engineered nanomicelles inhibit the tumour progression via abrogating the prostaglandin-mediated immunosuppression. J Control Release. 2024 368:548-565. doi: 10.1016/j.jconrel.2024.03.009. Online ahead of print. PMID: 38462044

59. Sharma J, Mondal S, Kumari M. Mitochondrial calcium: An essential element for skeletal muscle performance and function. J Physiol. 2024 . doi: 10.1113/JP286218. Online ahead of print. PMID: 38439553.

60. Shukla S, Murmu S, Mora T, Dhanasekaran K, Roy RP. Unravelling HDAC Selectivity for Erasing Acetyl Mark on Lys-5□of Histone H2B. Chembiochem. 2024 25(5):e202300875. doi: 10.1002/cbic.202300875. PMID: 38251898

61. Kaur E, Agrawal R, Arun R, Madhavan V, Srivastava V, Kumar D, Rath PP, Kumar N, Vedagopuram S, Pandey N, Priya S, Legembre P, Gourinath S, Bajaj A, Sengupta S. Small molecules that disrupt RAD54-BLM interaction hamper tumor proliferation in colon cancer chemoresistance models. J Clin Invest. 2024 e161941. doi: 10.1172/JCI161941. Online ahead of print. PMID: 38421735

62. Kar A, Agarwal S, Singh A, Bajaj A, Dasgupta U. Insights into molecular mechanisms of chemotherapy resistance in cancer. Transl Oncol. 2024 42:101901. doi: 10.1016/j.tranon.2024.101901. Online ahead of print. PMID: 38341963

63. Safwan SM, Kumar N, Mehta D, Singh M, Saini V, Pandey N, Khatol S, Batheja S, Singh J, Walia P, Bajaj A. Xanthone Derivatives Enhance the Therapeutic Potential of Neomycin against Polymicrobial Gram-Negative Bacterial Infections. ACS Infect Dis. 2024 10(2):527-540. doi: 10.1021/acsinfecdis.3c00471. PMID: 38294409

64. Kalita B, Sahu S, Bharadwaj A, Panneerselvam L, Martinez-Cebrian G, Agarwal M, Mathew SJ. The Wnt-pathway corepressor TLE3 interacts with the histone methyltransferase KMT1A to inhibit differentiation in Rhabdomyosarcoma. Oncogene. 2024 43(7):524-538. doi: 10.1038/s41388-023-02911-3. PMID: 38177411

65. Pal, G., Ingole, K.D., Yavvari, P.S., Verma, P., Kumari, A., Chauhan, C. Chaudhary D, Srivastava A, Bajaj A, Vemanna RS. Exogenous application of nanocarrier-mediated double-stranded RNA manipulates physiological traits and defence response against bacterial diseases. Molecular Plant Pathology, 2024, ,25, e13417.

66. Kaushik JK, Krishnan V, von Ossowski I. Editorial: Functional insights into the probiotic mechanisms of surface protein action. Front Microbiol. 2024 14:1355529. doi: 10.3389/fmicb.2023.1355529. PMID: 38249455 Free PMC article.

67. Kumar N, Sharma S, Kaushal PS. Cryo- EM structure of the mycobacterial 70S ribosome in complex with ribosome hibernation promotion factor RafH. Nat Commun. 2024 15(1):638. doi: 10.1038/s41467-024-44879-y. PMID: 38245551 Free PMC article.

68. Prajapat SK, Mishra L, Khera S, Owusu SD, Ahuja K, Sharma P, Choudhary E, Chhabra S, Kumar N, Singh R, Kaushal PS, Mahajan D, Banerjee A, Motiani RK, Vrati S, Kalia M. Methotrimeprazine is a neuroprotective antiviral in JEV infection via adaptive ER stress and autophagy. EMBO Mol Med. 2024 16(1):185-217. doi: 10.1038/s44321-023-00014-w. PMID: 38177535

69. Kupani M, Pandey RK, Vashisht S, Singh S, Prajapati VK, Mehrotra S. Prediction of an immunogenic peptide ensemble and multi-subunit vaccine for Visceral leishmaniasis using bioinformatics approaches. Heliyon. 2023 9(12):e22121. doi: 10.1016/j.heliyon.2023.e22121. PMID: 38196838

70. Sharma KB, Chhabra S, Kalia M. Japanese Encephalitis Virus-Infected Cells. Subcell Biochem. 2023;106:251-281. doi: 10.1007/978-3-031-40086-5_10. PMID: 38159231

Book Chapters

1. Tyagi S, Yadav RK, Krishnan V (2024). Determination of the Crystal Structure of the Cell Wall-Anchored Proteins and Pilins. In: Ton-That Hung (Eds) The Bacterial Cell Wall. Methods in Molecular Biology (Humana, New York) 2727: 159-191.

2. Sharma KB, Chhabra S, Kalia M (2023) "Japanese Encephalitis Virus-Infected Cells" Subcell Biochem 2023;106:251-281. doi: 10.1007/978-3-031-40086-5_10

3. Arora A, Kaushal PS#. (2023). Cryo-EM in the study of ribosome biogenesis. CRC Press Taylor & Francis Group.

Patent Applications

1. Guchhait Prasenjit and Asthana Shailendra (Resubmitted on June' 2023) 1,2-Disubstituted benzimidazolyl amino acids inhibits flaviviruses infection. Reference number 202011005513. From the Translational Health Science Technology Institute, Faridabad, India; Regional Centre for Biotechnology, Faridabad, India.

2. Shinde K, Ojha D, Vemanna R, Rode AB (2023). Novel small molecule modulators of CRISPR-Cas9 activity and method thereof; Indian Patent Application No. 202311058528.

ACADEMIC & TRAINING ACTIVITIES

ACADEMIC PROGRAMMES

1. PhD Programme in Biotechnology

RCB offers doctoral programme in Biotechnology to students holding a post-graduate degree (or an equivalent) in any field of science, medicine or technology and interested in pursuing research at the interface of multiple disciplines in the areas related (but not limited) to structural biology, molecular medicine, infectious disease biology, agricultural biotechnology, systems and synthetic biology, cancer & cell biology.

Currently, 105 students are pursuing PhD Programme in Biotechnology at RCB. During the period of this report, 12 students graduated with PhD degree.

2. PhD Programmes in Biostatistics & Bioinformatics

RCB offers an interdisciplinary doctoral programme in Biostatistics and Bioinformatics supported through a collaboration with the global pharmaceutical giant, GlaxoSmithKline Pharmaceuticals India Private Ltd. (GSK). These programmes are subject to RCB statutes, ordinances and regulations.

In addition to RCB faculty members, a virtual adjunct faculty pool created from partner institutions (IIT Delhi, NII New Delhi, ICGEB New Delhi, NIBMG Kalyani) act as mentors for the students admitted to these programme. Students receive a consolidated fellowship of Rs. 45000 per month for the first two years and Rs. 50000 for the next three years.

Currently, 10 students are pursuing PhD Programme in Biostatistics/Bioinformatics at RCB. During the period of this report, 01 student graduated with PhD degree.

3. MS-PhD Programme in Biotechnology

RCB introduced a MS-PhD Programme in Biotechnology in 2018-19 with focus on research-based learning. The programme provides extensive learning opportunities in the broad field of life sciences and biotechnology through rigorous classroom study and hands-on laboratory experiments. In the second year, the students work under the supervision of a faculty at RCB, in an area of mutual scientific interest, and submit a dissertation by the end of the fourth semester.

A student may exit the programme with a Master's degree or continue in the programme for pursuing PhD. The students admitted to the programme receive the RCB Ramachandran-DBT fellowship of Rs. 16000 per month for the first two years, after which, the Indian students continue in the PhD component with a fellowship from a national funding agency while the foreign students receive the RCB-DBT International Doctoral fellowship. At present, 57 students are registered in the programme. During the reporting period 15 students quit the programme with M.Sc. degree

4. Research & Training Programme at RCB

RCB offers research training to post-graduate students of biotechnology related areas from various universities/ institutions/ colleges of repute to carry out their project work towards partial fulfilment of their post-graduate degrees.

Short-term summer trainings/ internships are also offered to students interested in research areas of specialization in RCB. Selection is based on the strength of resume and evaluation of write-up on their research interests. Selected candidates undergo research training under the mentorship of RCB faculty. They learn to carry out their own research projects in collaboration with other group members. Trainees get a realistic experience of several facets of conducting modern biological research and embarking on a research career. The training programmes range from two to six months' duration.

During 2023-24, 39 research trainees joined for research and training programme at RCB.

5. Academic Programmes at RCB's Recognized Centers

RCB has granted academic recognition to the various institutions of excellence, as per Clause 10(1) f of the RCB Act and RCB Ordinance, for their academic programmes. Students admitted to these programmes are registered at RCB for their degrees. At present, following 15 institutions and their academic programmes are recognized by RCB. The number of students registered under the various programmes are provided below:

Name of Recognized Centre	Courses Recognized	Students Registered	Adjunct faculty
Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad	PhD (Biotechnology)	59	22
Center of Innovative and Applied Bioprocessing (CIAB), Mohali	PhD (Biotechnology)	2	8
National Institute of Animal Biotechnology (NIAB), Hyderabad	PhD (Biotechnology)	94	20
National Agri-Food Biotechnology Institute (NABI), Mohali	PhD (Biotechnology)	55	13
Institute of Life Sciences (ILS), Bhubaneswar	PhD (Biotechnology)	108	30
Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram	Msc (Biotechnology) PhD (Biotechnology)	39 62	38
Translational Health Science and Technology Institute (THSTI), Faridabad	MSc (Clinical Research; Specialization: Clinical Trials) PhD (Biomedical Sciences)	24 0	15
National Institute of Biomedical Genomics (NIBMG), Kalyani	MS-PhD (Integrated) (Biotechnology; Specialization: Biomedical Genomics)	39	20
	PhD (Biotechnology; Specialization: Biomedical Genomics)	44	
Christian Medical College (CMC), Vellore	PhD (Medical Biotechnology; Specialization: Haematology) PhD (Medical Biotechnology; Specialization: Biomedical Genetics)	15 4	9
National Centre for Cell Science (NCCS), Pune	PhD (Biotechnology)	52	23

ESIC Medical College & Hospital, Faridabad	PhD (Biomedical Sciences)	15	31
Institute of Bioresources and Sustainable Development (IBSD), Imphal	PhD (Biotechnology)	8	13
Institute for Stem Cell Science and Regenerative Medicine (inStem), Bangalore	PhD (Life Sciences)	28	11
Institute of Advanced Virology (IAV), Thiruvananthapuram	PhD (Virology)	1	8
Max Society of Medical Academics Innovation and Research (MSMAIR), New Delhi	Msc (Clinical Research)	13	0
Total	**661**	**261**	

Currently, 661 students are pursuing PhD/MS-PhD/MSc Programme at RCB Recognised Centres. During the period of this report, 65 students graduated from the RCB Recognised Centres.

Webinar/ Seminars

Date & Time	Speaker	Title
3 May, 2023	Prof. Colleen Aldous College of Health Sciences, School of Clinical Medicine, University of KwaZulu-Natal, Durban, South Africa	COVID-19: The importance of the totality of evidence to prevent human suffering
17 July, 2021	Prof. Prabal K. Maiti IISc Bangalore	Nanoscale structure and elasticity of nucleic acid structures
21 July, 2023	Dr. Gopala Krishnan IARI, New Delhi	Integrating genetic and genomic resources for improvement of rice
25 July, 2023	Dr. Yogesh Gupta University of Texas, USA	Structure, specificity and mechanism of RNA cap modification machinery of SARS-CoV-2
24 August 2023	Dr. Sharmila Bapat NCCS, Pune	Gene Regulation and Expression Plasticity in Ovarian Cancer
RCB-THSTI seminar series (1 presentation)		
15 September 2023	Dr. Manjula Reddy CCMB, Hyderabad	Dynamics of the Bacterial Cell Wall
19 September 2023	Dr. Srinivas V Kaveri CNRS France	Immunotherapy with Antibodies: there is more to it than the monoclonals
26 September 2023	Dr. Mahesh K. Kaushik University of Tsukuba, Japan	Solving the Mystery of Sleep: Narcolepsy-sleep Stress and Orexin
14 September 2023	Coordinated by Prof. Deepak Nair	Webinar on "IBDC and its services" with the Department of Biotechnology, VelTech University, Chennai, Tamil Nadu
29 September, 2023	Indian Biological Data Centre	Data Analytics In Agriculture And Medical Biotechnology
11 October 2023 RCB-THSTI seminar series (2nd presentation)	Dr. Tushar K. Maiti (RCB) Dr. Amit K. Yadav (THSTI)	Lipid Stress Response in Cells: Balancing Survival and Death (RCB) Harnessing Omics and Big Data for Understanding Metabolic Changes in NAFLD (THSTI)
8 November 2023 RCB-THSTI seminar series (3rd presentation)	Dr. Deepti Jain (RCB) Dr. Himanshu Gogoi (THSTI)	Structural insights into flagellar and biofilm gene regulation in Pseudomonas aeruginosa. Dendritic cells and lung tolerance

Date & Time	Speaker	Title
24 November 2023	Samrat Mukhopadhyay IISER, Mohali	A Deep Dive into Biomolecular Condensates
30 November 2023	Dr. Swarupa Panda Oslo University Hospital, Norway	Deciphering the Regulation of Ferroptosis by Ubiquitination during Infection and Inflammation
11 December 2023	Prof. P. Balaram Chair Professor, NCBS, Bangalore	Distinguished seminar on 'The Evolution of Biochemistry and the Birth of Biology'
13 December 2023	Dr. Narendra Chirmule Co-founder and CEO Symphony Tech Biologics	Advances in Advanced Therapies
13 December 2023 RCB-THSTI seminar series (4th presentation)	Dr. Sam J. Mathew RCB Dr. Vidushi Gupta THSTI	Targeting pathways regulating differentiation in genetic disorders Insights to optimal child growth and development: A GARBH-Ini birth cohort journey through interdisciplinary perspectives
20 December, 2023	Dr. Gayathri Pananghat IISER,Pune	Mechanistic insights into GTP- dependence and kinetic polarity of FtsZ filament assembly
10 January 2023 RCB-THSTI seminar series (5th presentation)	Dr. Krishnamohan Atmakuri THSTI Ms. Arundhanti Deb RCB	Insights into neonatal sepsis, the challenges it imposes and potential solutions Identification and characterization of host proteins interacting with NS5 protein of Japanese Encephalitis Virus
16 January 2024	Dr. Sahana Holla NCI, NIH	Location Matters: Spatial Control of Epigenetic Inheritance
22 January 2024	Dr. Roop Malik IIT Boambay	Targeting Kinesin on Monolayer Membranes: Implications to Lipid Homeostasis
21 February 2024 RCB-THSTI seminar series (6th presentation)	Dr. Ramu Vemanna RCB Dr. Sankar Bhattacharyya THSTI	Translation-associated proteins positively regulate plant defense against bacterial pathogens Dengue replication in differentiating K562-Megakaryocytes suppresses ROS levels and inhibits differentiation
21 February 2024	Dr. Ranjan Sankarnarayanan CCMB, Hyderabad	Chirality Enforcement during Protein Biosynthesis and its Evolutionary Implications

Date & Time	Speaker	Title
23 February, 2024	Ms Priyanka Manchanda *Organizational Psychologist*	Management Stress and Placement Anxiety
13 March 2024 RCB-THSTI seminar series (7th presentation)	Dr. Prasenjit Guchhait RCB Dr. Sweety Samal THSTI	Gain-of-function Tibetan PHD2$^{D4E;C127S}$ mutations protect from viral infections in hypoxia The quest for an indigenous, universal influenza vaccine
05 March, 2024	Dr. Sumeet Pal Singh Assistant Professor, University of Brussels, Belgium	Exploring the Mysteries of the liver in relation to regeneration and stress response
08 March, 2024	Manjiri Bakre Founder and CEO OncoStem Diagnostics Pvt Ltd	Entrepreneurship as a career option: A case in point
19 March 2024	Dr. Sanjeev Shukla IISER, Bhopal	Unraveling the Nexus: Hypoxic Tumor Microenvironment and Alternative Splicing

Events Organized

14th AFOB Regional Symposium

The AFOB Regional Symposium (ARS) is an annual event of the Asian Federation of Biotechnology (AFOB). The 14th ARS 2023 was held in the Regional Centre for Biotechnology, Faridabad, Haryana (National Capital Region) in collaboration with AFOB from April 27-29, 2023 on the theme 'Innovations and Emerging Technologies in Asian Biotechnology'. The 14th ARS 2023 focussed on the recent research findings on bioscience and biotechnology among the researchers, scientists & entrepreneurs from various countries under AFOB's partnership. Interactive sessions were held on diverse domains of biotechnology such as agriculture and food biotechnology, vaccines and biopharmaceuticals, biofuel and bioenergy, environmental biotechnology, bio-industry promotion and bio-entrepreneurship. Eminent researchers from across the globe participated in the symposium along with young scientists and students.

Hindi Pakhwada 2023

Hindi Pakhwada (Fortnight) is celebrated every year during the month of September and Hindi Diwas on 14th September to promote the progressive use of official language, Hindi, in government offices in compliance with the Official Language Policy of the Government of India. In this sequence, Hindi Pakhwada was organized from 14 to 29 September 2023 at the Regional Centre for Biotechnology.

The closing ceremony of the fortnight was held on 5 October 2023 under the chairmanship of the Executive Director, RCB at M. K. Bhan Auditorium. On this occasion Dr. Arvind Sahu (Executive Director, RCB), Dr. R.P. Roy (Dean Academics, RCB) and Dr. Nidhi Sharma (Hindi Nodal Officer, RCB), apprised the personnel about the importance of Hindi and its history. A total of seven competitions were organized during the fortnight in which the personnel and research students participated enthusiastically. The Executive Director and the Dean (Academics) jointly gave cash awards and certificates to the winning employees during the event.

Swachhata Pakhwada 2023

RCB observed Swachhta Pakhwada 2023 during 15 September - 2 October 2023. On this occasion Swachhta Shapath (Swachhta Pledge) was taken by all RCB employees to fulfill India's mission of "Clean India" and to make this massive mass movement a success.

A group Tree plantation programme was carried out on the occasion of Gandhi Jayanthi (2nd October, 2023) as a part of our Swachhata Campaign 3.0, and this activity is aimed at reducing CO_2 emissions and negating the impact of global warming.

Responding to the Hon'ble Prime Minister's appeal for citizen's participation in Swachhata Movement, RCB has taken the following steps:

1. Ban Single use plastic
2. Recycling of scrap materials as stationary products.

As a step towards stopping the use of single use plastic, RCB has issued instructions to stop the entry as well as use of single use plastics and have suggested alternate materials like cloth, paper and corrugated cartons to pack and carry materials in and out of the campus of NCR Biotech Science Cluster.

One Nukkad Natak directed and written by Mr. Sudhir Kumar (Section Officer, RCB) was performed by RCB along with THSTI at Government Girls Primary School, Bhankri to aware them how we can clean our surroundings.

Workshop on 'Basics to Create Successful Bioenterprise'

The workshop was conducted on 27 October, 2023. It was attended by 130 participants from academia and industry. The workshop was inaugurated by MD BIRAC, and Dr. V. Premnath, Dr. Sriram Raghavan, Dr. Kalaivani Ganesan were amongst other speakers.

Vigilance Awareness Week 2023

As per the directives of the Central Vigilance Commission and DBT, the Vigilance Awareness Week 2023 was observed at RCB during 30th October 2023 to 5th November 2023. The official

theme for Vigilance Awareness Week 2023 was "Say no to corruption; commit to the Nation," Accordingly, various activities were scheduled during the period of 'Vigilance Awareness Week 2023'.

Panel Discussion on 'Mobilising Biotechnology for Clean Air'

In celebration of 'World Science Day for Peace and Development' (which is celebrated every year on 10 November), RCB, UNESCO, UNEP and WHO, owing to mutual concern about air pollution on human health, organized a Panel Discussion on **'Mobilising Biotechnology for Clean Air'** on 7 November, 2023 at RCB, Faridabad. This event was attended by about 200 participants from school children, students, researchers, clinicians, start-ups, entrepreneurs, farmers, scientists and researchers.

The event was co-organized by RCB, UNESCO, UNEP and WHO.

2nd Convocation Ceremony 2023

Regional Centre for Biotechnology organised its 2nd Convocation Ceremony on 12 December 2023 at the M K Bhan Auditorium. The degrees were conferred to the students of PhD and Master's programmes, who passed out in academic sessions till 2022-23 by the Chief guest Prof. P. Balaram, Chair Professor, NCBS-Bangalore.

The Convocation began with a grand academic procession followed by Saraswati Vandana sung by the students of RCB. The Convocation was declared 'Open' by Dr. Rajesh Gokhale, the Secretary, DBT and Chairperson, Board of Governors, RCB. The Director's Report was presented by Dr. Arvind Sahu, the Executive Director, RCB.

A total of 130 students graduated. 53 PhD in Biotechnology and 77 Master of Science in Biotechnology degrees were awarded to the students.

Prof. P. Balaram, Chair Professor, NCBS-Bangalore addressed the Convocation. The Convocation was declared 'Closed' by Dr. Rajesh Gokhale, Secretary, Department of Biotechnology and Chairperson, Board of Governors, RCB.

Summer Research Internship Programme Facilitated by Gujarat State Biotechnology Mission GSBTM)

Regional Centre for Biotechnology organised a Summer Research Internship Programme facilitated by Gujarat State Biotechnology Mission (GSBTM), Department of Science and Technology, Govt. of Gujarat was from 05.06.2023 to 04.07.2023.

The main objective of the Programme was to provide early exposure to the students pursuing MSc/BE (Biotech) in Biotechnology and allied areas of Biotechnology about the research environment and mechanism that can help them take better career decisions.

A total number of 13 interns were allotted for the Programme who successfully completed their internship with hands-on exposure in the areas of Biotechnology like Cell Biology, Stem Cells, Agricultural Biotechnology, Industrial Biotechnology, Structural Biology, Virology, Animal Models and Cancer Biology in order to help them build an interest and enthusiasm to pursue higher education and instill a sense of aspiration to do future research in places of repute like RCB.

A Biotechnology Career Counselling session was also setup to help them decide on their future career path in the biotechnology industry/research. A visit to the Advanced Technology Platform Centre (ATPC) and BSc BioNEST Bioincubator (BBB) was also organised to enable them to understand the nuances of biotechnology research, and the research possibilities available at RCB.

National Science Day 2024

The National Science Day was celebrated at Regional Centre for Biotechnology on 28th February, 2024. Dr. Arvind Sahu, the Executive Director of the Regional Centre for Biotechnology, gave a welcome address to start off the National Science Day. The students' debated on the Topic: Artificial Intelligence – a boon or a bane for scientific progress. The students of RCB gave Pitch Talks and presented Posters after the Science Day Programme.

RCB Foundation Day 2024

In 2016, RCB was ordained with the status of an "Institution of National Importance" through an Act of the Parliament. It was brought into effect by a Gazette notification on 1st March, 2017. To commemorate this momentous occasion, 1st March has been adopted as the RCB Day.

The Foundation Day started out with mini-symposium presentations made before the panel of judges by the final year PhD students and the award for the best scientific presentation was distributed to the winners. After lunch, Dr. Arvind Sahu, the Executive Director of the Regional Centre for Biotechnology, gave a welcome speech to start off the programme. The day's guest of honour, Prof. Vasant Shinde, CSIR Bhatnagar Fellow, CCMB Hyderabad, visited RCB and delivered the RCB Day Oration followed by a splendid cultural performance by Padmashri Pt. Vishwa Mohan Bhatt and Prize distribution and felicitation.

International Women's Day 2024

On 08th March, 2024, the Regional Centre for Biotechnology observed International Women's Day. Guest of Honour for the day, Dr. Manjiri Bakre (Founder & CEO, OncoStem Diagnostics Pvt. Ltd. Bangalore) delivered a talk on the topic 'Entrepreneurship as a career option: a case in point'.

Outreach Programmes

Regional Centre for Biotechnology organised various outreach programmes as a part of the Scientific Social Responsibility (SSR) activity under SERB to imbibe a culture of social commitment among SERB Grantees. The following Programmes were organised:

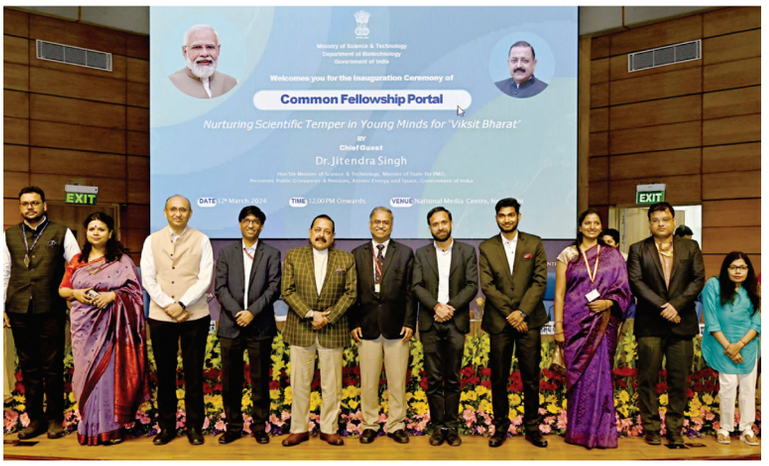
- Visit of students from DAV Public School, Sainik Colony, Faridabad on 28.11.2023.
- Visit of students from Delhi Public School, Vasant Kunj, Delhi on 18.12.2023.

The 'i3c BRIC-RCB PhD Programme in Biosciences': RCB has been entrusted with the responsibility of implementing the 'i3C BRIC-RCB PhD Programme in Biosciences', a common PhD program for all the Department of Biotechnology (DBT)-supported autonomous institutions which have been subsumed under the newly set up Biotechnology Research and Innovation Council (BRIC). The programme was launched by the Hon'ble Minister S&T on 5 February, 2024.

RCB has received the funding support for implementing the 'i3C-BRIC RCB PhD Programme in Biosciences'. It has been successful in securing support from the "Grand Challenges India" for supporting the 3 months immersion program. The institution is also in talks with

philanthropists to secure donations to support the G. N. Ramachandran Fellowship for Track II admission and has already received 2.0 Cr.

Launch of Common Fellowship Portal: Hon'ble Union Minister (IC) S&T, Dr. Jitendra Singh launched the Common Fellowship Portal- a single interface between applicants and various fellowship schemes by Department of Biotechnology, on 12 March 2024 at the National Media Centre. The Portal will streamline the entire fellowship process on one click and will serve as a gateway to research aspirations.



Scientific and Other Events Conducted

Prof Deepak T Nair

1. 17th Annual International Biocuration Conference held from 4-6 March, 2024 at the Regional Centre for Biotechnology
2. Workshop on IBDC and its services was conducted for participants from Vel Tech University, Chennai, on 14 September, 2023.
3. A thematic virtual lecture, "Data Analytics in Agriculture and Medical Biotechnology," was organized on 29 September 2023 as part of DBT events to showcase the Department of Biotechnology's 9 years of achievement.

Dr. Vengadesan Krishnan

1. RCB day at the Regional Centre for Biotechnology, Faridabad, on 1 March , 2024.
2. An online workshop on Improving research writing using Grammarly on 20 November , 2023.
3. An online webinar on Professional Science Figures in Minutes using Biorender on 27 March, 2024.

Prof Tushar Kanti Maiti

1. Organized Workshop on Biomedical Proteomics and Data Analysis at "Regional Centre for Biotechnology, Faridabad on 23 November, 2023.

Prof Chittur V Srikanth

1. Co-organized the joint panel discussion on 'Mobilising Biotechnology for Clean Air' on 7 November, 2023 at RCB, Faridabad. Event supported by RCB, UNESCO, UNEP and WHO
2. Co-organized the event entitled, 'Basics to Create Successful Bioenterprise' at RCB, Faridabad on 27 October 2023.

Dr Karthigeyan Dhanasekaran

1. Organized a Two-day training on 3D-SIM microscopy along with Nikon, India team in our ATPC facility on 5-6 March 2024.

Dr. Saikat Bhattacharjee

1. Co-organized the International 'Inositol Phosphates: The more the merrier' online Meeting 9–11 January , 2024.

Dr. Nidhi Adlakha

1. Co-organised International Women's Day.
2. Co-organised RCB Day.
3. Co-organised scientific visit of Delhi University students.

Membership of Professional/Academic bodies/Editorial boards

Prof Deepak T Nair

1. Member, Monitoring Committee Meeting to review Niche Creating High Science/ High Technology Projects (NCP) and Focused Basic Research (FBR) projects under the Healthcare (HTC) Theme of CSIR

2. Member of the National Committee for the International Union of Crystallography (IUCr) of the Indian National Science Academy.
3. Member, Academic Management Committee, Regional Centre for Biotechnology
4. Member, IT Committee, Regional Centre for Biotechnology
5. Head, Advanced Technology Platform Centre of the Regional Centre for Biotechnology
6. Head, Indian Biological Data Centre of the Department of Biotechnology
7. Chairman, Internal Works Committee, Regional Centre for Biotechnology
8. Member, Data Management Group (DMG) of DBT for implementation of BIOTECH PRIDE guidelines
9. Member, Working Group 2: Structural Data in the DMG of DBT
10. Member, of the Technical Committee to review proposals submitted to the European Synchrotron Radiation Facility Access Program of the Regional Centre for Biotechnology
11. Life Member, Indian Crystallographic Association
12. Life Member, Indian Biophysical Society
13. Life Member, Society of Biological Chemists
14. Member, Guha Research Conference
15. Fellow, Indian National Science Academy
16. Member, Equipment Purchase Committee in IAV, Thiruvananthapuram and ICGEB, New Delhi.

Dr. Vengadesan Krishnan

1. Member, Indian Crystallographic Association (ICA)
2. Member, Indian Biophysical Society (IBS)
3. Member, International Union of Crystallography (IUCr)
4. Member, Electron Microscopy Society of India (EMSI)
5. Member, Probiotic Association of India (PAI)
6. Member, Association of Microbiologists of India (AMI)
7. Member, Board of Studies, Regional Centre for Biotechnology

Dr Deepti Jain

1. Member of the selection committee for MK Bhan Post-Doctoral Fellowship program
2. Member, National Committee of International Union of Crystallography, INSA
3. Review Editor of Frontiers in Bioengineering and Biotechnology
4. Member, Indian Crystallography Association (ICA)
5. Member, Society of Biological Chemists (SBC)
6. Member, Electron Microscopy Society of India (EMSI)
7. Member, Protein Society of India (PS)

Dr. Prem S. Kaushal

1. Life Member, Indian Crystallography Association (ICA)
2. Life Member, Electron Microscopy Society of India (EMSI)

Prof Prasenjit Guchhait

1. Follow of the Indian National Science Academy (FNA), 2024
2. Member of the selection committee for Aegis Graham Bell Awards in Life Science, Govt. of India. 2023

3. Member of the Academic committee of Translational Health Science and Technology Institute (THSTI), Faridabad, 2023 – present.
4. Member of the Special Committee of Special Centre for Molecular Medicine, JNU, New Delhi, 2022-2025.
5. Member of the Academic committee of ESIC Hospital and Medical College, Faridabad, 2022-present.
6. Steering committee member of the Good Clinical Practice Professional Certification Scheme (GCPPCS), CDSA, THSTI, Faridabad. 2020-present.
7. Member of the Board of Study of the Apeejay Stya University, Gurugram. 2019-present.
8. Member of the Editorial Board for the journals, *Frontiers in Hematology*; *Annals of Clinical and Experimental Immunology*; *Cardiology: Open Access; Journal of Hypertension and Cardiology*; *World Journal of Hypertension,* 2012 onward.

Prof Tushar Kanti Maiti

1. General Secretary, Proteomics Society of India
2. Editorial Board Member, Scientific Reports
3. Member, American Society for Biochemistry and Molecular Biology

Prof. Sam J Mathew

1. Member, Institutional Stem Cell Research Committee, THSTI, Faridabad
2. Member, Indian Society for Developmental Biology (InSDB)
3. Member Secretary of the RCB Institutional Animal Ethics Committee (IAEC).
4. Member of the RCB Institutional Biosafety Committee (IBSC).

Prof Sudhanshu Vrati

1. Life Member, Indian Society for Cell Biology
2. Life Member, Society of Biological Chemists, India
3. Life Member, Association of Microbiologist of India
4. Life Member, Indian Immunology Society
5. Life Member, Indian Virology Society
6. Editorial Board Member, Therapeutic Advances in Vaccines (SAGE, UK)
7. Member, Covid-19 Solidarity vaccine Trial - WHO Candidate Vaccine Prioritization Working Group
8. Coordinator, Indian SARS-CoV-2 Genomics Consortium (INSACOG)
9. Chairman, Bharat Immunologicals and Biologicals Corporation Ltd. (BIBCOL)
10. Member, Advisory Board, Asian Federation of Biotechnology
11. Co-Chair, National Expert Committee for BSL-4 at DRDE, Gwalior
12. Chairman, Preliminary Design Review Committee, DRDE, Gwalior
13. Member, Confederation of Indian Industry (CII) National Committee on Biotechnology

Prof Chittur V Srikanth

1. Member, American Society for Microbiology
2. Editorial advisory board member, Journal of Gastrointestinal Infections
3. Member of Technical Evaluation committee of Infectious Disease Biology of DBT
4. Member of the MoE STARS grant (subcommittee on Cancer Biology)
5. Reviewer of mSphere and World Journal of Gastroenterology

Prof. Manjula Kalia

1. Member, American Society for Microbiology
2. Editor for Microbiology Spectrum
3. Review Editor for Frontiers in Cellular & Infection Microbiology
4. Review Editor for Frontiers in Neurology

Prof Arup Banerjee

1. Contributing member of the F1000 Faculty Infectious Diseases of the Nervous System Section in F1000Prime (https://f1000.com/prime)
2. Editorial Board member (Infectious Diseases) of Scientific Reports
3. Review editor, Virology section, Frontiers in Microbiology
4. Reviewer for Ph.D. Thesis from BHU, Calcutta University and IIT, Roorkee

Dr Anil Thakur

1. Reviewer for Scientific Report
2. Reviewer of Journal of Pharmaceutical Research International

Prof Avinash Bajaj

1. 2024-Present: Fellow National Academy of Sciences (FNASc) Allahabad, India.
2. 2024-Present: Member, Technical Expert Committee, Biomedical Science, Department of Biotechnology, Govt. of India.
3. 2022-Present: Elected Member, Guha Research Conference, India.
4. 2023-Present: Member, Molecular Immunology Forum, India.
5. 2022-2025: Co-Member: Program Advisory Committee, Biomedical and Health Sciences, SERB.
6. 2022-2025: Member, Travel Grant and Symposia Management (TGSM) Unit of CSIR-HRDG, India.
7. 2022-2025: Member, Technical Expert Committee (TEC), BIRAC, Department of Biotechnology, India.
8. 2023-2024: Member, Technical Expert Committee (TEC), Indian Council of Medical Research (ICMR), New Delhi, India.

Dr. Rajender K Motiani

1. Member, Veterinary Council of India, New Delhi.
2. Member, Rajasthan State Veterinary Council, Jaipur.

Dr Karthigeyan Dhanasekaran

1. Indian Society of Cell Biology member.
2. Indian Society of Chemical Biology member.
3. Indian veterinary council member.
4. Tamil Nadu state veterinary council member.
5. Veterinary Council of India member
6. External doctoral research committee member of Mr. Ajay Pradhan, NCCS.
7. DBT BITP 2023-24: Question Paper Setting Committee member for Cell Biology Immunology
8. ATPC advisory committee member since, Nov 2023.
9. NBRC PhD interview committee member, June 2023

Dr. Saikat Bhattacharjee

1. Member, International Society-Plant Molecular Microbe Interactions (IS-MPMI).

Dr. Divya Chandran

1. Member, DBT Technical Expert Committee (TEC) of Plant Biotechnology.
2. Invited Member, DBT Ramalingaswami Re-entry Fellowship Selection Committee, 2023-24.
3. Associate Editor, Plant Molecular Biology Reporter.
4. Member, International Society for Molecular Plant-Microbe Interactions.
5. Member, British Society for Plant Pathology.

Dr. Ramu S Vemanna

1. Life member – Indian Society of plant physiology (ISPP).
2. Life member – Indian Society for Plant Biochemistry and Biotechnology (ISPBB).

Dr. Prashant Pawar

1. Guest editor for "Methods for Studying the Plant Cell Wall" for Journal of Visualised Experiment.

Prof. Rajendra P Roy

1. Member, Governing Body, NCCS, Pune.
2. Member, Research Area Panel - Scientific Advisory Committee, NCCS, Pune.
3. Member, Research and Academic Advisory Committee, IISER Berhampur.
4. Member, American Peptide Society.
5. Member, Guha Research Conference.
6. Member, Association of Microbiologists of India

Dr. Ambadas B Rode

1. Member, Indian Biophysical Society.
2. Member, Society of Biological Chemists.
3. Member, Indian JSPS (The Japan Society for the Promotion of Science) Alumni Association.

Dr. Nidhi Adlakha

1. Review Editor, Frontiers in Bioengineering and Biotechnology.
2. Member, American Society of Microbiology.

Distinctions, Honours and Awards

Prof Deepak T Nair

1. Felicitated by the Kerala state government in an event titled "Honouring the Bhatnagar Award Winners of Kerala" organised by the Kerala State Higher Education Council and held at CSIR-NIIST, Thiruvananthapuram on 5th February, 2024

Dr Deepti Jain

1. Power fellowship, SERB

Dr. Prem S. Kaushal

1. EMBL Corporate Partnership Programme Fellowship, 2023

Prof Prasenjit Guchhait

1. Fellow of the Indian National Science Academy (FNA), 2024

Prof Sam J Mathew

1. Cover image for the article published in EMBO Molecular Medicine: Bharadwaj A*, Sharma J*, Singh J, Kumari M, Dargar T, Kalita B, and Mathew SJ (2023). Musculoskeletal defects associated with myosin heavy chain-embryonic loss of function are mediated by the YAP signaling pathway. *EMBO Molecular Medicine* 15(9):e17187. doi: 10.15252/emmm.202217187.
2. Lab publication on developing a mouse model to study the congenital musculoskeletal disease Spondylocarpotarsal Synostosis (Bharadwaj et al, EMBO Molecular Medicine, 2023) featured on the news portal "India Bioscience" in September 2023.

Prof Sudhanshu Vrati

1. Elected Fellow, National Academy of Sciences, India
2. Elected Fellow, Indian Academy of Science, Bangalore
3. Elected Fellow, Indian National Science Academy, Mew Delhi
4. Elected Member, Guha Research Conference
5. J C Bose National Fellow, SERB

Dr Anil Thakur

1. Ramalingaswami Fellowship from DBT, India

Dr. Rajender K Motiani

1. DBT/Wellcome Trust India Alliance Intermediate Fellowship (2020-2025).
2. INSPIRE Faculty Fellowship to Jyoti Tanwar, Post-Doctoral fellow in the lab (2022-2027).

Dr. Prashant Pawar

1. DST - INSPIRE Faculty.
2. DBT - Energy Bioscience Overseas Fellowship (Relinquish).

Prof. Rajendra P Roy

1. Elected Fellow, National Academy of Sciences, India.
2. Elected Fellow, Indian National Science Academy.
3. Elected Fellow, Indian Academy of Science.
4. JC Bose National Fellowship

Dr. Ambadas B. Rode

1. JSPS Bridge Fellowship (2024) from Japan Society for the Promotion of Science (JSPS).
2. Ramalingaswami Re-entry fellowship.

Lectures Delivered/Conferences attended/Visits abroad/Outreach

Prof Deepak T Nair

1. Delivered a talk titled "New answers for old questions regarding DNA synthesis by DNA polymerases" at Vistas in Life Sciences 2024 held at Jawaharlal Nehru University, New Delhi, from 21-24 January 2024.
2. Delivered a talk titled "Structural basis of SARS-CoV-2 neutralization by the P4A2 monoclonal antibody" at "International Conference on Structural Biology and Drug Discovery (ICSBDD-2023) held at Gautam Buddha University, Greater Noida during 11-12 October , 2023.
3. Delivered a talk titled "Old Questions and New Answers regarding DNA Synthesis by DNA polymerases" at BIOPHYSIKA-2024: National Conference on Recent Advancements in Biophysics and Structural Biology, held at the Centre for Interdisciplinary Research in Basic Sciences, Jamia Millia Islamia, New Delhi on 28 February, 2024.
4. Participated in the panel discussion titled "How Academic research can be translated?" at BioConnect Industrial Conclave Kerala 2023, organised by the Kerala State Industrial Development Corporation held at Thiruvananthapuram, Kerala from 25-26 May 2023.
5. Delivered a talk titled "The Indian Biological Data Centre: Past, present and Future" at the 17th Annual Biocuration Conference held at RCB, Faridabad, from 6-8 March 2024.
6. Delivered a talk titled "Structural characterization of P4A2-a broadly neutralizing anti-SARS-CoV-2 antibody" at the 50th National Seminar on Crystallography (NSC50) held at IMTECH, Chandigarh during 22-24 November, 2023.
7. Delivered a talk titled "DNA synthesis by DNA polymerases: old questions and new answers" at the 92nd Annual Meeting of the Society of Biological Chemists held at BITS-Pilani, KK Birla Goa Campus during 18-20 December, 2023.
8. Delivered a talk titled "Characterization of P4A2, a broadly neutralizing monoclonal antibody against SARS-CoV-2" organized by MagGenome Technologies Pvt. Ltd. at the "International Conference on Biological Applications of Nanoparticles 2023" on 19 April, 2023 in Chennai, India.

Dr. Vengadesan Krishnan

1. Attended the 17th Annual International Biocuration Conference (AIBC24) organized by RCB and Delhi University Indian Biological Data Center (IBDC), Faridabad during 5-8 March , 2024.
2. Participated and provided support for the Demonstration of Biomolecules and crystals in 3D in the India International Science Festival (IISF) organized by NCR Biotech Science Cluster, Faridabad and National Innovation Foundation (NIF) at NCR Biotech Science Cluster, Faridabad during 17-20 January , 2024.
3. Served as an editor for a special edition on 'Functional insights into the probiotic mechanisms of surface protein action' in Frontiers in Microbiology in December 2023.
4. Attended Clarivate online workshop on 'Basics of Bibliometrics' on 5-6 December, 2023
5. Attended 'Visualising science workshop' held at Regional Centre for Biotechnology on 27-28 November, 2023.
6. Delivered an invited talk on 'Targeting pilus-specific sortase from primary colonizer for controlling dental biofilm or plaque development' and participated in the National Seminar on Crystallography (NSC50) held at CSIR-Institute of Microbial Technology (IMTECH), Chandigarh during 22-24 November, 2023.
7. Attended the Curtain Raiser event of the Global BioIndia 2023 on 'Biotech Innovation ecosystem and Bio-manufacturing' organized by DBT and BIRAC on 3 November, 2023.
8. Delivered a plenary talk on 'Structure-based anti-adhesive approaches for controlling dental plaque development' and participated at the International Conference on

Structural Biology and Drug Discovery (ICSBDD2023) held at Gautam Buddha University (GBU), Greater Noida, India during 11-12 October, 2023.

9. Attended a two-day interactive online course: "SAXS in the pharmaceutical industry" during 4-5 October, 2023.
10. Attended the Wiley webinar on "AI and its impact on Academic publishing" on 1 September , 2023.
11. Participated as one of the instructors in the Hands-on Training course and workshop on "Macromolecular X-ray Crystallography: Principles and Practice" as part of the Prof M Vijayan School conducted at National Institute of Immunology (NII) during 25-29 September , 2023.
12. Attended the Wiley webinar on "Finding hidden treasures: Extend literature search to Online Books", on 24 August 2023.
13. Participated virtually in the launch of the Annual Capacity Building Plans (ACBPs) of the DBT on 17 August, 2023.
14. Attended a one-day workshop conference and meeting on "Optimizing CryoEM for Research: Strategies for Effective Utilization of the Facility" organized by the SATHI Foundation at IIT Delhi on August 2, 2023.
15. Attended an ACS library summit on "Emerging Trends in Scholarly Publishing" on 21 July, 2023.
16. Participated in an online workshop, "Elettra 2.0: New Structural Biology Opportunities" on 3 July, 2023.
17. Attended online workshop on ChatGPT organized by Capacity Building Unit, DBT on 21 June , 2023.
18. Participated in an online Awareness Workshop on Mobile Seva organized by C-DAC and MeitY, Govt of India on 6 June, 2023.
19. Attended the 14th AFOB Regional Symposium (ARS 2023) on "Innovations and Emerging Technologies in Asian Biotechnology" organized by RCB in association with the Asian Federation of Biotechnology at RCB, Faridabad during 27-28 April , 2023.
20. Attended Elsevier webinar on 'Empowering knowledge on ethical publishing: Mastering the art of identifying predatory, fake and cloned journals' on 8 June , 2022.
21. Attended 42nd DeLCON Steering Cum Negotiation Virtual Meeting on 17 April , 2023.

Dr Deepti Jain

1. Delivered an invited talk titled "Structural Insights into FleR, a regulatory checkpoint in flagellar assembly in P. aeruginosa" at the School of Life Sciences, JNU at annual research symposium BIOSPARK on 21 March, 2024
2. Delivered an invited talk titled "Pseudomonas aeruginosa: Structural insights into Biofilm regulation" at the Gargi College, Delhi University, to students of BSc Microbiology (H) on 6 March, 2024
3. Invited talk titled "Structural Insights into Flagellar Gene Hierarchy in *Pseudomonas aeruginosa*" at the Frontiers Symposium at IISER-TVM from 2-4 February 2024
4. Invited talk titled "Structural Insights into Regulation of flagellar genes in *Pseudomonas aeruginosa*" at the National Seminars in Crystallography at IMTECH Chandigarh from 22-24 November 2023
5. Invited talk at the Indo-US International Conference and workshop on antimicrobial resistance and human microbiome titled "Structure-based targeting of bacterial biofilms to overcome antimicrobial resistance" at THSTI, Faridabad from 15-18 November 2023
6. Invited talk titled "Regulation of polar flagellation in *Pseudomonas aeruginosa*" at IISER Bhopal from 24-27 July, 2023
7. Conducted a one-day hands-on structural biology workshop for Biotechnology undergraduate students visiting RCB from various Universities in Gujrat (sponsored by

Gujrat State Biotechnology Mission) on 4 July 2023.

8. Hosted a Visualising science workshop conducted by Nature India and India Alliance on 27-28 November , 2023, at RCB.

Dr. Prem S. Kaushal

1. Delivered an invited title "Sorting structural heterogeneity in single-particle cryo- EM data using RELION" at symposium on Understanding the Breathing of Biomolecules: Recent Advances in Cryo-EM and Chemical Biology organized by IIT Bombay on 7-9 March , 2024
2. Delivered an invited title "Mycobacterial ribosome hibernation: a unique strategy for its survival under hypoxia stress" at symposium on Understanding the Breathing of Biomolecules: Recent Advances in Cryo-EM and Chemical Biology organized by IIT Bombay on 7-9 March, 2024
3. Delivered an invited title "*The unique mode of mycobacterial ribosome hibernation revealed by Cryo- EM studies*" at National Seminar on Crystallography organized by IMTECH Chandigarh on 22-24 November , 2023.
4. Delivered an invited title "*Basic in the cryo- EM data processing*" at one-day introductory seminar series (online mode) on Cryo- Electron Microscopy for Structural Biology organized by NIT Warangal and SASTRA University Thanjavur on 18 November, 2023.(https://youtu.be/BnS-wSmDzH0).
5. Delivered an invited tile "*Cryo- electron microscopy (cryo- EM): the modern technique for the structure determination of biomolecules in atomic resolution*" at Prof. M. Vijayan Meneroal Annual Symposium organized by SASTRA University Thanjavur on 8 - 9 October, 2023.
6. Delivered an invited title "Unique mode of mycobacterial ribosome hibernation revealed through cryo- EM" at a workshop on Optimizing CryoEM for Research: Strategies for Effective Utilization of the Facility organized by SATHI Foundation, IIT Delhi on 2 August, 2023.
7. Delivered an invited titled "Career Prospects in Biotechnology Research" at Manav Rachna International Institute of Research and Studies, Faridabad, on 17th August 2023.
8. Presented poster at the EMBL conference on Protein Synthesis and Translation Regulation, Heidelberg, Germany, on 6-10 September, 2023.

Prof Tushar Kanti Maiti

1. Delivered an invited talk titled 'Deciphering cellular protein homeostasis mechanisms during lipid stress' at the 'The 15th Annual Meeting of the Proteomics Society, India (PSI) and the International Conference on Integrated Proteomics: Applications in Food, Nutrition, and Health (IPAFNH-2023)' organized by National Institute of Plant Genome Research in New Delhi, India, spanning from 20 - 22 November, 2023.
2. Delivered an invited talk titled 'Sample preparation for mass spectrometry based proteomics' at the "Education Day-PSI 2023" organized by National Institute of Plant Genome Research in New Delhi, India, 19 November, 2023.
3. Delivered an invited talk titled 'Clinical Proteomics and Biomarker discovery: Applications in Adverse Pregnancy Outcome' at the 'One-Day Symposium on Proteomics in Biotechnology and Biomedical Sciences for the celebration of Proteomics Day organized by *Translational Health Science and Technology Institute* (*THSTI*), Faridabad, India,18 March 2024.

Prof. Sam J Mathew

1. Delivered the invited talk "Myosins in adult homeostasis and musculoskeletal disease" at the Centre for Cellular and Molecular Biology (CCMB), Hyderabad on 17 April 2023.
2. Delivered the invited online talk "Myosins in adult homeostasis and musculoskeletal

disease" at the National Level Continuing Medical Education one-day symposium on "Emerging Role of Skeletal Muscle in Health and Disease" as part of the Diamond Jubilee of St. John's Medical College, Bengaluru, on 26 May 2023.

3. Hosted 13 undergraduate students from Gujarat, sponsored by the Gujarat State Biotechnology Mission (GSBTM) on 27 June 2023, as part of their month-long visit to RCB, giving the talk "Animal models in research" and conducting practical sessions.
4. Invited speaker at the 5th BIOGroup India meeting where a talk titled "Signals that regulate skeletal muscle structure and function" was delivered at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, 17-18 July, 2023.
5. Delivered the talk "Targeting pathways regulating differentiation in genetic disorders" in the THSTI-RCB seminar series, at the M.K Bhan auditorium, NCR Biotech Science Cluster, on 13 December, 2023.

Prof Sudhanshu Vrati

1. Making of the Indian rotavirus vaccine. Lecture delivered at Bennette University, Greater Noida on 14 September 2023.
2. Foundation Day Lecture, Indian Veterinary Research Institute, Bareilly on 8 December 2023.
3. Session Chair on Chemical and Bio-therapeutics for AMR at the Indo-US International Conference and Workshop on Antimicrobial Resistance and Human Microbiome held at Translational Health Science and Technology Institute, Faridabad on 15 November 2023.
4. Session Chair on Viral Immunology at the Global Immunology Summit 2024 held at Translational Health Science and Technology Institute, Faridabad on 15 February 2024.

Prof Chittur V Srikanth

1. Delivered an invited talk titled, "Effector SUMOylation governs *Salmonella Typhimurium* virulence through modulation of lysosomal function", as a part of Organellar Biology and Membrane Trafficking Meeting held on 9-11October 2023.
2. Delivered an invited talk titled "Rab7 dependent secretory function of intestinal cells in colitis (IBD)", at the international workshop organised by EMBO on SUMOylation: from discovery to translation at Povoa de Varzim, Portugal on 25-28 September 2023.
3. Delivered an invited talk titled '*Rab7-SUMO tug-of-war in gut homeostasis*' at the international conference held at ICGEB, Delhi on 5-7 November 2023.
4. Delivered an invited talk titled '*Salmonella mediated host epigenetic manipulation in immune evasion and chronic infections*' at the national conference held at Science City Kolkata on 4-5 April 2024.
5. Represented RCB and delivered a seminar and poster at the International Symposium of the Category 2 Institutes and Centres under the auspices of UNESCO in the Field of Natural Sciences held at Kuala Lumpur, Malasia during 15-17 May 2024.
6. Participated as a chairperson in the Indo-US international conference & Workshop on Antimicrobial Resistance and Human Microbiome Held at THSTI, Faridabad during 15-18 November 2023.

Dr. Manjula Kalia

1. Delivered an invited talk titled 'Methotrimeprazine is a neuroprotective antiviral in JEV infection through adaptive ER stress and autophagy' at Autophagy India Network meeting, Autophagy dynamics: Insights for Health and Disease, IIT Bombay, 16-18 Feb 2024.
2. Delivered an invited talk titled 'Host-pathogen interactions of Flaviviruses' Organelle Biology and Molecular Trafficking meeting, NBRC, Manesar, 9-11 October , 2023.

3. Delivered an invited talk titled 'Japanese encephalitis virus hijacks ER-associated degradation regulators to derive its replication complex' at IISc Bangalore '7th Molecular Virology Meeting' 22-23 September, 2023.

Dr. Arup Banerjee

1. Delivered an invited talk titled 'Impact of dengue virus infection on neutrophil biogenesis and functions' on the 7th Edition of Molecular Virology Conference, 2023, on 22 -23 September at the Biological Sciences Division of the IISc, Bangalore.
2. Delivered an invited talk titled 'Extracellular Vesicles in Host-viral Interactions and Immune Modulation' on the occasion of International Immunology Day on 29 April 2024, organized by the Department of Molecular and Cellular Medicine, ILBS, New Delhi,

Dr Anil Thakur

1. Participated in "National Technology Week" in Pragati Maidan, New Delhi, from 11-14 May, 2023
2. Participated in "India International Science Festival (IISF)" at NCR Biotech Science Cluster, Faridabad, India, from 17-21 January, 2024.
3. Delivered an invited talk titled "Harmless turned assassin: the story of fungal infection, host pathogen interaction and more". at the workshop on Unveiling microbial drug resistance: Theory and practical insights organized by University School of Biotechnology, Gautam Buddha University, Greater Noida on 12-13 March, 2024

Prof Avinash Bajaj

1. Delivered an invited talk entitled "Engineered Chimeric Nanomicelles Target the Tumor Microenvironment and Activate the T Cell Immunity." at the National Institute of Pharmaceutical Education and Research Ahmedabad on 11 March, 2024.
2. Delivered an invited talk entitled "Engineered Nanomaterials Target the Tumor Microenvironment and Activate the T Cell Immunity." at the International Conference on Translational Materials for Sustainable Technology (TransMAT-2k24) held at the Indian Institute of Technology (BHU), Varanasi, India, from 1-4 February , 2024.
3. Delivered an invited talk entitled "How to Tackle the Failures of Cancer Nanomedicine: A Personal Perspective?" at the ACS Conclave on Engineering Healthcare held in Mysore, India, from 29-31 January, 2024.
4. Delivered an invited talk entitled "Understanding the Role of Sphingolipid and Ganglioside Metabolism in Cancer Therapy" at the Annual Congress of Immuno-Oncology Society of India: I-OSICON 2024, held at the National Centre for Cell Science (NCCS) Pune, India from 12-14 January, 2024.
5. Delivered an invited talk entitled "Impact of Nature Product Chemistry in Healthcare: Challenges and Future Perspective." at the Annual Meeting on Open Dialogue with Other Knowledge Systems held in Shanghai, China, from 19 November - 3 December, 2023.
6. Delivered an invited talk (online) entitled "Engineered Nanomaterials Target the Tumor Microenvironment and Activate the T Cell Immunity." 3rd International Conference on Nanomaterials in Biology (ICNB 2023) held at IIT Gandhinagar, India, from November 19-22, 2023.
7. Delivered an invited talk entitled "Chimeric Nanomicelles Target the Immunosuppression and Activate T Cell Immunity in Tumor Microenvironment." at 7th International Conference on Translational Research, Innovation in Translational Research: Transforming Tomorrow" held at JLN Auditorium, AIIMS, New Delhi, India from 16-18 October, 2023.
8. Delivered an invited talk entitled "Unlocking the Chemistry of Lipids (Bile Acids) for

Cancer Treatment." at a symposium "Frontiers in Chemical Biology and Organic Materials" held at Indian Institute of Science, Bangalore on 21 July, 2023.

9. Delivered an invited talk entitled "Unravelling the Cross-talk between Lipid Metabolism and Tumor Microenvironment for Cancer Therapeutic Strategies" at the Molecular Immunology Forum meeting at the Corbett National Park, Uttarakhand, from 4-8 May, 2023.

Dr. Rajender K Motiani

1. Delivered an invited lecture titled "Role of mitochondria in melanosome biology" at Amity Institute of Biotechnology, Amity University, Gurgaon, 9 May 2023.
2. Delivered a lecture to masters students undergoing training at RCB as part of Gujarat State Biotechnology Mission (GSBTM) titled "Keeping peace with peacekeeper to curtail pancreatic cancer" on 7 June 2023. These students further did one-day rotation in our laboratory.
3. Delivered an invited talk titled "Mitochondrial calcium dynamics is a critical determinant of human skin pigmentation" at 11th India Alliance (DBT/Wellcome Trust) Conclave, Hyderabad, 14 July, 2023.
4. Delivered an invited lecture titled "Zebrafish: Rearing, Breeding, Microinjections and Model System" at 4th Workshop on Basic Training in Animal Handling and Experimentation, Institute of Liver and Biliary Sciences (ILBS), New Delhi, 4 November 2023.
5. Delivered an invited talk titled "Calcium signaling in Pancreatic Cancer: a promising therapeutic pathway" at 1st Kolkata Pancreas Meeting, Indian Institute of Liver and Digestive Sciences (IILDS), Kolkata, 17 Dec 2023.
6. Delivered an invited talk titled "Mitochondrial calcium signaling is an important regulator of vertebrate pigmentation" at "Vistas in Life Sciences 2024" to celebrate the Golden Jubilee of School of Life Sciences, JNU, New Delhi, 22 Jan 2024.
7. Attended FASEB-sponsored International Conference "The Calcium and Cell Function" at Dublin, Ireland 25 to 30 June, 2023. Delivered a selected short talk at this conference on 27 June 2023.
8. Delivered a popular Science talk on "Cancer Biology" for class XI and XII students at Birla Vidya Niketan School, New Delhi, on 8 August 2023.
9. Delivered an invited lecture during National Science Day celebrations at Manav Rachna University, Faridabad, on 23 Feb 2024.

Dr. Karthigeyan Dhanasekaran

1. Delivered a talk titled "Centrosome and Cilia in Disease Pathobiology" at the OBMT meeting, NBRC, Manesar, 9 -10 Oct, 2023.
2. Attended the 39th National Training Program in Biological Electron Microscopy for Scientific Investigators held at AIIMS, SAIF facility between 22 Nov-5 Dec, 2023.

Dr. Saikat Bhattacharjee

1. Delivered an invited Seminar titled 'A rapidly evolving Pseudomonas syringae pathogen effector suppresses immune elicitation at the post-transcriptional/translational level' at the 'Molecular Intricacies of Plant Associated Microorganisms (MIPAM)-2024,' Meeting at Central Tribal University of Andhra Pradesh, Vizianagaram, and Centurion University, Vizianagaram., India, 18-20 March, 2024.

Dr. Divya Chandran

1. Delivered an invited lecture entitled "Here comes the SUN! An inner nuclear envelope protein that regulates plant nuclear dynamics and immunity" as part of the Molecular Intricacies of Plant-Associated Microorganisms organized by Central Tribal University of A.P., on 19 March , 2024.

2. Delivered an invited lecture entitled "Harnessing omics data to dissect plant-pathogen interactions" as part of the National Conference on Plant 'Omics': Recent Trends and Applications organized by Savitribai Phule Pune University, Pune, on 22 February, 2024.
3. Attended the 12th Training Programme on Science and Technology for Rural Societies for Women Scientist and Technologists organized by the Indian Institute of Public Administration (IIPA), New Delhi, from 26 February - 01 March, 2024.
4. Attended a 2-day residential workshop on Design The Thinking® organized by the School of Design Thinking, Chennai, from 08-09 January, 2024.
5. Attended and presented a poster at the 12th International Congress of Plant Pathology (ICPP) organized by the International Society for Plant Pathology and the French Phytopathological Society in Lyon, France, from 18-25 August , 2023.
6. Co-organized the "Visualizing Science Workshop" in partnership with Nature India and DBT Wellcome India Alliance at RCB, Faridabad, from 27-28 November, 2023.

Dr. Ramu S Vemanna

1. Delivered invited talk entitled "Ribosomal RNA biogenesis and translation ability regulate drought tolerance of plants" 20th International Symposium on Rice Functional Genomics (ISRFG2023), held at the University of Agricultural Sciences (UAS), Bangalore on 3-5 November, 2023.
2. Delivered invited talk entitled "Gene editing technologies to create genetic variability to improve agronomic traits and crop protection" at ICGEB- DBT International Conference and Hands-on Workshop on Redesigning Crops for Smart Agriculture, 06–10 November 2023, New Delhi, India.
3. Delivered invited Web talk on "Improving the climate adaption of plants" at Divisional seminar theme "Genetics for Environmental Research: Classical to Modern Biotechnological Intervention" 24 Nov 2023 @ ICFRE-Forest Research Institute, Division of Genetics and Tree Improvement, Dehradun.
4. Delivered invited talk on "Improving the productivity of plant" Department of Biotechnology, Manav Rachna International Institute of Research & Studies, Faridabad and Agilent Technologies, Manesar. Event at Faculty Development Program on "Fundamentals and Applications of Genomics", from 8-13 Jan 2024.
5. Delivered Invited talk on "Translational landscapes regulate the rice development and stress response" at the Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi organised a 3-day workshop titled "Application of Molecular and Genomic Tools for Biofortification in Crops," from 5 - 7 March, 2024.

Dr. Prashant Pawar

1. Delivered an invited talk titled "Effective conversion of lignocellulosic biomass by In planta modification of cell wall properties" at ICRABR Conference, Kapurthala organised by NIBE, MNRE.

Prof. Rajendra P Roy

1. Delivered a talk entitled "An enigmatic sortase endowed with tunable activity" at Guha Research Conference, Havelock, Andaman Islands, 3-6 Nov, 2023.
2. Delivered the Keynote lecture entitled "Fusion of chemistry and protein engineering: Unravelling the secrets of epigenetic modifications" at An Interactive International Conference on Convergence of Scientific Disciplines to Advance Biotechnology (CSDAB) 21-23 Nov, 2023, IISER Berhampur.

Dr. Ambadas B Rode

1. Delivered an invited talk entitled "Role of alternate RNA conformations in human health and disease" at the International Symposium on Nucleic Acids: Prospect and

Therapeutic Applications, organized by National Chung Hsing University, Taichung, Taiwan, from 6- 8 July 2023.

2. Delivered an invited talk entitled "Role of alternate RNA conformations in human health and disease" at the international symposium ANNA 2023, organized by Slovenian NMR Institute Maribor, Slovenia from 18-21 October, 2023.
3. Delivered an invited talk entitled "Unravelling the Mysteries of Nucleic Acids" at the international symposium FISNA 2024, organized by Konan University, Kobe, Japan, from 29 February to 2 March , 2024.

Dr. Nidhi Adlakha

1. Delivered an invited talk titled 'Path to Product-Development of microbial cell factories for innovative bioproduction' held on 23 February, 2023 organised by Shaheed Rajguru College of Applied Sciences for Women, University of Delhi.
2. Attended IISF Mega Expo (IISF2022) held in MANIT, Bhopal from 21- 24 January, 2023.
3. Attended 14th AFOB Regional Symposium from 27-29 April, 2023.

Reviewer of Proposals/Thesis/Research Articles

Prof Deepak T Nair

1. Guest Associate Editor, IUBMB Life for research articles related to "Biochemistry and Molecular Biology of Human RNA viruses"
2. Reviewer for the journals Nucleic Acids Research, Nature Catalysis, Proteins, ChemBiochem & Protein Science.
3. Reviewer of proposals submitted for synchrotron beamtime to the European Synchrotron Radiation Facility Access Program of the Regional Centre for Biotechnology
4. Review of faculty recruitment and promotion applications in two institutes and one university
5. Examiner for PhD theses from IIT, IISc and AcSIR

Dr. Vengadesan Krishnan

1. Viva-voce examiner and reviewer for PhD thesis from International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi.
2. Reviewer for PhD thesis from Jawaharlal Nehru University (JNU), Delhi University (DU), and Indian Institute of Technology (IIT), New Delhi.
3. Reviewer for *Cell Reports, Proteins, Biophysical Chemistry*, *International Journal of Biological Macromolecules, Journal of Biomolecular Structure and Dynamics*, *Archives of Microbiology, Frontiers in Microbiology, Medical Microbiology, Biomedicine, Vaccines, Technology and Health care, Food Chemistry, Pathogens, Vaccines, Protein & Peptide Letters*, *Future Microbiology,* and *Expert Opinion on Therapeutic Targets.*

Dr. Prem S. Kaushal

1. Reviewer for research grants of DST-SERB & DBT

Prof Prasenjit Guchhait

1. Reviewer for R&D Proposals under CSIR-HRDG-ASPIRE Scheme 2024
2. Reviewer of the *DBT/Wellcome* Trust India *Alliance* (India *Alliance*) grants, 2023
3. Reviewer for research proposals for BIRAC, Govt. of India, 2019-present.
4. Reviewer for research grants of DBT and DST (Govt. of India). 2015-present

5. Reviewer for research grants of Council of Science & Technology (Uttar Pradesh Govt.) 2020-2022.
6. Reviewer for scientific journals: *Blood*, *eLife*, *Frontiers in Immunology*, *Emerging Microbes and Infections*; *Antioxidants and Redox Signaling*; *Frontier in Bioscience*; *Journal of Thrombosis and Thrombolysis*; *British Journal of Hematology*; *Haematologica*; *Journal of Immigrant and Minority Health*. 2011-Present
7. Reviewer for PhD thesis of 3 students of other University in India

Prof Tushar Kanti Maiti

1. Reviewers for Biochemical J, Biomacromolecules, J Proteomics, Bioscience Report, Int J Biol. Macromol
2. Reviewer, DST-CRG grant proposal
3. Reviewer, DBT grant proposal
4. Reviewer, PhD thesis from JNU (one), IISER Kolkata (One), AcSIR (IICT Hyderabad) (one), Tezpur University (One)

Prof. Sam J Mathew

1. Reviewer for research proposals for DBT, CSIR, SERB, CEFIPRA, French Muscular Dystrophy Association (AFM-Telethon), Israel Science Foundation, Medical Research Council (UK), and INSERM-CNRS (France).
2. Reviewer for PhD thesis from AcSIR, Indian Institute of Science, Jawaharlal Nehru University, Kalinga Institute of Industrial Technology, Manipal University, and Sastra University.
3. Reviewer for *Acta Physiologica*, *Cell Death and Disease*, *Developmental Biology*, EMBO Molecular Medicine, *FASEB Journal*, *Journal of Cell Science*, *FEBS Letters*, *Molecular Therapy*, *Molecular Therapy-Nucleic Acids*, *IUBMB Life, Frontiers in Immunology* and *Zoology.*

Prof Manjula Kalia

1. Reviewer for *Autophagy, Journal of Virology, mBio, Journal of Medical virology, Vet. Microbiology, Virus Research, Virus Disease,*
2. Reviewer & PhD viva-voce examiner for PhD thesis from IISc Bangalore & NBRC.

Dr Anil Thakur

1. Reviewer for research proposal/grants for SERB-DST, DBT

Prof Avinash Bajaj

1. Reviewer, American Chemical Society.
2. Reviewer, Royal Chemical Society

Dr. Rajender K Motiani

1. Reviewer of research proposals submitted to SERB (Core Research Grants and Power Grants), DBT and Swiss National Science Foundation (SNSF).
2. Reviewer for the Journals: iScience, Cell Calcium, Cells and Scientific Reports.
3. Ph.D. Thesis Examiner of Ms. A Meghana, Institute of Genomics and Integrative Biology (IGIB), New Delhi.
4. Ph.D. Viva Examiner of Ms. Sunanda, Institute of Genomics and Integrative Biology (IGIB), New Delhi.

Dr Karthigeyan Dhanasekaran

1. Reviewer for IEEE Access
2. Reviewer for Cytoskeleton

Dr. Saikat Bhattacharjee

1. Reviewer for *J. Agri. Food Chem*, *Physiol. Mol. Biol. Plants*, *Planta*, and *The Plant J.*
2. Expert Reviewer for multiple DBT proposals.
3. Reviewer of PhD theses from NIPGR (JNU), New Delhi and CUK, Kerala.

Dr. Divya Chandran

1. Ad hoc Reviewer for the *European Journal of Plant Pathology*, *Plant Direct, Frontiers in Plant Science*.
2. Reviewer for Ph.D. thesis for Shiv Nadar University, Delhi University, and Amity University.

Dr. Ramu S Vemanna

1. Proposal reviewer- SERB, CRG Scheme, DBT.
2. Thesis evaluation: "Identification of Finger development associated genes in fingermillet" H.S. Hemashree, M Sc (Agri) degree in Plant Biotechnology, of the University of Agricultural Sciences, Bangalore
3. Manuscript Reviewer for *Plant Biotechnology, Plant Molecular Biology Reporter, Tissue and Organ Culture, Plant Physiology reports, Molecular Biotechnology.*

Dr. Prashant Pawar

1. Reviewer for Frontiers in *Bioengineering and Biotechnology, Frontiers in Energy Research, Plant Physiology and Biochemistry, Journal of Visualised Experiment (JoVE)*.

Ambadas B. Rode

1. Reviewer for DST research grant proposals.
2. Reviewer for *ChemBioChem*, *Journal of Applied Biochemistry and Biotechnology*, *Process Biochemistry*, *Genes*, and *Biomolecules*.

Dr. Nidhi Adlakha

1. Reviewer for research grants of DBT and CSIR.
2. Reviewer for *Applied and Microbial Technology and Infections* and *Biotechnology for Biofuels and Bioproducts.*

EXTRAMURAL ACTIVITIES & NETWORKING

Photo Credit: Sahil Kumar

ESRF Access Program

Regional Centre for Biotechnology (RCB) and the European Synchrotron Radiation Facility (ESRF) had entered into an agreement concerning the medium-term use of synchrotrons for non-propriety research for the benefit of the Indian scientific community as a whole, and notably the structural biology research groups in the country. The program provided access to Indian investigators to experimental stations for macromolecular crystallography, small angle X-ray scattering and Cryo-Electron Microscopy located in ESRF.

The DBT-supported ESRF access program of the RCB helped Indian researchers carry out experiments at this unique facility located in Grenoble, France. The program was flagged off in June 2017 by the Honourable Minister for Science & Technology, Dr. Harsh Vardhan, in the presence of the then Executive Director, Prof. Sudhanshu Vrati, and the then DBT Secretary, Prof. K. VijayRaghavan. The next DBT Secretary, Dr. Renu Swarup, supported the renewal of the agreement by Prof. Vrati and Dr. Francesco Sette (Director General, ESRF) for another three years till January 2023. The program has now ended on 31st January 2024 due to a lack of adequate funding to renew the agreement between RCB and ESRF.

In the last seven years, researchers from 30 different institutes from all over India have obtained X-ray diffraction, small angle X-ray scattering, or Electron Microscopy data for different macromolecules and macromolecular assemblies. The list of institutions are as follows: - All India Institute of Medical Sciences (New Delhi), CSIR-Central Drug Research Institute (Lucknow), CSIR-Central Leather Research Institute (Chennai), CSIR-Institute of Genomics & Integrative Biology (New Delhi), CSIR- Institute of Microbial Technology (Chandigarh), Indian Institute of Science (Bangalore), Indian Institute of Science Education & Research-Bhopal, Indian Institute of Science Education & Research-Pune, Indian Institute of Science Education & Research-Thiruvananthapuram, Indian Institute of Science Education & Research-Tirupathi, Indian Institute of Technology-Bombay (Mumbai), Indian Institute of Technology-Delhi, Indian Institute of Technology-Kharagpur, Indian Institute of Technology-Roorkee, Institute of Life Sciences (Bhubhaneswar), Institute of Stem Cell & Regenerative Medicine (Bangalore), International Centre for Genetic Engineering and Biotechnology (New Delhi), Jawaharlal Nehru University (New Delhi), National Centre for Cell Sciences (Pune), National Chemical Laboratories (Pune), National Institute of Immunology (New Delhi), National Institute of Mental Health & Neurosciences (Bangalore), National Institute of Plant Genome Research (New Delhi), National Institute of Science Education & Research (Bhubhaneswar), Poornaprajna Institute of Scientific Research (Bangalore), Regional Centre for Biotechnology (Faridabad), Saha Institute of Nuclear Physics (Kolkata), St. Xaviers College (Kolkata), Translational Health Science and Technology Institute (Faridabad), and University of Madras (Chennai).

The DBT-supported program ensured that young researchers in India had access to facilities at par with researchers in Europe and USA. The ESRF access program has enabled Indian researchers to publish more than two hundred research papers involving basic and applied research in the last seven years, in international peer-reviewed journals. The number of publications will continue to rise for the next two years, and researchers will process and publish the data collected in the reporting period. Due to this program, more than a hundred researchers, largely PhD students, have been trained in cutting-edge methods in Structural Biology. The program has helped Indian scientists to obtain data that will aid the formulation of innovative solutions to problems faced by the nation in the areas of health, agriculture, and environment.

Indian Biological Data Centre (IBDC)

The Indian Biological Data Centre (IBDC) is the first national digital data repository mandated to archive all life science data generated from publicly funded research in India. It is supported by the Government of India (GOI) through the Department of Biotechnology (DBT). At present, IBDC is a joint collaboration between the Regional Centre for Biotechnology (RCB), the National Institute of Immunology (NII), the International Centre for Genetic Engineering & Biotechnology (ICGEB), and the National Informatics Centre (NIC). The Executive Director of RCB, Dr. Arvind Sahu, is the designated lead coordinator of the IBDC project, and the Director of NII, Dr. Debasisa Mohanty, is the co-coordinator. Dr. Dinesh Gupta from ICGEB and Prof. Deepak T. Nair from RCB are the other PIs in the project with the latter also serving as acting Head of IBDC.

The IBDC enables the implementation of the "Biotech-Pride Guidelines" (Promotion of Research and Innovation through Data Exchange). The computational infrastructure, including a High-Performance Computing (HPC) facility and archival data storage, is hosted at RCB and NIC, Bhubaneswar. RCB houses a computing power of about 800 Tera Flops (AI mixed precision) along with a 4.5 PB (PetaByte) of storage, while NIC (Bhubaneswar) has a data storage capacity of about 1 PB. The two sites are connected by high band-with internet connectivity through NKN. The biological data generated by researchers in India is being archived and curated at IBDC. The measures for routine and scheduled maintenance to ensure the proper functioning of the HPCC facility have been carried out on a timely basis. The major milestones in the development of the data center are depicted in Figure 1.

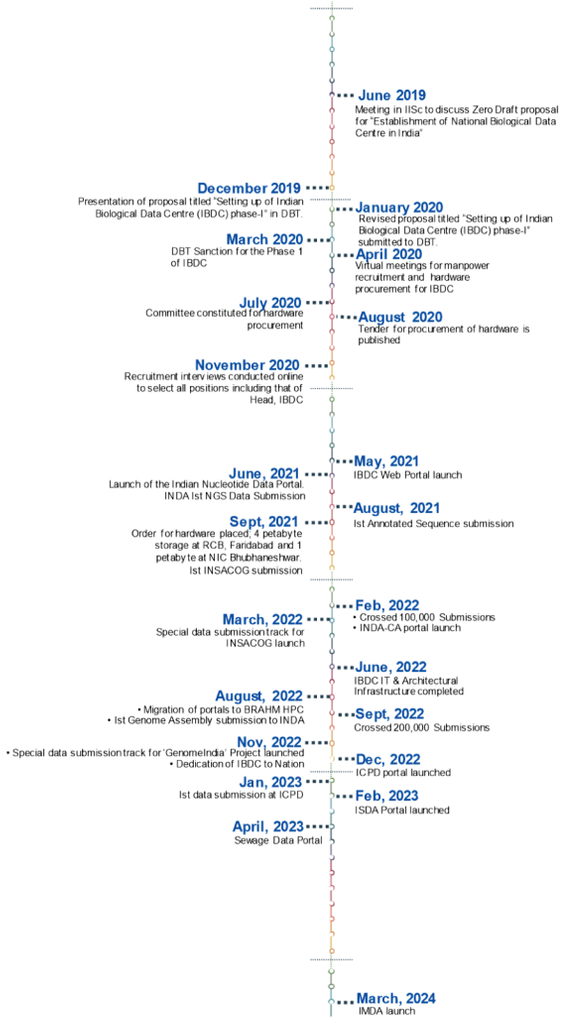


Figure 1. Milestones during the development of the Indian Biological Data Center (IBDC).

Owing to the magnitude and complexity of the expected data, IBDC is being developed in a modular nature. Currently, IBDC operates through four specialized data portals dedicated to the management of diverse biological data types (Figure 2).

Figure 2. Active data archival portals of Indian Biological Data Center (IBDC).

Indian Nucleotide Data Archive: INDA is an open-access (Time-released) platform for archiving, managing, and sharing diverse types of nucleotide sequencing data generated across India. Data is synched with INSDC (The International Nucleotide Sequence Database Collaboration) repositories like GenBank-NCBI, ENA, and DDBJ. Submission to IBDC automatically generates both IBDC and INSDC (GenBank, ENA-EMBL, and DDBJ) accessions, and thus, there is no need to re-submit the data to international repositories (Fig. 3).

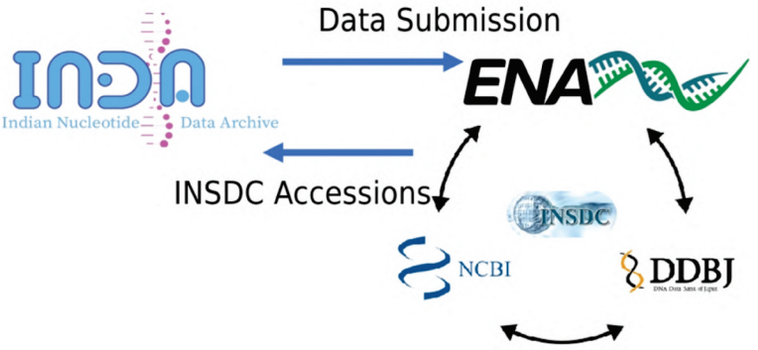


Figure 3. Nucleotide data submission cycle at IBDC

A Total of 4330 Raw Data submissions, 100 Assembly submissions, and 5 annotated sequences have been submitted to IBDC from 81 Different organisms (Table 1), accounting for 41753533804542 bases and 26266457579070 bytes. The distribution of study types and data access are given in Figure 4.

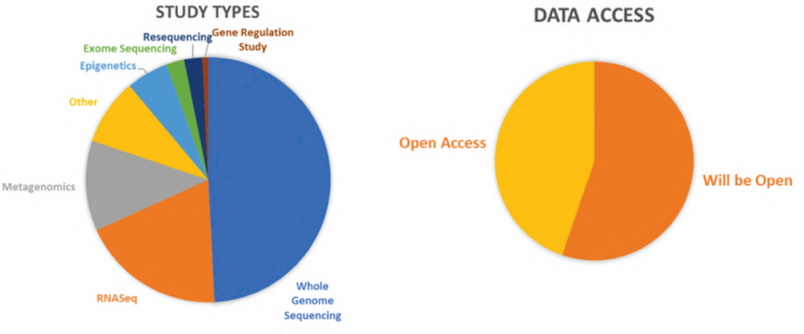


Figure 4: Study types and Data access distribution in INDA

Acinetobacter baumannii	*Enterobacter sp.*	*metagenome*
Acinetobacter lwoffii	*Enterococcus faecium*	*Morganella morganii*
Acinetobacter nosocomialis	*Escherichia coli*	*Mus musculus*
Acinetobacter radioresistens	*groundwater metagenome*	*Mycobacterium tuberculosis*
Acinetobacter sp.	*Homo sapiens*	*Oryza meyeriana var indandamanica*
Aeromonas sp.	*Klebsiella aerogenes*	*Oryza officinalis*
Allium cepa	*Klebsiella pneumoniae*	*Oryza sativa*
Arabidopsis thaliana	*Klebsiella quasipneumoniae*	*Oryza sativa Indica Group*
Bacillus anthracis	*Klebsiella variicola*	*plant metagenome*
Bacillus paramycoides	*Lacticaseibacillus rhamnosus*	*Proteus mirabilis*
Bos indicus	*Lactobacillus crispatus*	*Pseudomonas aeruginosa*
Brassica carinata	*Lactobacillus gasseri*	*Pseudomonas putida*
Brassica juncea	*Lactobacillus jensenii*	*Salmonella enterica subsp. enterica serovar Typhimurium*
Brevibacillus parabrevis	*Lactobacillus vaginalis*	*Serratia marcescens*
Burkholderia cenocepacia	*Lactobacillus crispatus*	*Sesamum indicum*
Burkholderia sp.	*Lactobacillus gasseri*	*Severe acute respiratory syndrome coronavirus 2*
Carthamus tinctorius	*Lactobacillus jensenii*	*soil metagenome*
Chlorocebus sabaeus	*Lactobacillus johnsonii*	*Solanum lycopersicum*
Chrysolophus amherstiae	*Lactobacillus paragasseri*	*Staphylococcus aureus*
Citrobacter freundii	*Lactobacillus vaginalis*	*Staphylococcus epidermidis*
Citrobacter sp.	*Leptospira interrogans*	*Staphylococcus hominis*
compost metagenome	*Limosilactobacillus fermentum*	*Staphylococcus sp.*
Delftia acidovorans	*Limosilactobacillus mucosae*	*Stenotrophomonas maltophilia*
Dunaliella salina	*Limosilactobacillus oris*	*Stutzerimonas stutzeri*
Elizabethkingia anophelis	*Limosilactobacillus reuteri*	*Triticum aestivum*
Enterobacter cloacae	*manure metagenome*	*Triticum sphaerococcum*
Enterobacter hormaechei	*Medicago truncatula*	*Vigna umbellata*

Table 1: List of source organisms for which nucleotide data was deposited in INDA

Indian Nucleotide Data Archive-Controlled Access: INDA-CA is a controlled access platform for archiving and managing diverse types of nucleotide sequencing data (similar to INDA) generated across India. In contrast to INDA, data submitted to INDA-CA is not shared with any international repository and resides securely on servers in India (IBDC) only. Data submitters can control the access of their data sets in consultation with the data center team. IBDC has also developed special submission tracks for projects of national relevance such as INSACOG, INSACOG Sewage Surveillance, and GenomeIndia.

On the INDA-CA portal, 2269 submissions from 12 organisms have been received. A total of 229773 SARS-CoV-2 genomes from 60 different institutes have been submitted via the INSACOG portal, with a total of 1189 variants identified. The FASTA files from the INSACOG portal can be accessed by signing up to the portal. A total of 1145 SARS-CoV-2 sewage surveillance samples from five different institutes have been submitted via the INSACOG sewage surveillance portal. A total of GenomeIndia 9753 samples have been submitted to IBDC which include GVCF/UBAM and FASTQ files.

Indian Crop Phenome Database: ICPD is an open-access (Time-released) platform facilitating the digitization, management, storage, and exchange of crop phenotyping data following FAIR data guidelines. The portal provides universal data formats for the submission of phenotyping datasets from 30 different crops. Data from 6571 different plant traits using over 7000 different experimental techniques can be submitted. All submissions are provided permanent accessions by IBDC. Currently, 16 datasets belonging to one crop involving 21 traits, 17 tissues, 19 developmental stages, 1 gene, and 12 treatments have been submitted by 4 users of three different organizations (Figure 5). The data portal also provides

personalized desktops for the users where they can view and analyze their submitted data sets. Tools for graphical visualization and statistical analysis of the submitted data are also provided on the web dashboard.

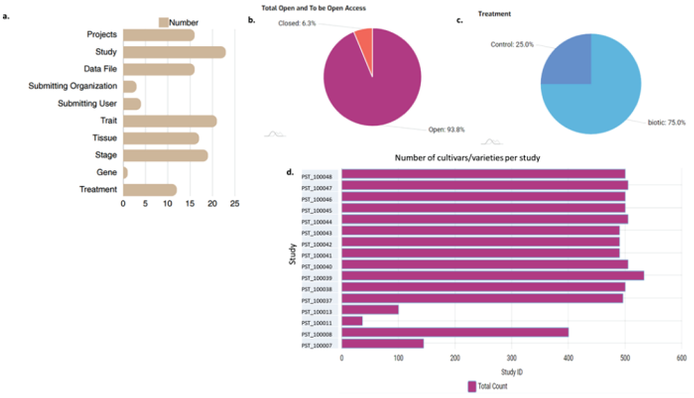


Figure 5: The data statistics of the phenome data submitted at ICPD. (a) the number of different data statistics, (b) the proportion of open vs. control access data, (c) the proportion of the type of treatment conditions, and (d) the number of genotypes/cultivars screened per study.

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

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

Upcoming Data Portals: The data archiving portals for proteome [Indian Proteome Databank (IPD)] and imaging data [Indian Biological Image Archive (IBIA)] are in the final testing phase of development and are going to be released soon (Figure 6). Another application, Multi-Omics Analysis Toolbox of IBDC (MATI), aimed to help the research community in conducting various types of bioinformatics analysis by utilizing multiple tools and software for processing. and analysing different forms of biological data is under development, and version 1 will be released soon (Figure 6).

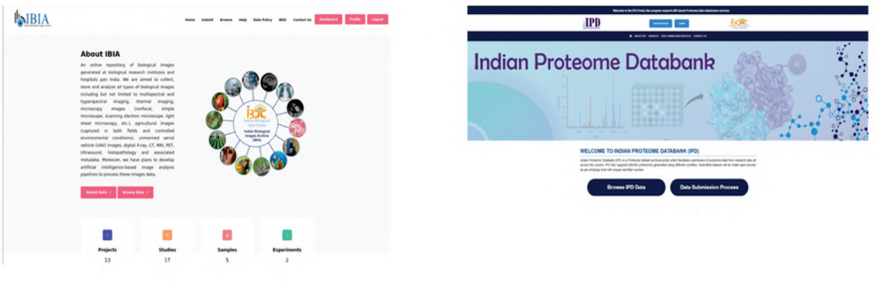


Figure 6. Snapshots of IBIA, IPD, MATI, and BRAHM HPC portal.

Integration with DBT-CDAC integrated computing environment (ICE)

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

BRAHM HPC Access

In addition to data archiving services, IBDC also provides bioinformatics data analysis and access to 'BRAHM-HPC' to the research community upon request. A total of 49 principal investigators from 35 different organizations are using the HPCC (Table 2; Figure 6). On average, about 1900 jobs per month have been executed on BRAHM HPC by the users. To further provide seamless services to our users, a dedicated web portal for managing the HPC access and data analysis requests has been developed and implemented on the IBDC web page (https://ibdc.rcb.res.in/hpcrequest). The screenshot of the portal is shown in Figure 7.

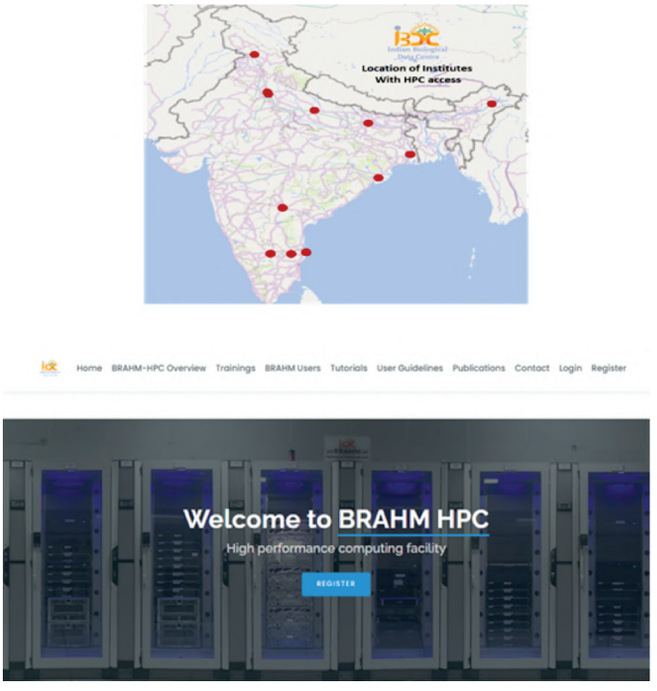


Figure 7. The map shows the distribution of HPC users within the country and the screenshot of HPC portal is shown in lower panel.

Data Analysis Service

In addition to data archiving services, IBDC also provides bioinformatics data analysis and access to 'BRAHM-HPC' to the research community upon request. Several research groups are already availing of the HPC storage service and analysis support from IBDC. To guide and explain to the users the submission process of data to IBDC portals database-specific SOPs, the HPC request form and BRAHM-HPC access guide and video tutorials are made available on the IBDC website under tutorials-SOP section (https://ibdc.rcb.res.in/tutorial-sop/).Further, IBDC support (support@ibdc.rcb.res.in) dedicatedly handles all user-specific queries and service requests. IBDC also provides data analysis services (In-depth Whole Genome Variant call and phylogenetic analysis, RNA-seq analysis, *de novo* genome assembly, MiRNA microarray data analysis, SARS-CoV-2 variant analysis, etc.) to 11 different research groups affiliated with 8 institutions.

Table 2. List of institutions of BRAHM HPC users.

1. All India Institute of Medical Sciences (AIIMS) Bibinagar, Hyderabad
2. All India Institute of Medical Sciences (AIIMS), New Delhi
3. B. R. Ambedkar Center for Biomedical Research (ACBR), Delhi
4. Babasaheb Bhimrao Ambedkar University, Lucknow
5. Bennett University, Noida
6. Bose Institute, Kolkata
7. Center for Healthcare Science and Technology, Indian Institute of Engineering Science and Technology, Shibpur (IIEST)
8. Central University of Himachal Pradesh
9. CSIR-Centre for Cellular and Molecular Biology (CCMB), Hyderabad
10. Department of Genetics, University of Delhi, Delhi
11. Department of Integrative Biology
12. G.B Pant Hospital, New Delhi
13. Indian Council of Agricultural Research (ICAR), New Delhi
14. ICAR-Research Complex for Eastern Region (RCER), Patna
15. International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi
16. Indian Council of Medical Research (ICMR)-Regional Medical Research Centre (RMRC) (NE Region)
17. ICMR-Rajendra Memorial Research Institute of Medical Sciences (RMRIMS), Patna
18. Indian Institute of Technology (IIT), New Delhi
19. Indian Institute of Science (IISc), Bangalore
20. Institute of Genomics and Integrative Biology, New Delhi
21. Institute of Life Sciences
22. Jaypee Institute of Information Technology, Noida
23. Jawaharlal Nehru University (JNU), New Delhi
24. King George Medical University, Lucknow
25. National Institute of Immunology, New Delhi
26. National Institute of Plant Genome Research (NIPGR), New Delhi
27. Regional Centre for Biotechnology, Faridabad
28. School of BioSciences & Technology
29. Department of Science & Technology, Delhi
30. School of Life Sciences (SLS), Jawaharlal Nehru University
31. St. Xavier's College, Kolkata
32. Translational Health Science and Technology Institute (THSTI), Faridabad
33. University of Delhi, Delhi
34. University of Madras
35. Vellore Institute of Technology (VIT), Vellore, Tamil Nadu, India

To guide and explain to the users the submission process of data to IBDC portals database-specific SOPs, the HPC request form and BRAHM-HPC access guide and video tutorials are

made available on the IBDC website under tutorials-SOP section (https://ibdc.rcb.res.in/tutorial-sop/). Further, IBDC support (support@ibdc.rcb.res.in) dedicatedly handles all user-specific queries and service requests.

Figure 8. Summary of various outreach activities of IBDC.

Workshops

To spread the word about the activities of IBDC, training, and workshops are conducted on a regular basis for data submission (nucleotide data, phenome data, INSACOG data, and GenomeIndia data); IBDC BRAHM HPC Usage and data analysis discussions. As of now, a total of 100 workshops with more than 1000 participants associated with 67 institutions have been successfully conducted. The map showing the distribution of institutions is shown in Figure 9.

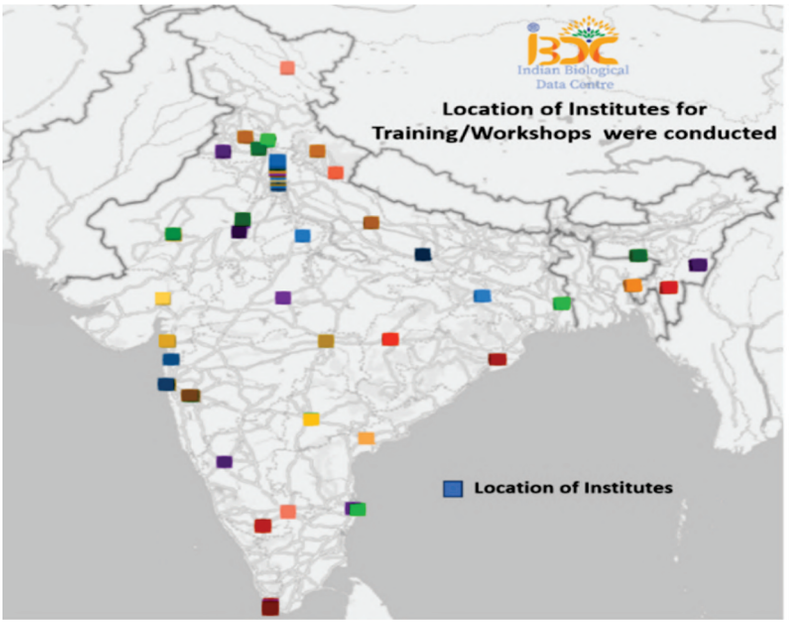


Figure 9. Location of institutions participated in IBDC workshops.

IBDC Team

Team IBDC comprises experts from diverse disciplines, including different domains of biological sciences, bioinformatics, information technology, etc. A total of 32 personnel have been recruited and trained extensively in various IBDC activities (Table 3).

Table 3. List of IBDC Personnel

S. No.	Name of the person	Name of the Post
1	Dikshant Sharma	Administrative Officer
2	Kuldeep	Administrative Officer
3	Dr. Pawan Kumar	Data Curator
4	Ms. Isha Saini	Data Curator
5	Dr. Nivedita	Data Curator
6	Dr. Indu Kumari	Data Curator
7	Himanshu Bhusan Samal	Data Curator
8	Abhisek Kumar Behera	Data Curator
9	Asha Verma	Data Curator
10	Amit Kumar	Data Curator
11	Dr. Vikram Singh	Data Curator
12	Satuluri Sriharsha	Data Curator
13	Mr. Kalpanath Paswan	Database Engineer/ Software Developer
14	Mr. Abhay Shankar Pandey	Database Engineer/ Software Developer
15	Dr. Vibha Oberoi	Database Engineer/ Software Developer
16	Mr. Mayank Chauhan	Database Engineer/ Software Developer
17	Mayuri Jain	Database Engineer/ Software Developer
18	Mohit Kumar Vats	Database Engineer/ Software Developer
19	Mayank Mamgaain	Database Engineer/ Software Developer
20	Rahul Dahiya	Database Engineer/ Software Developer
21	Shivendra	Database Engineer/ Software Developer
22	Dr. Atul Tyagi	Database Manager
23	Dr Venkatesh	Database Manager
24	Manoj Kumar	Network Administrator
25	Nitu Kumari	Programmer
26	Dr. Sonia Balyan	Scientist
27	Arun Sharma	Scientist
28	Dr. Shivani Sharma	Scientist
29	Sanjay Deshpande	Scientist
30	Mr. Vipul Adhana	Technical Assistant-A
31	Mr. Gautam Kanwal	Technical Assistant-A
32	Mr. Rajesh Kumar	Technical Assistant-A

Figure 10. Picture of IBDC personnel.

MoU with CDRI

RCB has entered an MoU with CSIR-Central Drug Research Institute, Lucknow to provide cooperation through collaborative research programs, student and faculty exchange programs, sharing of instrumentation facilities and submission of joint projects.

Collaborators of Faculty Members

RCB Principal Investigator	Collaborators
Prof. Deepak T. Nair	Prof. D. N. Rao (IISc, Bangalore), Dr. Arvind Sahu (RCB) Dr. Dinakar M. Salunke (ICGEB, New Delhi), Prof. Sudhanshu Vrati (RCB), Dr. VG Vaidyanathan (CSIR-CLRI, Chennai), and Dr. Shailendra Asthana (THSTI, Faridabad),
Dr. Vengadesan Krishnan	Dr. Priti Saxena (SAU, New Delhi), Dr. Amit Kumar Pandey (THSTI, Faridabad), Dr. Airi Palva's group (University of Helsinki, Finland), Dr. RP Roy (RCB, Faridabad)
Dr. Deepti Jain	Prof. Sudhanshu Vrati, Prof. Deepak T Nair, Dr. Divya Chandran, Ambadas Rode (RCB), Dr. Gopaljee Jha, (NIPGR, New Delhi), Prof. Sunil Kumar Khare (IIT Delhi)
Dr. Prem S. Kaushal	Prof. Ruchi Anand, IIT Bombay, Prof Ajay Saxena, JNU, Prof. Nisheeth Agarwal, THSTI, and Prof. N. Gourinath, JNU.
Prof Prasenjit Guchhait	Dr. Ashley L St. John (Duke-NUS Medical School, Singapore), Dr. Sumana Sanyal (University of Oxford, UK), Prof. Josef T Prchal (Univs of Utah, USA), Prof. Perumal Thiagarajan, Prof. Miguel M Cruz, Dr. Andrew Yee (Baylor College of Medicine, USA), Prof. Jorge Di Paola (Washington Univs, St Louis, USA), Prof. Tulika Seth, Prof. Rajesh Khadgawat, Prof. Parvaiz Kaul (SKIMS, Srinagar), Prof. Anil K Pandey, Dr. Nikhil Verma, Dr. Priyanka Sharma, Dr. Pooja Pandey (ESIC Hospital, Faridabad), Prof. Asim Das (ESIC Hospital, Alwar), Dr. Shailendra Asthana, Dr. Milan Surjit, Prof. Ramandeep Singh, Dr. Soumen Basak (NII, New Delhi), Dr. Garima Agarwal (IIT, Mandi), Prof. Manjula Kalia, Prof. Tushar K Maiti, Prof. CV Srikanth, Dr. Rajender Motiani, Dr. Sam Mathew, Dr. Arvind Sahu (RCB, Faridabad).
Prof. Tushar Kanti Maiti	Dr. Shinjini Bhatnagar, Dr. Bhabatosh Das, Dr. Nitya Wadhwa, Dr. Pallavi Kshetrapal (THSTI, Faridabad); Dr. Partha P Majumder, Dr. Arindam Maitra (NIBMG, Kalyani, West Bengal); Dr. Dinakar M Salunke and Dr. Neel Sarovar Bhavesh (ICGEB, New Delhi); Dr. Prasenjit Guchhait, Dr. Sam Mathew, Dr. Sivaram Mylavarapu, Dr. Manjula Kalia, Dr. Prem Kaushal, Dr. Karthigeyan Dhanasekaran (RCB); Dr. Sobhan Sen (JNU, New Delhi); Dr. Hrishikesh Kumar and Dr. Supriyo Choudhury (Institute of Neuroscience Kolkata)
Prof. Sam J Mathew	Dr. Tushar Maiti (RCB, Faridabad), Dr. Manoj Menon (IIT, New Delhi), Dr. Suchitra Gopinath (THSTI, Faridabad), Dr. Munia Ganguli (IGIB, New Delhi), Dr. Jayanth Kumar (AIIMS, New Delhi), Dr. Gargi Bagchi (Amity University, Gurugram), Dr. Ruchi Tandon (THSTI, Faridabad), Dr. Vivek Natarajan (IGIB, New Delhi).
Prof Chittur V Srikanth	Dr. Vineet Ahuja, Gastroenterology, AIIMS, Delhi Dr. Girish Ratnaparkhi, IISER, Pune Dr. Pramod Garg, THSTI, Faridabad Dr. Sujoy Paul, Gastroenterology, AIIMS, Delhi Dr. Prasenjit Das, Gastroenterology, AIIMS, Delhi
Dr. Manjula Kalia	Dr. Dinesh Mahajan (THSTI); Dr. Shailendra Asthana (THSTI); Dr. Santosh Chauhan (CSIR-CCMB)
Dr. Arup Banerjee	Dr. Sujata Mohanty (AIIMS, New Delhi), Dr. Anirban Basu (NBRC, Manesar), Dr. Jayanta Bhattacharyya (IIT, Delhi), Dr. Sweety Samal (THSTI, Faridabad)
Dr. Anil Thakur	Dr. Alan G. Hinnebusch (NIH, USA), Dr. Ishaan Gupta (IIT – Delhi), Dr. Rekha Puria (GBU Greater Noida)

RCB Principal Investigator	Collaborators
Prof Avinash Bajaj	Dr. Sagar Sengupta, Dr. Vinay Nandicoori, Dr. Arnab Mukhopadhyay, Dr. Santiswarup Singha, and Dr. Veena S Patil (NII), Dr. Ujjaini Dasgupta and Dr. Rajendra Prasad (Amity University Haryana), Dr. Aasheesh Srivastava (IISER Bhopal), Dr. Prasenjit Das, Dr. Vineet Ahuja, Dr. Shalimar and Dr. Sunil Kumar (AIIMS), Dr. C. V. Srikanth and Dr. Ramu Vemanna (RCB)
Dr. Rajender K Motiani	Dr. Manjula Kalia, Dr. Tushar K Maiti (RCB, Faridabad), Dr. Sridhar Sivasubbu (IGIB, New Delhi), Dr. Subhragshu Chatterjee (Bose Institute, Kolkata) and Dr. Shantanu Chowdhury (IGIB, New Delhi).
Dr Karthigeyan Dhanasekaran	Dr. Soumik Siddhanta (IIT-Delhi), Prof. Sudhanshu Vrati (RCB, Faridabad), Prof. R. P. Roy (RCB, Faridabad), Dr. Santosh Kumar (NCCS, Pune)
Dr. Saikat Bhattacharjee	Dr. Girish TR & Sailaja Nori (Sea6 Energy Pvt. Ltd., Bengaluru), Dr. Souvik Bhattacharjee (JNU, New Delhi), Dr. Nimisha Sharma (GGSIPU, New Delhi), Dr. Ramu Vemanna (RCB, Faridabad), Dr. Prashant Pawar (RCB, Faridabad), Dr. Debabrata Laha (IISc, Bengaluru), Dr. Vipin Hallan (CSIR-IHBT, Palampur), Dr. Subhra Chakraborty (NIPGR, New Delhi), Dr. Gabriel Schaaf (University of Bonn, Germany).
Dr. Divya Chandran	Dr. Senjuti Sinharoy, Dr. Senthil Kumar Muthappa (NIPGR, New Delhi), Dr. Bonamali Pal (Thapar Institute of Engineering and Technology, Patiala), Dr. Archana Chugh (IIT, Delhi), Dr. Deepti Jain (RCB, Faridabad).
Dr. Ramu S Vemanna	Dr. Kiran Mysore, (Oklahoma State University, USA), Dr. Prasanna Kumar M (University of Agricultural Sciences, Bangalore), Dr. Avinash Bajaj, Dr. Saikat Bhattacharjee (RCB, Faridabad).
Dr. Prashant Mohan Pawar	Dr Saikat Bhattacharjee, Dr Vengadesan (RCB, Faridabad), Dr Yashwant Kumar (THSTI, Faridabad), Dr. Ewa Mellerowicz (SLU, Sweden), Dr Jeongim Kim (University of Florida, USA), Dr Aline Voxeure (INRA, France).
Dr. Ambadas B Rode	Prof. Sheshnath Bhosale (Goa University, Goa), Dr. Ramandeep Singh (THSTI, Faridabad).
Dr. Rajendra P Roy	Dr. Srinivasa-Gopalan Sampathkumar (NII, New Delhi), Prof. Krishnan Vengadesan and Dr. Karthigeyan Dhanasekaran (RCB, Faridabad).
Dr. Nidhi Adlakha	Dr. Syed Shams Yazdani (ICGEB, New Delhi), Dr. Charanpreet (NABI, Mohali), Dr. Tarun Sharma (GBU, Gujarat), Prof. Rakesh Bhatnagar (JNU, New Delhi), Bharat Petroleum Corporation Limited (BPCL).

Extramural Funding

S.No.	Investigator	Title of project	Funding agency	Sanctioned budget (Rs.)	Project duration
1	Prof. Deepak T. Nair (PI)	Renewal of access to Structural Biology Facilities at ESRF, France	DBT	2639.8 lakhs	2021-24
2	Prof. Deepak T. Nair (PI) Dr. Vengadesan Krishnan, Dr. Deepti Jain, Dr. Prem S. Kaushal (co-PIs)	Bioinformatics Centre for Computational Drug Discovery- BIC at Regional Centre for Biotechnology, Faridabad	DBT	197.3 lakhs	2021-26
3	Prof. Deepak T Nair (PI)	Identification of lead molecules for the development of novel therapeutic strategies against viruses	DBT	242.71 lakhs	2022-27
4	Prof. Deepak T. Nair (co-PI)	Chemical synthesis of adducts induced by 3-nitrobenzanthrone and evaluation of the effect of these adducts on natural DNA synthesis	SERB	15 lakhs	2022-24
5	Prof. Deepak T. Nair (PI)	Structural Insight regarding the interaction between the processivity clamp and DNA polymerase I in prokaryotes	SERB	47 lakhs	2023-26
6	Prof. Deepak T. Nair (PI)	Setting up of the Indian biological Data Centre-Phase 1	DBT	7578.8	2020-23
7	Prof. Vengadesan Krishnan (PI)	Elucidating the Structural characteristics of pilus components from *Enterococcus faecalis*, an opportunistic pathogen of the Urinary tract	DBT	49.7 lakhs	2022-25
8	Prof. Deepti Jain (PI)	Investigating the mechanism of regulation of flagellar gene expression by FliA-FlgM and FliA-RNAP complex from *Pseudomonas aeruginosa:* Implication in pathogenesis and virulence	SERB-Power fellowship	35 lakhs	2023-26
9	Prof. Deepti Jain (PI)	Antibiotic tolerance And Resistance In Biofilm-Associated Infections: A Belgian-Indian Networking Approach to Address a Worldwide Problem - A joint Indo-Belgian Network	Indo-Belgian Networking Grant Department of Biotechnology	35 lakhs	2022-25

S.No.	Investigator	Title of project	Funding agency	Sanctioned budget (Rs.)	Project duration
10	Prof. Deepti Jain (PI)	Targeting Bacterial Motility and Adherence for Inhibition of Biofilms from *Pseudomonas aeruginosa*	DBT	84.6 lakhs	2022-2025
11	Dr. Prem S. Kaushal (PI)	Understanding the role of HspX protein from *Mycobacterium tuberculosis* in translation regulation: its implication in structure based drug design.	DST-SERB	42.61 lakhs	2023-26
12	Dr. Prem S. Kaushal (PI)	Exploring the *Entamoeba histolytica* ribosome as a potential drug target to treat amoebiasis.	DBT	94.17 lakhs	2023-26
13	Dr. Prem S. Kaushal (PI)	Identification of small molecule inhibitors of SARS-CoV-2 non-structural protein 1 (Nsp1) for the treatment of COVID-19.	CSIR	24 lakhs	2023-26
14	Dr. Prem S. Kaushal (PI)	EMBL Corporate Partnership Programme Fellowship	EMBL	1000 euros	2023
15	Prof. Prasenjt Guchhait (PI)	Dietary Alpha-ketoglutarate as a potential therapeutic against acute respiratory distress syndrome (ARDS) and pulmonary fibrosis in Covid-19 infection.	BIRAC, DBT	49.5 lakhs	2023-25
16	Prof. Prasenjt Guchhait (PI)	Investigating the severity of dengue infection in diabetes	ICMR	149.5 lakhs	2023-26
17	Prof. Prasenjt Guchhait (Co-PI)	Lethal Aortopathy syndrome associated with novel FBLN4D203A Mutation among Mappila Children of Malabar, Kerala - seeking novel clinical, molecular genetics and anthropological insights.	ICMR	Total grant: 149. 5 lakhs *RCB:* 20.5 lakhs	2023-26
18	Prof. Tushar Kanti Maiti	Multi-Omics Signatures of Human Placenta: Real time assessment of underlying mechanisms for prediction of birth outcomes.	DBT	*Total grant:* 396.7 lakh *Grant for RCB:* 64.7 lakh	2020-24
19	Prof. Tushar Kanti Maiti	A bench to bedside" model for clinical and translational science between academic research institutes and hospitals focused on fetal growth restriction and preterm birth.	DBT	*Total grant:* 681.9 lakh *Grant for RCB: 23.13* lakh	2018-24
20	Prof. Tushar Kanti Maiti	Inter-Institutional Program for Maternal, Neonatal and Infant Sciences A translational approach–interdisciplinary Group for Advanced Research on BirtH outcomes-DBT INdia Initiative (GARBH-Ini Phase II).	DBT	*Total grant:* 2935.5 lakh *Grant for RCB: 138.40* lakh	2021-26

S.No.	Investigator	Title of project	Funding agency	Sanctioned budget (Rs.)	Project duration
21	Prof. Tushar Kanti Maiti	MOMI: Biorepository local analysis- INDIA.	BMGF	*Total grant:* 516.7lakhs *Grant for RCB: 61.85* lakhs	2021-24
22	Prof. Tushar Kanti Maiti	MOMI Ideas Fund 2021: N-linked glycosylation in gestational diabetes mellitus.	BMGF	*Total grant: 73.97* lakhs *Grant for RCB:* 57.9 lakhs	2022-24
23	Dr. Sam J Mathew	Functional characterization of skeletal muscle myosin heavy chain-embryonic in adult muscle regeneration and disease.	DBT	77 lakhs	2020-24
24	Dr. Sam J Mathew	The Wnt signaling pathway and its repressor Transducin-like Enhancer of Split 3 (TLE3) as therapeutic targets to treat Rhabdomyosarcoma tumors	ICMR	54 lakhs	2021-24
25	Dr. Sam J Mathew	Regulation of mammalian growth, homeostasis and differentiation by Transducin-like Enhancer of Split (TLE) proteins.	SERB	53 lakhs	2022-25
26	Dr. Sam J Mathew and Dr. Manoj Menon	Sensitizing cells to the chemotherapeutic SMAC mimetics and investigating the dependence on cellular differentiation	IITD-RCB collaborative grant	10 lakhs per year (5 lakhs per year for RCB)	2023-24
27	Dr. Masum Saini	Role of Sprouty2 as a modulator of MET signaling during mammalian skeletal muscle development, regeneration and disease.	Wellcome Trust/DBT India Alliance Early Career Fellowship	167 lakh	2018-24
28	Prof. Sudhanshu Vrati (PI), Prof. Deepak T Nair, Dr. Deepti Jain (co-PIs)	Development of small molecule antivirals against Chikungunya and Japanese encephalitis virus	DBT	480.7 lakhs	2020-25
29	Prof. Sudhanshu Vrati	Covid-19 Bioresource at the NCR Biotech Science Cluster	DBT	94.43 lakhs	2020-23
30	Prof. Sudhanshu Vrati	Genomic surveillance for SARS-CoV-2 in India: Indian SARS-CoV-2 Genomics Consortium (INSACOG)-Phase II	DBT	48.48 lakhs	2022-24
31	Prof. Sudhanshu Vrati	J C Bose Fellowship	SERB, DST	90.00 lakhs	2021-26
32	Prof. Chittur V Srikanth Dr. Girish Ratnaparkhi	From the gut SUMO cycles its way into gastrointestinal disorders	MHRD	93.3 lakhs	2020-24

S.No.	Investigator	Title of project	Funding agency	Sanctioned budget (Rs.)	Project duration
33	Prof. Chittur V Srikanth Dr Vineet Ahuja	Studying the mechanism of Rab7 based regulation of Goblet cell function in Ulcerative colitis	DBT	8699280	2023-26
34	Dr. Manjula Kalia	Role of Guanylate-binding proteins and Gasdermin D in the inflammatory response to Japanese encephalitis virus infection and link to pyroptotic cell death	SERB	48.8 lakhs	2021-24
35	Dr. Manjula Kalia	Preclinical evaluation and development of FDA-approved antipsychotic phenothiazine as drug reposition candidate against Japanese encephalitis	Ignite Life Science Foundation	7 lakhs	2023- 24
36	Dr. Arup Banerjee	Assessing the efficacy of engineered extracellular vesicles targeting NLRP3 inflammasome in the neuroinflammatory disease model	ICMR	55.0 lakhs	2024-27
37	Dr. Anil Thakur	Translation dynamics govern fungal virulence and drug resistance in Candida species	DBT	42.50 lakhs	2020-25
38	Dr. Anil Thakur	"Genetic and translational landscape of *Candida glabrata* pathogenesis for identification of novel antifungal drug targets	SERB	44.85 lakhs	2023-26
39	Prof. Avinash Bajaj	Engineering of Long-lasting Breast Hydrogel Implants for Cancer Immunochemotherapy.	DBT	95.5 lakhs	2023-26
40	Prof. Avinash Bajaj	Synthesis and Identification of Antibiotic Adjuvants for Mitigation of Pan-resistant Gram-negative Bacterial Infections.	DBT	80.6 lakhs	2023-26
41	Prof. Avinash Bajaj	Developing Repertoire of Orally Deliverable Phospholipid-Drug Conjugates (PDCs) for Targeting Colorectal and Hepatocellular Carcinoma.	SERB	67.8 lakhs	2023-26
42	Dr. Rajender K Motiani	Role of ER and Mitochondria in Pigmentation: Organellar Calcium signaling perspective.	DBT/ Wellcome Trust India Alliance	360 lakhs	2020-25
43	Dr. Rajender K Motiani	Demystifying the mystery of Orai3 function in pancreatic cancer: Elucidating role of Orai3 in partial EMT and chemoresistance.	SERB	64 lakhs	2024-27

S.No.	Investigator	Title of project	Funding agency	Sanctioned budget (Rs.)	Project duration
44	Dr. Rajender K Motiani	Lethal Aortopathy syndrome associated with novel FBLN4D203A Mutation among Mappila Children of Malabar, Kerala - seeking novel clinical, molecular genetics and anthropological insights.	ICMR (In collaboration)	Total grant: 150 lakh (RCB grant for 56 lakhs)	2024-27
45	Dr. Karthigeyan Dhanasekaran (PI)	Impact of Falviviral proteins on centrosome and cilia	SERB	27.89 lakhs	2022-24
46	Dr. Karthigeyan Dhanasekaran (PI)	Centrosome as a target for viral pathogenesis intervention	RLF-DBT	42.50 lakhs	2021-26
47	Dr. Karthigeyan Dhanasekaran (Co-PI)	Tracking protein dynamics in cells using clusteroluminescence	IITD-RCB collaborative grant	10 lakhs	2023-25
48	Dr. Karthigeyan Dhanasekaran (Co-PI)	Tracking protein dynamics in cells using clusteroluminescence	SERB	12 lakhs	2024-27
49	Dr. Saikat Bhattacharjee (Co-PI) Dr. Souvik Bhattacharjee, JNU (PI)	Translating the Phylogenetic affinities between a plant pathogenic oomycete *Phytophthora infestans* and a human pathogen *Plasmodium falciparum* to reveal evolutionary convergence in virulence secretion using *In-silico*, proteomic and metabolomics approaches.	SERB	9.9 lakh (RCB)	2021-24
50	Dr. Saikat Bhattacharjee (Co-PI) Ramu Vemanna, RCB (PI)	Nanogel-mediated Gene Editing (CRISPR/Cas9) Technologies to Improve Crop Protection against Bacterial Leaf Blight in Rice.	DBT	118 lakh	2022-25
51	Dr. Saikat Bhattacharjee (PI)	Characterization of a novel post-transcriptional/translational mode of plant immune surveillance and evasive strategies deployed by a class of rapidly evolving and economically threatening pathogen effector.	SERB	44.9 lakh	2023-26
52	Dr. Divya Chandran (PI, RCB) (PI and Project Coordinator: Dr. Senjuti Sinharoy; Co-PI: Dr. Senthil-Kumar Muthappa, National Institute of Plant Genome Research)	Generation of a retrotransposon-based mutant population of chickpea for functional genomics studies.	DBT	Total grant: 128 lakh (RCB grant for 39.10 lakhs)	2022-25

S.No.	Investigator	Title of project	Funding agency	Sanctioned budget (Rs.)	Project duration
53	Dr. Divya Chandran (PI, RCB) (PI: Dr. Bonamali Pal, Thapar Institute of Engineering and Technology)	Nanocarriers for topical delivery of pathogen-specific RNAi molecules for sustained protection of pea crop against powdery mildew.	DBT	Total grant 63.5 lakh (RCB grant for 38.3 lakhs)	2021-24
54	Dr. Divya Chandran (Co-PI: Dr. Deepti Jain, RCB)	Elucidation of the functional interactome of legumes with the fungal pathogen *Erysiphe pisi* as keys to powdery mildew disease resistance.	SERB	44 lakhs	2020-24
55	Dr. Divya Chandran (PI, RCB) (PI: Dr. Archana Chugh, IIT Delhi)	Latarcin-derived membrane-active peptides for powdery mildew disease management in leguminous crops.	IITD-RCB collaborative grant	Total grant 20 lakhs (RCB grant for 10 lakhs)	2023-25
56	Dr. Ankita Alexander (mentor Dr. Divya Chandran)	Modulation of stomatal aperture regulating genes to improve carbon gain and crop yield.	MK Bhan Fellowship	87 lakhs	2023-26
57	Dr. Ramu S Vemanna	Influence of drought stress on ribosomes and protein synthesis and understanding the functional relevance of Ribosomal Protein L10 in rice.	SERB	28 lakhs	2020-23
58	Dr. Ramu S Vemanna Dr. Prashant Pawar (Co-PI)	Nanogel-mediated Gene Editing (CRISPR/Cas9) Technologies to Improve Crop Protection against Bacterial Leaf Blight in Rice.	DBT	118 lakhs	2022-25
59	Dr. Prashant Pawar (PI)	Understanding plant cell wall biosynthesis to optimise lignocellulosic biomass.	DST-INSPIRE	35 lakh	2018-23
60	Dr. Shouvik Das (mentor Dr. Prashant Pawar)	An integrated molecular genomics approach to unveil genomic and epigenetic complexity of adaptive traits, like flowering time, seeds size and plant cell wall.	MK Bhan Fellowship	87 lakhs	2021-24
61	Dr. Prashant Pawar	An integrated cell wall biochemistry-based strategy for promoting the resilience and circularity of rice cultivation.	DBT	150 lakhs	2023-26
62	Dr. Ambadas B Rode	Rationally targeting & tuning riboswitch mediated gene regulation for therapeutic and synthetic biology application.	DBT	88 lakh s	2018-23
63	Dr. Ambadas B Rode	Targeting riboswitches with synthetic small molecules for development of anti-tubercular drugs.	SERB	46.1 lakhs	2023-26

S.No.	Investigator	Title of project	Funding agency	Sanctioned budget (Rs.)	Project duration
64	Dr. Ambadas B Rode	Regulation of miRNA expression and maturation via targeting G- quadruplex conformations using small molecules for glioma therapy.	RCB-IITD	10 lakhs	2022-24
65	Dr. Rajendra P Roy	Semisynthetic histones with defined chemical marks for interrogation of eraser specificity	SERB	40.73 lakhs	2020-23
66	Dr. Nidhi Adlakha	Aptamer-nanoparticles conjugate: a next generation theranostic agent for phytopathogenic fungi.	DBT-NanoAgri Call	Total grant 57 lakhs (grant for RCB 19.4 lakhs)	2022-25
67	Dr. Nidhi Adlakha	Rational engineering of Talaromyces sp. to augment cellulase production	SERB	55.84 lakhs	2023-26
68	Suman Gupta (PI, RCB & Consortium Coordinator) (Other Members: THSTI, AIIMS, PGIMER & Vaxfarm Lifesciences LLP)	Development of a recombinant vaccine against the Hepatitis E virus and immunological characterization of Hepatitis E immune cohort and potential vaccine recipient cohort	NBM, BIRAC	Total grant: 696.3 lakhs; Grant for RCB: 97.5 lakhs	2021-24
69	Suman Gupta (Project Coordinator)	MSME Idea Hackathon 3.0 (Women) - for the development of ideas and Utilization of Funds of the approved ideas under Incubation Component of MSME Innovative Scheme	Micro, Small, and Medium Enterprises (MSME)	15.0 lakhs	2023-24
70	Suman Gupta (Project Coordinator)	Startup India Seed Fund - To provide financial assistance to startups for proof of concept, prototype development, product trials, market entry and commercialization	Department for Promotion of Industry and Internal Trade (DPIIT), Department for Promotion of Industry and Internal Trade	315.00 lakhs	2022-25

RESEARCH & INNOVATION INFRASTRUCTURE

Photo Credit: Dundigalla Bhavya

BSC BioNEST Bio-Incubator (BBB)

BSC BioNEST Bio-Incubator (BBB), a BIRAC's Associate Partner, continues to foster Bio entrepreneurship as a leading startup ecosystem enabler in the National Capital Region. The year was eventful with BBB, selecting seven startups for funding support under the Startup India Seed Fud Scheme from DPIIT, Government of India, to further support entrepreneurial ecosystem. In its sprawling 35,000 Sq. Ft incubation space, new startups have been on boarded and existing incubatees continue to support 'Make in India' initiative through development of innovative indigenous products across thrust domains of Biopharmaceuticals, Nutraceuticals, Diagnostics, Industrial Biotechnology, Medical Devices and Anti-infective. Selected accomplishments during this financial year by incubator includes:

1) **Recognition by Ministry of Micro Small Medium Enterprises (MSME):** Regional Centre for Biotechnology (RCB) has been recognized and registered as a Host Institute (HI) under the MSME Scheme. For creating entrepreneurial skills among youngsters, an Idea Hackathon 3.0 (Women), was launched. One proposal from DKS Incorporate has been approved under the Incubation Component for funding and mentoring assistance.

2) **Designated Partner for Empowering Youth for Undertaking Value Added Innovative Translational Research (E-YUVA):** BBB has been designated as "**Knowledge Partner**" to Punjab University under E-Yuva scheme by BIRAC. This scheme is mandated to promote a culture of applied research and need-oriented (societal or industry) entrepreneurial innovation among young students and researchers. BBB has been providing necessary handholding and mentoring support in addition to technical evaluation of proposals for E-YUVA fellows.

   In addition, BBB team has been part of multicentre project by NBM, titled "Development of a recombinant vaccine against the Hepatitis E virus and immunological characterization of Hepatitis E immune cohort and potential vaccine recipient cohort" as Consortium Coordinator.

Salient accomplishments by BBB incubatees are as follows:

1) Dharaksha Ecosolutions Pvt. Ltd clinched a golden opportunity to showcase its vision on the acclaimed television show Shark Tank India and grabbed an all Shark deal for mentorship.
2) Inte-e-labs Pvt. Ltd. selected for funding under the Biotechnology Ignition Grant by BIRAC and funding from ICMR
3) Vanguard Diagnostics joined hands with CCMB, Hyderabad for pioneering Invitro diagnostics (IVD) tests in RT-PCR and POCT formats for early Sickle Cell Disease (SCD) detection
4) Anziam Bio Pvt. Ltd. secured a CDSCO Manufacturing license for the manufacturing of Class C & D medical devices
5) Translational Research & Innovations Pvt. Ltd. successfully launched their product- First Vegan Fish Feed

BBB participated in the Global Bio India - 2023 during December and Government's flagship event of India International Science Festival (IISF) at Faridabad, Haryana, during January, disseminating its growing impact and attracting young minds towards Bio entrepreneurship and its promise in solving public health issues, in an innovative manner. RCB along with its funded startups participated to showcase in mega startup festival organised by ASSOCHAM along with key stakeholders from the Indian startup ecosystem and the industry "Startup Mahakumbh".

Outreach activities continue to happen through release of quarterly newsletter, effective use of social media platforms and engagement with young students of colleges and universities. BBB continues to impart training to UG and PG students from colleges / universities located in NCR, through a series of workshops designed to enhance skill set in Biotechnology and related domains. SPARK 3.0 Innovation Challenge, a unique Ideathon competition, was conducted by BBB with aim to promote entrepreneurial thinking among UG and PG student community.

Recently, BBB, RCB executed MoU with Foundation for Innovation & Research in Science & Technology (FIRST), IIT Kanpur & BITS BioCyTiH Foundation (BBF) to enable collaborations in diversified areas of entrepreneurship.

BBB Team:

Startups Supported since inception

S.No	Company	Area	Type of Incubatee
1	SHC Shine Biotech Pvt. Ltd	Diagnostic	Residential
2	QbD BioSciences Pvt. Ltd.	Bio-Pharma	Residential
3	Bioheaven 360 Genotec Pvt. Ltd.	Molecular Diagnostic	Residential
4	NextGen InVitro Diagnostics Pvt. Ltd.	Diagnostic	Residential
5	VaxFarm Life Sciences LLP	Bio-Pharma	Residential
6	AIGen Therapeutics Pvt. Ltd.	Anti-infective	Residential
7	InnoDx Solutions Pvt. Ltd.	Diagnostic	Residential
8	BioDva Life Sciences Pvt. Ltd.	Bio-Pharma	Residential
9	Stellar Diagnostics India Pvt. Ltd.	Diagnostic	Residential
10	Vanguard Diagnostics Pvt. Ltd.	Diagnostic	Residential
11	Incredible Devices Pvt. Ltd.	Medical Device	Residential
12	BioCredence	Nutraceuticals	Residential
13	AptaBharat Innovation Pvt. Ltd.	Diagnostic	Residential
14	Sunny Corporation Pvt. Ltd.	Diagnostic	Residential
15	Biotide Solutions LLP	Anti-infective	Residential
16	Organic 121 Scientific Pvt. Ltd.	Industrial Biotechnology	Residential
17	Dharaksha Ecosolutions Pvt. Ltd.	Environmental Biotech	Residential
18	Peptomer Therapeutics Pvt. Ltd.	Anti-infective	Residential
19	Sleepiz India Pvt. Ltd.	Medical Device	Residential
20	Inte-e-Labs Pvt. Ltd.	Bio-Pharma	Residential
21	Genvynn Biologics Pvt. Ltd.	Bio-Pharma	Residential
22	Kantech Research Solutions	Anti-infective	Residential
23	3CR Bioscience Ltd.	Diagnostic	Non-Residential
24	TechInvention Lifecare Pvt. Ltd.	Bio-Pharma	Residential
25	Anziam Bio Pvt. Ltd.	Bio-Pharma	Residential
26	Celleome Biosciences LLP	Diagnostic	Residential
27	PriDignity Pvt. Ltd.	Sanitation	Residential

S.No	Company	Area	Type of Incubatee
28	Valetude Primus Healthcare Pvt. Ltd	Diagnostic	Residential
29	Ruhvenile Biomedical OPC Pvt. Ltd	Anti-infective	Residential
30	Mr. Sharad Rai	Nutraceuticals	Residential
31	Advinogen Innovations Pvt. Ltd.	Diagnostic	Residential
32	Biotrends India Pvt. Ltd.	Industrial Biotech	Residential
33	Micronic Analytical Device Pvt. Ltd.	Diagnostic	Residential
34	Meraki Herbzz	Nutraceutical	Non-Residential
35	Florecer Services Pvt. Ltd.	Industrial Biotech	Residential
36	Tritek innovation Pvt. Ltd.	Diagnostic	Residential
37	Translational Research Innovations Pvt. Ltd	Industrial Biotech	Residential
38	Biolytics Research & Innovation Pvt. Ltd.	Diagnostic	Residential
39	Dr. Suman Das	Diagnostic	Residential
40	Mr. Nidhin Murali	Bio-Pharma	Residential
41	Tropical Animal Genetics Pvt. Ltd.	Bio-Pharma	Residential
42	East Ocyon Bio Pvt. Ltd.	Bio-Pharma	Residential
43	Cellogen Therapeutics Pvt. Ltd.	Bio-Pharma	Residential
44	I2 Cure Pvt. Ltd.	Bio-Pharma	Residential
45	Third AI Platforms Pvt. Ltd	Digital Health	Non-Residential
46	Vegen Labs LLP	Bio-Pharma	Non-Residential
47	Innovationsatss Pvt. Ltd.	Social Impact	Non-Residential
48	Pro Ortho Perfect India Pvt. Ltd.	Healthcare	Non-Residential
49	Grailmaker Innovations Pvt. Ltd.	Healthcare	Non-Residential
50	Biopan Scientific Pvt. Ltd.	Industrial Biotech	Non-Residential
51	Jivanu Therapeutics Pvt. Ltd.	Bio-Pharma	Residential

Grants/Awards secured by startups in FY 2023-24

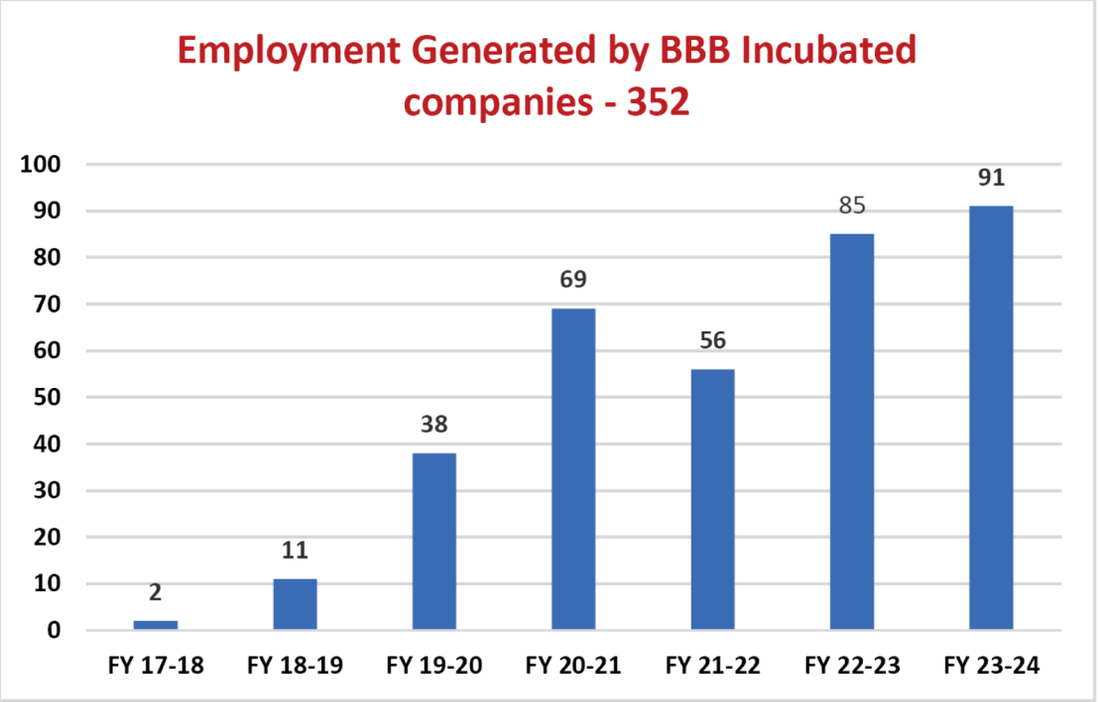
S.No	Name of Incubatee Company	Grant & Awards
1	Inte-e-labs Pvt. Ltd.	BIRAC BIG, ICMR
2	Vegen Labs LLP	IKP fellow award
3	Advinogen Innovations Pvt. Ltd.	CSR Grant

Startups on boarded during FY 2023-24

BBB has incubated 08 new startups during FY 2023-24

S.No	Company	Area
1	I2 Cure Pvt. Ltd.	Bio-Pharma
2	Third AI Platforms Pvt. Ltd.	Digital Health
3	Vegen Labs LLP	Bio-Pharma
4	Innovationsatss Pvt. Ltd.	Social Impact
5	Pro Ortho Perfect India Pvt. Ltd.	Healthcare
6	Grailmaker Innovations Pvt. Ltd.	Healthcare
7	Biopan Scientific Pvt. Ltd.	Industrial Biotech
8	Jivanu Therapeutics Pvt. Ltd.	Bio-Pharma

Employment generated by BBB Incubatees



Events Conducted during FY 2023-24

BBB is actively promoting the entrepreneurial aptitude among young innovators through its strategic programs & outreach activities. It also regularly conducts workshops, seminars and facilitates the interaction between entrepreneurs & mentors. 31 events were conducted in FY23-24.

S.No	Event Name	Category	Month
1	Delhi Innovation Summit - roundtable discussion on Strengthening Research translation in life sciences	Networking	April 2023
2	Visit by students from Department of Life Sciences, J.C. Bose University of Science and Technology, YMCA	Awareness Session on Entrepreneurship Development	April 2023
3	Visit of Delegates from Asian Federation of Biotechnology (AFOB)	Networking	April 2023
4	Panel discussion in a Conference on 'BioDesign Innovation for Development of HealthTech Solutions – 2023" organized by THSTI	Awareness Session	May 2023
5	Outreach activity in National Technology Week; The theme of the event was 'School to Start - Up - Igniting Young Minds to Innovate',	Networking	May 2023
6	State workshop for Women Entrepreneurs - Organized by Startup Haryana	Workshop	May 2023
7	Workshop on Science communication	Workshop	June 2023
8	Seminar on Advanced technologies in Immuno-Biology followed by a Demo session in collaboration with Thermo Fischer	Workshop	June 2023
9	Awareness Session on Entrepreneurship Development & IP for students from Gujrat	Awareness Session	June 2023
10	Keynote speaker on the occasion of 4-week Technology based Entrepreneurship Development Programme (TEDP), focused on Bio-Entrepreurship, sponsored by Department of Science & Technology, Govt. of India, organized by Institute Innovation Council (IIC), School of Biomedical Sciences & School of Business, Galgotia University, Greater Noida UP	Awareness Session	July 2023
11	Awareness Session on BIG Call by BIRAC	Awareness Session on BIG	July 2023

S.No	Event Name	Category	Month
12	Visit of the delegates from Department of Science & innovation, South Africa accompanied by officials from Foreign, Commonwealth & Development Office(FCDO), India and BIRAC	Networking	July 2023
13	Awareness Session on BIG Call by BIRAC	Awareness Session on BIG	July 2023
14	Visit of MD, BIRAC @ BBB Facility & interaction with Entrepreneurs	Networking	August 2023
15	Workshop on "Data Integrity & Quality Management Systems")	Workshop	August 2023
16	Introductory talk by India Accelerator: One of India's leading HealthTech accelerator	Awareness Session	October 2023
17	Incubator visit by students from DPS Vasant Kunj	Awareness Session	October 2023
18	Workshop on "Basics to Create a Successful Bio-Enterprise" including Global Bio India Roadshow	Workshop	October 2023
19	Physical boot camp under National Incubator Capacity Development Program	Networking & Awareness Program	November 2023
20	Visit of the incubator by Dr. Amitabha Bandyopadhyay, Professor-in-Charge, SIIC, IIT-Kanpur	Networking	November 2023
21	Incubator visit by students from Krishna Chandra College, Hetampur, Birbhum, West Bengal	Awareness Session	November 2023
22	Outreach booth at Global Bio India – New Delhi	Networking	December 2023
23	IP clinic with Dr. Malathi Lakshmikumaran	Mentoring	December 2023
24	Ideathon Competition for students- SPARK	Innovation Challenge	January 2024
25	Outreach booth at India International Science Festival (IISF) - Faridabad	Networking	January 2024
26	Workshop on Accelerating Diagnostics 2024 - to learn advanced technology in Lateral Flow Assay	Workshop	February 2024
27	Visit of Delegates from Indo-Euro Synchronization visited BBB facility	Networking	February 2024
28	Workshop - Incubator Connect 2.0: Innovation and Internationalization workshop with Incubators from India and Germany	Workshop	February 2024

S.No	Event Name	Category	Month
29	Keynote speaker in a workshop on Nurturing Entrepreneurship & Incubating Innovation (Bridging Ideas to impact)	Awareness Session on Entrepreneurship Development	March 2024
30	Workshop on "The Basics of Bioprocessing: Upstream & Downstream"	Workshop	March 2024
31	Outreach booth at "STARTUP MAHAKUMBH"	Networking	March 2024

Pictures of Events @ BBB

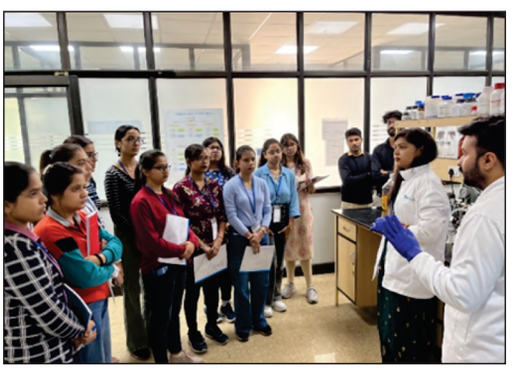
Awareness Session & Visits

"Basics to Create a Successful Bio-Enterprise" Workshop

Workshop on "Science Communication"

Workshop on "Data Integrity & Quality Management Systems"

Workshop on "The Basics of Bioprocessing: Upstream & Downstream"



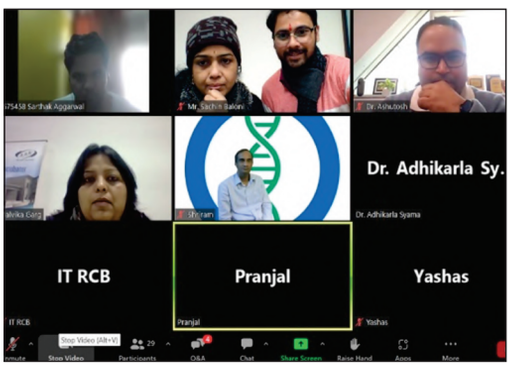
Global Bio India 2023

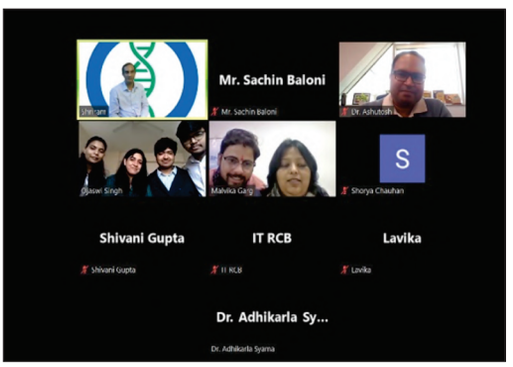
India International Science Festival (IISF) – Faridabad 2024

Startup Mahakumbh, Jan 2024

IP Clinic

SPARK 3.0 – Innovation Challenge Organized by BBB and RCB





Biosafety Support Unit (BSU)

Biosafety Support unit (BSU) is a unit established by Department of Biotechnology, Government of India as a part of the reforms to strengthen biosafety regulatory system in partnership with Regional Centre for Biotechnology (RCB).

A. Major activities undertaken by BSU during the year 2023-24 include:

- Provided assistance to RCGM/GEAC (Statutory bodies established under Rules 1989 of EPA 1986) in the scrutiny of all the applications received for conducting research in biotechnology, product development and monitoring field trials. The activities of BSU includes desk review of all applications to ensure the completeness of the data requirements, compliance of the approved protocols/procedures to be followed at the time of field trials (Event selection, BRL-I and BRL-II) and preclinical toxicology (PCT) data and other regulatory compliances.
- Developed and updated a number of guidelines, Standard Operating Procedures and policy documents.
- Assisted the RCGM Secretariat in developing revised guidelines and protocols for generating biosafety data to address the challenges raised by the emerging new areas of Biotechnology such as Genome Editing.
- BSU team is also fulfilling the training needs of the personnel engaged in Biosafety regulations and developing e-learning modules for IBSCs and other stakeholders working in the regulatory science.
- BSU is fully engaged in providing a communication platform for scientific community and other stakeholders through Indian Biosafety Knowledge Portal, an online portal for all transaction and submission and tracking of applications.
- BSU provided all necessary services to RCGM and assisted RCGM Secretariat in organizing scheduled meetings of the RCGM, various sub-committees and monitoring teams, etc.

B. Major accomplishments:

B.1. RCGM/GEAC Related Activities:

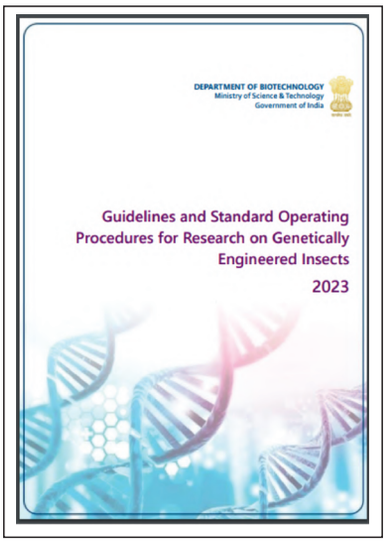
- *Review of applications*: BSU evaluated a total of 2962 applications in the field of Biopharma and Agri-Biotechnology submitted to Review Committee on Genetic Manipulation (RCGM), of which 839 applications were considered in RCGM meetings (255th to 280th Meetings) during year 2023-24. BSU extended its support towards conducting all the meetings of RCGM by preparing Agenda notes and draft Recommendations. 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).
- *Certification of BSL-3 facilities Nation-wide*: To ensure compliance with biosafety for high containment facilities, 'Guidelines for the Establishment of containment facilities: Biosafety Level 2 (BSL-2) & -3 (BSL-3) and certification of BSL-3 facility, 2020' defining specifications and SOPs for these facilities have been notified. Further, a mechanism for certification of such facility based on review of documents was also devised and now being followed with ongoing review of the applications. BSU assists in preliminary examination of applications for Certification of BSL-3 facility and has assessed 56 applications so far. Of these, 45 facilities have been recommended by the Interministerial committee for BSL-3 certification and approved by RCGM. Further BSU assists in preliminary

examination of applications for annual revalidation of certified BSL-3 facilities and has evaluated 29 applications during this period. BSU also facilitates site visit to BSL-3 facilities, to understand the design, procedures and engineering controls in the facility, and provide suggestions so that the facility meets to the specific requirements.

- *Biosafety Protocols and Guidelines*: New/Revised/Updated: BSU has undertaken a major activity of drafting/revising/updating of various guidelines related to biosafety of recombinant DNA research.

The following guidelines have been notified:

DBT notified the Guidelines and Standard Operating Procedures for Research on Genetically Engineered Insects 2023, vide OM dated 17.04.2023. This document has been prepared for GE insects including vectors of human diseases (Mosquitoes like Aedes aegypti, Aedes albopictus and Anopheles stephensi), crop insect pests (e.g. pink bollworm, fruit fly species and diamond back moth) and beneficial insects (e.g., silkworm, honeybees and biological control agents like insect parasitoids and predators). It aims to specify the regulatory pathway for import, export, transfer and receive as well as for conducting research on GE insects. The document also addresses the containment requirements as well as data requirements for ensuring biosafety and trait efficacy.



DBT notified the Entry of Pseudorabies virus in "List of Infective Microorganisms corresponding to different Risk Groups, 2021" superseding the Annexure I of "Regulations & Guidelines for Recombinant DNA Research and Biocontainment, 2017", vide OM dated 09.07.2023.

DBT notified the Entry of Hansenula polymorpha in "List of Infective Microorganisms corresponding to different Risk Groups, 2021" superseding the Annexure I of "Regulations & Guidelines for Recombinant DNA Research and Biocontainment, 2017", vide OM dated 27.12.2023.

DBT notified the Entry of Hansenula polymorpha in "List of Infective Microorganisms corresponding to different Risk Groups, 2021" superseding the Annexure I of "Regulations & Guidelines for Recombinant DNA Research and Biocontainment, 2017", vide OM dated 27.12.2023.

DBT notified the Entry of Banana Bract Mosaic Virus in "List of Infective Microorganisms corresponding to different Risk Groups, 2021" superseding the Annexure I of "Regulations & Guidelines for Recombinant DNA Research and Biocontainment, 2017, vide OM dated 09.02.2024.

OFFICE MEMORANDUM

In addition, the following guidelines are under preparation:

- Draft National Guidelines for the establishment of Biosafety Level - 3 (BSL-3) containment facility, 2024.
- Draft Guidelines on Genetically Engineered plants containing stacked events, 2024.
- Handbook for Institutional Biosafety Committees (IBSCs), 2024.

Further the revision/drafting of following guidelines is under consideration:

- Updation of Guidelines on Similar Biologics.
- Updation of Regulations & Guidelines for Recombinant DNA Research and Biocontainment.
- Revision of List of infective Microorganisms corresponding to different Risk Groups.

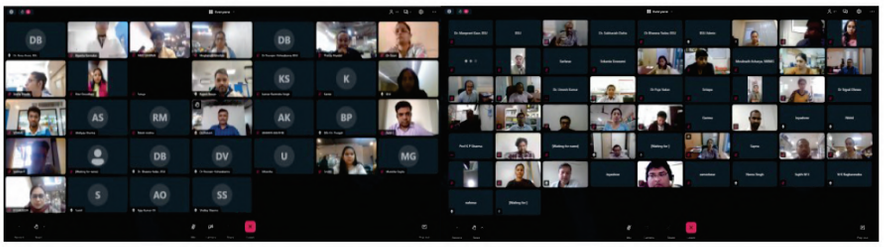
Commissioning of Indian Biosafety Knowledge Portal (IBKP): The Portal facilitates registration of Institutional biosafety committees and uploading of new applications through portal. It is the nodal point for IBSC registration and monitoring, in addition to submission of respective applications for RCGM consideration and notification of the appropriate decision to the applicant. BSU evaluated the following, since commencement of the Portal:

Number of organization registrations approved	1150
Number of IBSCs registered	735

Monitoring of IBSCs and Assessment of compliance documents: DBT-RCGM has taken several reforms including empowering of IBSCs, hence stringent mechanism to monitoring the IBSCs through their Minutes, Annual Compliance Reports and Medical Surveillance Reports has been started with IBKP portal. BSU is facilitating RCGM in the monitoring of IBSCs and assessment of compliance documents.

- **Biological Research Regulatory Approval Portal (BioRRAP)**: BioRRAP tracks the regulatory approvals for a research proposal on a single portal and provides more credibility and recognition to such biological researches. BSU facilitates the functioning of BioRRAP.

- **Interactive sessions for awareness raising of Researchers**: DBT along with BSU scientists provided training sessions to Researchers (Principal Investigators, Scientists, Post-doctoral researchers) from Academia, Start-ups and Industry. 23 sessions were conducted during this financial year, which were attended by approximately 1050 participants.



Training and Capacity Building:

- **BSL-3 facility visit:**
  - BSU Scientist along with the visiting team from Inter-Ministerial Committee for Certification of BSL-3 facility visited the BSL-3 facility at Regional Centre for Biotechnology, Faridabad on 27.09.2023, to understand the design, procedures and engineering controls in the facility, and provide suggestions so that the facility meets to the specific requirements.
  - BSU Scientist along with the visiting team from Inter-Ministerial Committee for Certification of BSL-3 facility visited the BSL-3 facility at Translational Health Science and Technology Institute, Faridabad on 27.09.2023, to inspect if the facility meets the requirements of a BSL-3 facility.
  - BSU Scientists (03) visited BSL-3 facility (modular) and BSL-3 Primate facility, at National Institute of Immunology, New Delhi on 18.09.2023, to enhance and enrich their acquaintance with the Engineering aspects of a BSL-3 facility.
  - BSU Scientist along with visiting team from Inter-Ministerial Committee for Certification of BSL-3 facility visited the BSL-3 facility at Shiv Nadar University, Greater Noida on 09.06.2023. The Team inspected the BSL-3 facility to understand the design and provide suggestions so that the facility meets to the specific requirements.
- **Central Compliance Committee (CCC) visits:**
  - First CCC visit was held on 12.03.2024 to monitor the event selection trial under confined field condition of fourteen GE cotton lines in Aurangabad.
  - Third CCC visit was held on 14 - 15 March, 2024 for post-harvest monitoring of the Biosafety Research Level-I (BRL-I) 1st Year trial of GE maize at two trial locations in Raichur.
  - First CCC visit was held on 25.02.2024 to monitor three Event Selection Trials under confined field conditions of GE *Brassica juncea* lines in Delhi.
  - Second CCC visit was held on 14.02.2024 to monitor the harvest/ termination/ completion of BRL-I 1st Year trial of GE cotton Event in Khandwa.
  - Second CCC visit was held on 08.02.2024 to monitor the termination of Event Selection Trial under confined field conditions of ten GE cotton lines in Janwada.

- Second CCC visit was held on 07.02.2024 to monitor the termination of Event Selection Trial under confined field conditions of ten GE cotton lines in Jalna.
- First CCC visit was held on 08.12.2023 to monitor Biosafety Research Level-I (BRL-I) of GE cotton Event in Khandwa, RVSKVV, *Kharif* 2023.
- Second CCC visit was held on 15.12.2023 to monitor the termination of Event Selection Trial conducted under confined field conditions of four GE Brinjal lines at Aurangabad, Maharashtra during *Kharif* 2023.
- First CCC visit was held on 16 -19 October, 2023 to monitor Event Selection Trial under confined field conditions of ten GE cotton lines at two trial locations viz., Hyderabad, Telangana and Jalna, Maharashtra.
- First CCC visit was held on 17.10.2023 to monitor Event Selection Trial under confined field conditions of four GE Brinjal lines at Aurangabad.
- First CCC visit was held on 27.10.2023 to monitor Event Selection Trial under confined field conditions of ten GE pigeon pea lines at New Delhi.
- First CCC visit was held on 26 -27 September, 2023 to monitor Biosafety Research Level-I (BRL-I) 1st Year trial of GE cotton Event at two trial locations *viz*. Panghal, and Hisar.
- First CCC visit was held on 02.09.2023 to monitor Biosafety Research Level I (BRL-I) 1st Year trial of GE potato line at Kufri.

• Conference/Workshop/Training:

- BSU Scientist attended the ICMR One Health Webinar Series on Avian Influenza: A Looming Threat, organized by ICMR, Headquarters, New Delhi, held on 22.02.2024.
- BSU Scientist attended the National Conference on Blue Economy: "Navigating Marine Ecosystem Value Chain", organized by KIIT University, Bhubaneswar, held on 19 - 20 February, 2024.
- BSU Scientists (3) attended the National Conference on Strategic Trade Controls (NCSTC), organized by Directorate General of Foreign Trade (DGFT) and the Ministry of External Affairs (MEA), at Vigyan Bhawan, New Delhi held on 30.01.2024.
- BSU Scientist attended the On-site training on the 'Laboratory System and Internal Audit program as per ISO/IEC 17025:2017' organized by Training and capacity building cell of Quality Council of India (TCB/QCI), New Delhi held on 29 – 31.01.2024.
- BSU Scientists (3) attended the annual training event "CBT Course Series 2023", organized by DBT Center of Excellence for Biopharmaceutical Technology (COE-CBT), IIT Delhi, New Delhi (11 – 15 December, 2023).
- Coordinator and Scientists (3), BSU attended the ICGEB-DBT International Hands-on Workshop on Redesigning Crops for Smart Agriculture, ICGEB, New Delhi (06 - 10 November, 2023).
- BSU Scientist attended 4th International Conference on Bacteriophage Research and Antimicrobial Resistance, University of Madras, Chennai, on September 28-30, 2023.
- BSU Scientist delivered presentation on "Regulatory landscape" for 1st Meeting of Precision Biotherapeutics - mRNA Therapy - Sub-sectorial Expert Committee on Biomanufacturing, Department of Biotechnology, held on 25.08.2023

- BSU Scientists (03) facilitated the **First Workshop to create awareness about Biosafety measures** and to facilitate filing of proposal applications organized by IBSC, BITS Goa on 02.08.2023
- BSU Scientist attended 6-days **Advanced Vaccinology course (TIVaC)**, Translational Health Science and Technology Institute (THSTI) (22- 27 May, 2023).

B.2. Other activities:

- BSU supports RCGM/GEAC for drafting affidavits/ replies for biosafety related matters for Parliamentary Standing Committee, Court Cases, Parliament questions etc.
- BSU provides background information to various Sub-committees (eg. GE Mosquito, BGIII RRF, Risk group updation, engineering controls, Gene therapy).

BSU Team (Coordinator, Scientists & Admin staff)

BSU Team (Coordinator, Scientists & Admin staff)

Advanced Technology Platform Centre

The center's mission is to act as a catalyst for multidisciplinary basic and translational research and development by providing relevant state-of-the-art instrumentation and professional services for research laboratories in industry and academia, training personnel in the use of these technologies, and developing new technologies in collaboration with academia and industry.

A picture of the ATPC-BBB building is displayed. The ATPC facilities are present on the lower floor of this building.

The Centre plugs a massive lacuna in the innovation pipeline that has previously attenuated Indian researchers' ability to realize their true potential. At present, the ATPC has six operational platform facilities equipped with various high-end technologies for aiding biotechnology researchers and start-ups.

1. Protein Purification and Molecular Interactions Facility

This facility houses state-of-the-art technologies for protein production and downstream purification and studying biomolecular interactions. The molecular interaction platform is currently providing scientific and technical support for a diverse range of projects involving the following state-of-the-art equipment:

- Production of recombinant proteins in 7-liter and 14-liter Bioreactors (New Brunswick™_Bioflo® 415 - 7L, 14L).
- Protein purification by affinity and size-exclusion chromatography using AKTA prime and AKTA pure FPLC systems (Acta Pure M from Cytiva).
- Molecular interaction studies using BioLayer Interferometry – BLI (Pall ForteBio), MicroScale Thermophoresis -MST (Nanotemper tech.), Multiangle Light Scattering –MALS(Malvern) and Multi-mode microplate reader (Molecular Devices)

2. Mass Spectrometry Facility

Mass spectrometry houses a suite of leading-edge instrumentation for proteomics and metabolomics. Highly sensitive and accurate mass spectrometry services that are being provided include the following:

- Identification and quantitation (labeled, TMT /iTRAQ/SILAC/label-free) and intact mass analysis of proteins by high-resolution liquid chromatography ESI Q-TOF (SCIEX 5600 Plus Triple–TOF) system and a high-throughput SCIEX 5800 Plus matrix-assisted

laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF-TOF-MS) system with EKSpot MALDI spotter.

- Peptide enzymatic digest analysis (In-gel/In-sol) for protein identification and post-translational modifications (PTMs) determination.
- Ultra-low-level identification and MRM-based targeted and untargeted, absolute and relative quantitation of both small and large molecules, secondary metabolites, lipids, and proteins by triple quadrupole linear ion trap spectrometer SCIEX QTRAP® LCMS/MS 6500+ system.
- Fractionation and separation of TMT/iTRAQ/SILAC-labelled peptides for deeper coverage of the whole proteome and PTM analysis by a high-flow Perkin Elmer Flexar™ HPLC.

The ESI-Mass Spectrometer (SCIEX QTRAP® LCMS/MS 6500+) is shown here.

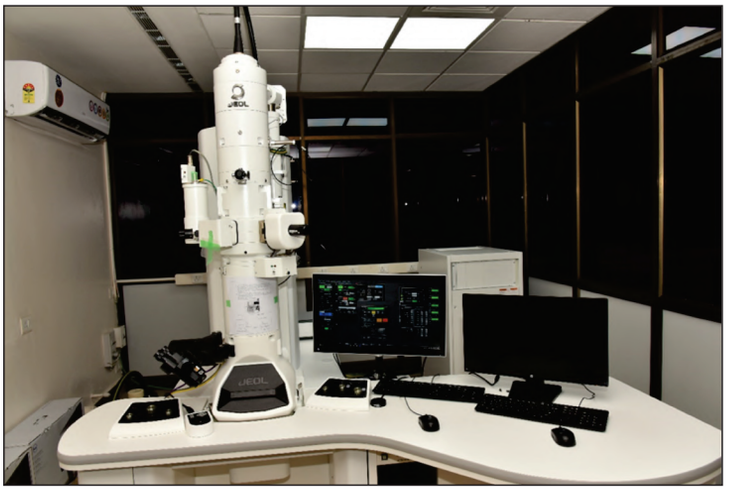
Recently, a high-resolution mass spectrometry solution ZenoTOF 7600 system that combines powerful MS/MS sensitivity, fragmentation technology, and a step-change in data-independent acquisition (DIA) to deliver a high depth of coverage, particularly on low abundance species, quickly and robustly.

3. Electron Microscopy Facility

The electron microscopy facility at ATPC is furnished with state-of-the-art instruments. The electron microscopy facility consists of:

- Cryo-electron microscope (200kV JEM 2200FS)
- Transmission electron microscope (120kV JEM-1400 Flash)
- Field emission scanning electron microscope (Apreo Volume Scope)

The JEM-2200FS is a field emission electron microscope with a 200 kV field emission gun (FEG), piezo-controlled goniometer, holders for cryo-observation and tomography, in-column energy filter (Omega filter), and Gatan direct detection camera (K2 summit). This instrument is capable of high-resolution cryo-electron microscopy, zero-loss imaging, energy-filtered imaging, and tomography. JEM1400 Flash is 120 kV TEM equipped with a tungsten filament and a highly-sensitive sCMOS camera. It can achieve high-contrast imaging of samples from biological and material science. FESEM provides novel serial block-face (SBF) imaging that enables excellent z-resolution from multi-energy deconvolution SEM combined with the efficiency of in situ sectioning. The instrument is equipped with in-lens and in-column detectors for HiVac, and LoVac analysis of samples and energy-dispersive X-ray spectroscopy (EDS) detectors for elemental analysis. The facility is furnished with accessory equipment e.g. Cryo-plunger, glow discharge, plasma ion cleaner, carbon coater, critical point dryer, sputter coater, and an ultramicrotome.



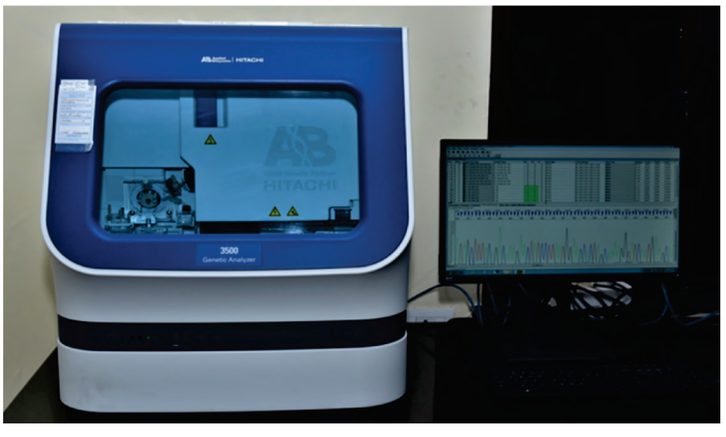
The 120 kV JEOL 1400 Flash Transmission Electron Microscope is shown here.

4. Genomics Facility

Genomics Facility caters to the needs of researchers, especially from Biotech Science Cluster institutes in NCR, from the standpoint of their requirement for DNA-based services. This facility currently provides scientific and technical support for various research projects through the usage of the following state-of-the-art equipment:

- Automated DNA Sequencing using AB3500 Genetic Analyzer
- Droplet Digital PCR (ddPCR) using BioRad QX200

Human Cell Line Authentication (CLA) and Mycoplasma Contamination Testing is also conducted at the Genomics facility.



The AB3500 Genetic analyzer utilized for DNA sequencing is shown here.

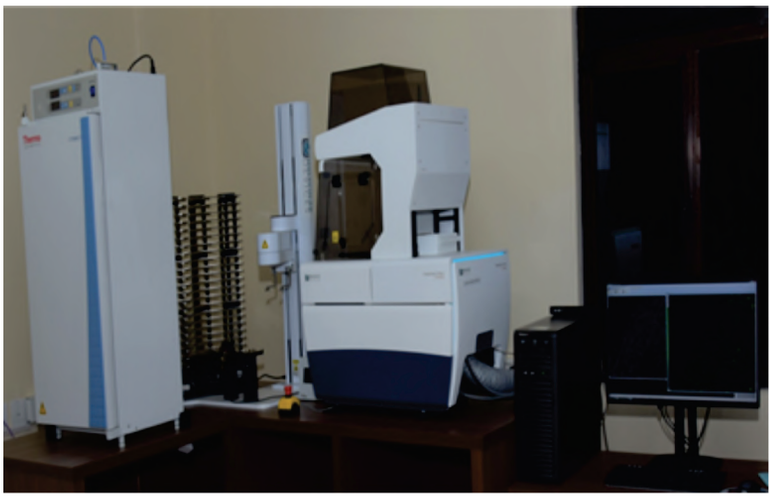
5. Optical Microscopy facility

The optical microscopy centre is equipped with state-of-the-art research facilities, skilled personnel, and world-class infrastructure. With an intent to make a significant contribution to the global research pool, the facility is ever vigilant about generating reproducible and reliable data that comply with international research standards.

The optical Microscopy facility hosts the following state-of-the-art fluorescence-based imaging instruments:

- Super Resolution Microscope; Elyra PS1, Carl Zeiss
- Laser Scanning Confocal Microscope; LSM 880, Carl Zeiss
- High Content Imaging System; ImageXpress, Molecular Devices

The scientists and researchers who use the facilities come from both academia and industry, mainly from RCB and Cluster institutes.

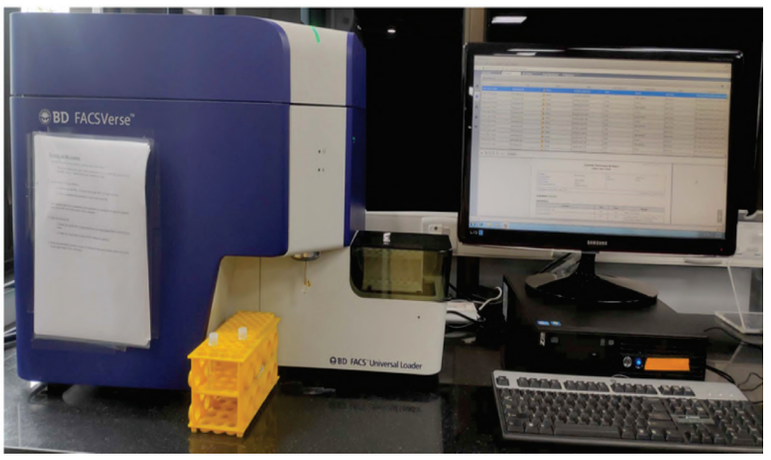


The Elyra PS1 super-resolution microscope is shown here.

6. Flow Cytometry

Flow Cytometry Facility is aiding the scientist fraternity in addressing key cell biology and immunological research questions by providing services, with scientific and technical inputs through the deployment of the following technologically advanced equipment, which includes 2 Analyzers:

- BD FACSVerse (3-lasers and 8-colours analyzer)
- BD Accuri C6 (2-lasers and 4-colours analyzers)



The BD FACSVerse flow cytometer is shown here.

ATPC team

The team comprises technical personnel who maintain, operate, and help users in the six facilities. A total of 9 personnel including two interns carry out all the ATPC activities. The activities of the ATPC are supervised by the Acting head, Prof. Deepak T. Nair.

S. No.	Name of the person	Name of the Post	Primary Facility
1	Atin Jaiswal	Technical Officer	Genomics
2	Dharmender Gupta	Technical Assistant	Protein Purification & Molecular Interactions
3	Madhava Rao Medikonda	Technical Officer	Electron Microscopy
4	Meena Kapasiya	Technical Officer (Contractual)	Flow Cytometry & Mass Spectrometry
5	Reena Rani	Technical Assistant	Electron Microscopy
6	Suraj Tewari	Technical Officer	Optical Microscopy
7	Ashutosh	Apprentice	Flow Cytometry
8	Samiksha Shukla	Apprentice	Mass Spectrometry
9	Rajesh Kumar	Instrument Engineer (Contractual)	ATPC
10	Hemanshu Pawar	MTS (Contractual)	ATPC

ATPC Usage & Revenue

The details on how to access the facilities at ATPC are available at the website https://atpc.rcb.res.in. From April 2023 to March 2024, 11222 samples were processed under 1235 user engagements. The users were from 41 different institutions (16 Research Institutes, 12 Universities, 12 Commercial organizations, and 1 Govt. organization) utilized different facilities of the ATPC. During the reporting period, services worth a cumulative amount of Rs. 143 lakhs were provided to the users by different facilities of the ATPC.

High Performance Computing Cluster & IT Infrastructure

High Performance Computing Cluster & IT Infrastructure

In terms of IT Infrastructure & Computing Facilities hosted & managed by RCB, A high performance computing (HPC) cluster with 8 nodes and a total of 128 processors & a Schrodinger suite server with 3 clients, and workstations are placed at **Graphics Lab** for research in computational biology and structure-based drug design. The Information and Communication facilities at RCB are continuously evolving with state-of-the-art facilities. All the computers at RCB are provided with the latest updated software and hardware. Internet, printing and scanning facilities are also available throughout the network.

An impressive array of information technologies and resources have been deployed with a harmonious blend of old and new, notable among these are:

Computing Facilities

The Institute has three state of the art Computer facilities. All the computers facility in the Institute are provided with the latest updated software and hardware. Internet, printing and scanning facilities are also available through network. Desktops/ Laptops, multifunction printers have been provided to the staff with internet connectivity. There are about 250+ client machines with windows 10, Linux (CentOS, Red Hat Enterprise Linux) and Mac OS X. There are common Personal Computer in each research lab and MSc lab for students to access various commercial off-the-shelf software such as Adobe Premium & Standard Suite, Systat, Sigma Plot, PyMol, Graphpad Prism, SPSS, Turnitin, Endnote, Grammerly, and Corel Draw Graphics Suite for preparing manuscripts, various reports and presentations. Face Recognition Biometric Attendance System has also been enabled for the staff, to register attendance by simply presenting his/her biometric. In addition, online resources are available for scholars for research, case studies and for preparation of their projects.

Internet Connectivity

RCB has 1 Gbps shared internet leased line from National Knowledge Network offering high-speed Internet connectivity in the campus. Additionally, a 125 Mbps fiber connectivity has been provisioned from an alternate service provider as a backup. The internet connection is distributed to users and facilities through RCB's network infrastructure comprises about 1000 metres of fibre, with a 10Gbps backbone, 115+ wireless access points, and 45+ network switches that provide on-campus wireless & wired connectivity. The RCB has implemented a security policy to ensure the highest levels of network health and security. The Centre has been functioning in conformity with the guidelines of the Government of India with regard to guidelines on IPV6 implementation and has also been an active participant in the Government initiatives of the "Digital India Campaign". The campus is fully covered by Wi-Fi into all the administrative buildings, labs, advanced platform technology centre (ATPC), associated centres, and hostels. Wi-Fi access is provided to internal users by Captive portal & media access control (MAC) address authentication and to visitors by separate guest accounts.

E-mail and Website

The e-mail system at RCB, offers a user-friendly web-based e-mail allowing users to access mails, both from inside the campus and outside. A very competent & experienced IT service support team has been put in place and the Centre is also in the process of developing & implementing a highly attractive, user-friendly and dynamic web-site. All major information

about the institute, academic research, infrastructure, people, job portal, news and announcements is being regularly updated on the website.

Internet Security

The Campus Network is protected using Shopos XG310 - where Unified Threat Management as a primary network gateway defense solution has been implemented with traditional firewall built into an all-inclusive security product able to perform multiple security functions: network firewalling, network intrusion detection/ prevention (IDS/IPS), gateway antivirus (AV), gateway anti-spam, content filtering, load balancing, data loss prevention, and on-appliance reporting. Quick heal Seqrite end point security total edition 18.0 has been implemented as protection from viruses, adware, spyware etc.

Telephone Connectivity

The Campus has a PRI connectivity from Bharat Sanchar Nigam Limited and a distribution of about 300+ extensions for ease of communication within the campus and connecting with the outside world.

Audio Visual and Video Conferencing Facility

Auditorium, conference and seminar halls are equipped with a hi-tech sound and projection system, digital podium and Internet connectivity. These facilities are actively used for regular seminar series, colloquia and distinguished lectures, hands-on workshops and symposiums/ conferences. In addition, projection facility has been setup in classrooms and discussion rooms for regular teaching, lab meetings and scientific discussions. RCB has an Internet-based Video Conferencing Facility setup in the Seminar Hall. In addition to this, RCB has enrolled subscriptions for various virtual conference meeting rooms for holding virtual seminars or conferences. Classrooms, meeting rooms and conference halls are furnished with the latest digital technology i.e. digital podium, LCD projection system with audio/ video facility and video conferencing systems in the Institute.

Digital Library

RCB has a small but fully functional library with several copies of standard international textbooks spanning various areas of biotechnology practiced by its researchers and taught in its coursework. The RCB library houses over 1400 books including scientific textbooks, administrative, engineering and Hindi books in multiple copies. Web-based Online Public Access Catalogue (WebOPAC) has been set up through KOHA Open Source Library Management Software at RCB Library to provide online access to RCB library catalogues. In addition, an electronic library provides access to a vast range of primary literature in the form of peer-reviewed journals and reviews, through the DBT electronic library consortium (DeLCON). The RCB library provides access to online resources to users 24 X 7 via Intranet/Internet. Library also contains common Personal Computer systems for browsing online resources (e.g. journals and books) and checking for plagiarism.

Office Automation

RCB is moving towards adapting a paperless work environment in which the use of paper is eliminated or greatly reduced. This is done by converting documents and other papers into digital form and development of various online applications (services or facilities) through the intranet portal named eRCB. All the faculty and students have access to this customised online software package being used for administrative applications. The major modules in eRCB are online leave management, user management, vehicle booking, vendor management, HR, visitor management, bill claim portal, purchase workflow etc. In continuation of paperless work environment using office automation, IT has to implement

the ERP System in the upcoming year. This system will provide paperless centralised automation mechanism to complete any task faster with the better traceability & reporting. This system will have centralized cover of all the major activities for five sections i.e. Finance, HR, Purchase, Academics & General Administration. In addition to this, many other online services are available over internet accessible from outside Institute. The majors are:

- Implemented GeM for all kind of purchases at RCB
- An online system of APAR (Annual Performance Appraisal System) be made more consultative and transparent. The full APAR including the overall grade shall be communicated to the concerned officer after the report is complete with the remarks of the reviewing officer.
- Central e-Procurement Portal)eWizard(for online tendering of any value
- PhD and Integrated PhD Admission portals with integration of payment gateway
- Job Portals with integration of payment gateway
- Google forms are being used for various online application to reduce paper usages
- Online Class Attendance for all programs
- Google Classroom / Zoom Meeting are available for conducting Online Classes
- Micro websites for various research workshops & conferences and facility for online registrations.
- Online Payment Gateway for collecting Student Fee, any conference registration fee etc.
- Alumni portal for establishing closed relations between RCB alumni
- Vendor Registration portal etc.

Further, the RCB has implemented Academic and Payroll portals. The RCB Academic portal gives a centralize repository of Student's Academic records and their research progress for RCB and its affiliated centres. At present date, approx. 650 students have been registered for their course and research work of RCB and affiliated Centres both. Also, the RCB has recently implemented Online Payroll system for RCB officials and students for their online leave approval workflow and other payroll features like TDS declaration, leave records, daily IN/OUT punching details, salary slip etc.

In addition to the above core activities, the IT department of RCB will also play a critical role in the development of the following two centres:

Indian Biological Data Center (IBDC) The IBDC has deployed & start functioning soon by RCB, NII, ICGEB and NIC with support from Department of Biotechnology, Govt. of India. The computational infrastructure of IBDC will include High Performance Computation (HPC) cluster and High capacity archival data storage. The data will be curated at RCB and will be hosted by NIC, Bhubaneswar. The RCB IT-department is providing technical support for the development and day-to-day operations of the RCB component of IBDC. Detailed information on the kind of infrastructure developing under IBDC project is provided into separate section of this annual report.

Bioinformatics Center

The DBT has sanctioned the development of a Bioinformatics centre for computational drug discovery at RCB. The centre will have personnel and equipment to help researchers carry out structure based drug design to identify potential drugs against different pathogens. The RCB IT-department will provide technical support for the development of this centre.

DBT-HRD Project Management Unit (DBT-HRD PMU) at RCB

Human resource development in Biotechnology and its allied areas is of utmost importance to the Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India. Recognizing the need for nurturing large pool of skilled and dynamic human capital which are critical for success of the Indian Biotechnology sector, DBT supports several human resource development programmes for the capacity-building as well as competency-building of students, research scholars, faculty, scientists, entrepreneurs, etc.

Since the year 2020, DBT has initially entrusted RCB as the Nodal Implementation Agency for management of three (3) key human resource development programmes through establishment of DBT-HRD Project Management Unit (DBT-HRD PMU) at RCB. Thereafter, DBT has assigned four (4) additional HRD programs to RCB for implementation on a national scale.

Currently, the programmes being managed by the DBT-HRD PMU are as follows:

1. Ramalingaswami Re-entry Fellowship Programme (RRF)
2. Junior Research Fellowship Programme (JRF)
3. Post-Graduate Teaching Programme (PG Program)
4. DBT Research Associate ship (RA) Program
5. Biotech Industrial Training Program (BITP)
6. DBT – TWAS Fellowship Program (TWAS)
7. DBT Bio-Care Program (Bio-Care)

Summary of the activities undertaken and the progress made in the year 2023-2024 are given below.

1. Ramalingaswami Re-entry Fellowship Programme (DBT RRF)

Ramalingaswami Re-entry Fellowship supports Indian Nationals who are working overseas in various fields of biotechnology and life sciences and are interested in taking up scientific research positions in India. In the year 2023-2024, a total of 37 Indian researchers working abroad joined the Ramalingaswami Re-entry Fellowship programme against the call for applications initiated in 2022-2023 by DBT-HRD PMU.

DBT-HRD PMU has disbursed the total grant of Rs. 38.285 Crores to 227 Ramalingaswami fellows working in different universities/institutions across the country in the FY 2023-24.

In response to the advertisement under the Ramalingaswami Re-entry Fellowship 2022-23, a total of 193 applications were received through the online portal. The Round I meeting was convened on 22-23 May, 2023 for screening of applications received under the Ramalingaswami Re-entry Fellowship 2022-23 wherein 87 applications were screened-in. The Selection Committee (Round II) meeting held on 8-10 June, 2023 evaluated the screened-in applications and recommended 47 candidates to be supported under the Ramalingaswami Re-entry Fellowship 2022-23.

Further, a Review Committee Meeting was also conducted on 29 - 30 January, 2024 to evaluate the progress of the ongoing projects being supported under the Ramalingaswami Re-entry Fellowship program wherein a total of 117 ongoing projects were reviewed.

The DBT-HRD PMU also initiated the call for applications for the year 2023-2024 through the online portal and the same was announced on 27 December 2023 with a submission deadline

upto February 2024. A total of 171 applications have been received for this prestigious fellowship under the Ramalingaswami Re-entry Fellowship 2023-24 which are currently under review.

2. Junior Research Fellowship Programme (DBT JRF)

The DBT -Junior Research Fellowship Programme support students to pursue doctoral studies in the discipline of Biotechnology and Life-sciences across any recognised universities/ institutions in India.

Biotechnology Eligibility Test (BET) is the qualifying examination for issuance of fellowship award under the programme. BET 2023 was conducted on 20 April, 2024. A total of 15,589 applications were received out of which 12,691 candidates appeared for the examination conducted at 94 centres in 54 cities across the country. BET 2024 result shall be announced during May 2024.

DBT HRD-PMU has disbursed fellowship grant of Rs. 54.95 crores for ~1200 fellows during the financial year 2023-24. This includes disbursals performed for DBT BINC programme as it has been merged with DBT JRF Programme.

DBT JRF Programme is managed by an online Program Management Software. During the year 2023-24 new feature added to the portal was for eliciting the publication data. Also, to capture the program outcomes, a form had been created and hosted on the program portal for eliciting the placement details from alumni of the programme.

3. Post-Graduate Teaching Programme (DBT PG Program)

In FY 2023-24, DBT HRD PMU managed DBT supported Post Graduate (DBT PG) Programme in Biotechnology (70 programs) for around ~1300 students across India. DBT HRD PMU at RCB has disbursed Rs.19.30 Crores in FY: 2023.24 to host universities/institutions under the DBT PG program.

During the year 2023, Department has selected 23 new PG Teaching program across the India, out of which, 18 have submit their consent and seat matrix details and approved by DBT. GAT-B 2023 was held on 13 May 2023 at 72 centres in 55 cities across India, where 9116 candidates appeared. Based on the results of GATB 2023, 760 candidates have been admitted in DBT supported postgraduate programmes in Biotechnology in 63 participating host universities/institutions. In addition, ongoing PG programs as mentioned in the 15th FC have been reviewed in August 2023.

4. Biotech Industrial Training Programme (BITP)

Biotech Industrial Training Programme (BITP) is a scheme to provide six months' industrial hands- on training to fresh B.E./B.Tech. /M.Sc. /M. Tech Biotechnology students. The objective of this program is to impart skill based training to students for their holistic development so that their employability increases in relevant industries.

DBT has adopted apprenticeship model for implementation of DBT-BITP Programme, and linkages have been developed with Life Science Sector Skill Development Council (LSSSDC), New Delhi for selection of partnering industries for providing apprenticeship in Biotechnology sectors. A stipend of Rs. 10,000/- per month is paid to all selected candidates for six months' period and companies are also providing apprenticeship to all trainees.

BITP was conducted on 21st January 2024 in 36 cities across India. During the call, 1131 candidates were registered for the exam, out of which 909 candidates appeared for the exam.

BITP Expert Committee has reviewed the requisitions received from companies and approved 144 requisitions for 25 companies and had shortlisted 147 candidates accordingly. Approval for 41 requisitions was also taken from DBT for additional 11 industries to facilitate training under BITP 2024, thus making a total of 185 requisitions received from 36 companies. Matchmaking and placement process is underway.

5. DBT-Research Associateship (DBT-RA) programme

In April 2022, DBT transferred the implementation of DBT-Research Associateship (DBT-RA) programme from the Indian Institute of Science, Bengaluru to RCB, Faridabad. DBT Research Associateship programme was initiated in the year 2001 with the objective to train post-doctoral students in frontier areas of research in life sciences and biotechnology at premier institutions in country as well as enhance to the post-doctoral culture in the country.

There is a provision for award of 100 fellowships through two call for applications per year. RCB had announced Call for Applications under 2023-24/ Call-I in September, 2023 with receipt of 1075 applications. RCB organized the meetings of DBT-RA Screening and Selection Committee for review of applications towards award of fellowship to 50 candidates. RCB also announced the second call in January, 2024 with a receipt of 883 applications. The process of final selection of awardees with announcement of results will be completed shortly.

During the reporting period, RCB also organized two meetings of DBT-RA Evaluation Committee for evaluating the performance of ongoing fellows, where they presented the work carried out by them during the reporting period.

A grant of Rs. 8.19 crores was disbursed to ongoing and newly joined fellows during 2023-2024 under DBT-RA programme.

6. DBT - Biotechnology Career Advancement & Re-orientation Programme (BioCARe) programme

Biotechnology Career Advancement & Re-orientation Programme (BioCARe) programme mainly supports the career development of Indian National women scientists who had a break in their careers to help them re-enter into the mainstream research and to provide a launch pad for further forays into the field of science and technology.

Subsequent upon the transfer of the Program implementing agency of the BioCARe program from ICGEB, New Delhi to RCB, Faridabad in January 2023, DBT-HRD PMU had organized 5 meetings of Letter of Intent (LoI) Screening Committees for shortlisting of 390 LoIs received under the 6th Call of BioCARe programme.

The full-length proposals were then elicited for the shortlisted LoIs and Five Area specific Selection Committee meetings were organized for the identified areas namely Animal Biotechnology & Marine Biotechnology, Bioengineering and Biomaterials, Environmental Biotechnology & Bioenergy, Plant and Agriculture Biotechnology and Medical Biotechnology & Allied areas. The Committees recommended 62 applicants for the award of BioCARe grant, out of which 55 applicants had accepted the BioCARe award and the grant has been disbursed subsequently.

Further, three Area specific Review Committee meetings were also organized wherein a total of 49 ongoing/completed BioCARe projects were reviewed.

DBT-HRD PMU has disbursed the total grant of Rs. 10.345 Crores to 56 BioCARe fellows working in different universities/institutions across the country in the FY 2023-24.

7. DBT-TWAS Fellowship Programme

The Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India and The World Academy of Sciences (TWAS), Trieste, Italy have jointly supported the "DBT-TWAS Fellowship programme" to foster Science and Technology (S&T) for scientists in developing countries of the South through research collaborations and capacity building. The DBTHRD Project Management Unit (DBT HRD PMU) established at the UNESCO Regional Centre for Biotechnology, Faridabad is coordinating the DBT-TWAS Fellowship Programme w.e.f 1st April 2022.

The DBT-TWAS program address the societal challenges through S&T application in emerging areas of biotechnology such as agriculture sciences, biological systems and organisms, chemical sciences, medical and health sciences, structural and molecular biology for scientists from developing countries who wish to pursue research in India.

During the reporting period, the DBT HRD PMU has made remarkable progress in the program development by conducting proactive program management, liaising with the program partners and fellows and disbursement of funds to the ongoing fellows and new joining through their Indian Host institution.

Over Rs. 95 lakhs have been disbursed in FY 2023-24 to 22 fellows under the program including Post Graduate and Post-Doctoral fellows.

A total of 47 applications (Post Graduate - 24 and Post Doctoral - 23) were received under 2023 program call. applications received will be reviewed shortly.

DBT HRD PMU Team

DBT Steering Committee Meeting

DBT TWAS Fellows with Nodal Officer, Student Fellowship, DBT

FINANCIAL STATEMENTS

Photo Credit: Sahil Kumar

REGIONAL CENTRE FOR BIOTECHNOLOGY, FARIDABAD

BALANCE SHEET AS AT 31st MARCH, 2024

Amount (₹)

LIABILITIES	Schedule	31.03.2024	31.03.2023
Corpus / Capital Fund	1	11,55,46,595	7,77,54,578
Reserves and Surplus	2	1,19,91,85,248	83,47,57,667
Earmarked/Endowment Funds	3	-	-
Secured Loans and Borrowings	4	-	-
Unsecured Loans and Borrowings	5	-	-
Deferred Credit Liabilities	6	-	-
Current Liabilities and Provisions	7	27,60,46,354	1,55,89,48,476
TOTAL		**1,59,07,78,197**	**2,47,14,60,721**
ASSETS			
Fixed Assets	8	99,73,68,711	64,56,39,703
Investment From Earmarked/Endowment Funds	9	-	
Investment-Others	10	29,61,37,261	37,18,11,366
Current Assets, Loans, Advances etc.	11	15,87,19,225	54,66,75,055
Capital Work In Progress	8	13,85,53,000	90,73,34,597
TOTAL		**1,59,07,78,197**	**2,47,14,60,721**
Significant Accounting Policies and Notes on Accounts	24		
Contingent Liabilities		NIL	NIL

Schedules 1 to 24 form an integral parts of Accounts

(SANJEEV KUMAR GOYAL)
FINANCE OFFICER

संजीव कुमार गोयल, वित्त अधिकारी
S. K. Goyal, Finance Officer
क्षेत्रीय जैवप्रौद्योगिकी केन्द्र
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मृनेल्क के तत्वावधान में जैवप्रौद्योगिकी विभाग, भारत सरकार द्वारा स्थापित
फरीदाबाद, हरियाणा / Faridabad, Haryana-121 001

(Dr. SUDEEP BHAR)
CONTROLLER of ADMINISTRATION

(PROF. ARVIND K. SAHU)
EXECUTIVE DIRECTOR

डॉ. अरविंद के. साहू / Dr. Arvind K. Sahu
कार्यपालक निदेशक / Executive Director
क्षेत्रीय जैवप्रौद्योगिकी केन्द्र / Regional Centre for Biotechnology

REGIONAL CENTRE FOR BIOTECHNOLOGY,FARIDABAD

INCOME & EXPENDITURE ACCOUNT FOR YEAR ENDED 31st MARCH, 24

Amount (₹)

INCOME	Schedule	31.03.2024	31.03.2023
Income from Sales/ Services	12	2,38,15,614	2,28,47,186
Grants/Subsides	13	39,66,66,808	34,23,12,648
Fees/Subscriptions	14	68,29,710	55,28,372
Income from Investments	15	-	-
Income from Royalty, Publication etc.	16	-	-
Interest Earned	17	2,40,99,292	1,81,61,839
Other Income	18	32,63,707	13,03,348
Increase/(Decrease) in stock of Finished goods and works in progress	19	-	-
Deferred Income-Fixed Assets		11,41,82,615	8,01,05,479
TOTAL (A)		**56,88,57,746**	**47,02,58,872**
EXPENDITURE			
Establishment Expenses	20	15,01,17,641	14,46,07,236
Other Administrative Expenses etc.	21	26,67,65,473	22,54,83,079
Expenditure on Grants , Subsidies etc.	22	-	-
Interest	23	-	-
Depreciation (Net Total at the year-end-corresponding to Schedule 8)		11,41,82,615	8,01,05,479
Prior period Adjustment A/c (ANN-A)			-
TOTAL(B)		**53,10,65,729**	**45,01,95,794**
Balance being excess of Income Over Expenditure (A-B)		**3,77,92,017**	**2,00,63,078**
Transfer to special Reserve(Specify each)			-
Transfer to /from General Reserve		3,77,92,017	2,00,63,078
BALANCE BEING SURPLUS /DEFICIT CARRIED TO CORPUS/CAPITAL FUND		-	-
Significant Accounting Policies and Notes on Accounts	24		
Contingent Liabilities		NIL	NIL

Schedules 1 to 24 form an integral parts of Accounts

(SANJEEV KUMAR GOYAL)
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क्षेत्रीय जैवप्रौद्योगिकी केन्द्र / Regional Centre for Biotechnology

Regional Centre for Biotechnology

Schedule 24: Accounting Policies and Notes Forming Parts of the Balance Sheet and Income & Expenditure Account for the Year Ended at 31st March, 2024.

1. The annual accounts have been broadly prepared in the revised format of accrual system of accounting, **except for extramural funds and other project grants**.

2. The liability on account of terminal benefits to regular employees that is leave encashment & gratuity have been accounted for in accordance with Accounting Stanbdard-15 on actuarial valuation basis.

3. (a) Recurring Grants have been recognised in the Income & Expenditure Account and Non-Recurring Grants have been shown as part of Capital reserve.

(b) Grant of core funds relating to depreciable fixed assets are treated as deferred income and recognised in the Income and Expenditure Account on a systematic and rational basis over the useful life of such assets i.e. such grants are allocated to income over the periods and in the proportions in which depreciation in charged (As per Accounting Standard-12 title Accounting for Government Grants). During the year income recognised in respect of such Grants amounts to **Rs.11.42 crores.**

4. (a) The depreciation has been provided w.e.f. the date of installation/put to use of fixed assets as per the rates prescribed as per section 32 of Income Tax Act 1961.

(b) Depreciation has been charged during the year of acquisition and no depreciation is provided during the year of assets sold / discarded. In respect of additions to/deductions from fixed assets during the year, depreciation is considered on pro-rata basis.

5. Fixed assets have been created with core grants received from the Department of Biotechnology. No equipment procured out of project funds has been capitalized.

6. All purchases of chemicals, glassware, consumables and stationary etc. have been charged to consumption after purchase.

7. Further all entries relating to purchase of consumables /equipments or other fixed assets in accounts are being passed only after submission of satisfactory Bill/Invoice, inspection/installation report irrespective of the date of actual receipt of the supplies /equipment.

8. Transactions denominated in foreign currency are accounted at the exchange rate charged by banks on the date of transaction.

9. The institute has a policy of incurring expenditure on various projects in accordance with the sanctioned budget under various heads of accounts irrespective of the actual releases during a financial year. Since the actual release of money by the sponsoring agency is subject to various factors, the expenditure on approved heads of accounts is incurred within the overall sanction budget of the project.

10. The balances of the previous year have been rearranged/regrouped as per requirement and shown in Balance Sheet against the relevant heads.

11. Expenses and Overheads incidental to completed building of institute as well as other buildings in the NCR BSC, as reported by the Project Monitoring Unit have been capitalised.

13. The Capital Work-in-progress booked in the accounts includes the construction of laboratory buildings of ATPC, Bio-incubator and hostels & faculty housing, common facilities, BSL-3 laboratory, Office of Connectivity Building, etc. under Phase-I Extension and Phase II. The expenditure under Phase-I was transferred to the respective stakeholders as per their contribution and area wise expenditure. Expenditure under phase-I was capitalised during the FY 2019-20 Phase- II has been settled during FY 2022-23 & that of under Phase-I Extension has been settlement during 2023-24. The remaining WIP appearing in the Balance Sheet exclusively relates to under construction hostel building.

14. Interest earned on saving bank account and fixed deposits during the financial year 2023-24 amounting to Rs.23.14 Lakhs has been allocated to the respective projects on pro-rata basis.

15. No income tax or GST scrutiny is pending for any of the years.

(SANJEEV KUMAR GOYAL)
FINANCE OFFICER
संजीव कुमार गोयल, वित्त अधिकारी
S. K. Goyal, Finance Officer
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क्षेत्रीय जैवप्रौद्योगिकी केन्द्र / Regional Centre for Biotechnology

सत्यमेव जयते

कार्यालय महानिदेशक लेखापरीक्षा केन्द्रीय व्यय
पर्यावरण एवं वैज्ञानिक विभाग
नई दिल्ली-110 002
OFFICE OF THE DIRECTOR GENERAL OF AUDIT CENTRAL EXPENDITURE
ENVIRONMENT & SCIENTIFIC DEPARTMENTS,
A.G.C.R. BUILDING, I.P. ESTATE
NEW DELHI-110 002

स.म.नि.ले.प.के.व्यय(पर्या.एवं वै.वि)/नि./4(46)/RCB/SAR/2024-25/338-339 दिनांकः 06-12-2024

सेवा में,

डॉ. अरविंद के. साहू
कार्यपालक निदेशक
क्षेत्रीय जैव प्रौधोगिकी केन्द्र
तृतीय मील पत्थर, फरीदाबाद-गुड़गांव एक्सप्रेसवे,
फरीदाबाद-121001

विषयः क्षेत्रीय जैव प्रौधोगिकी केन्द्र वर्ष 2023-24 के लेखों पर पृथक ऑडिट रिपोर्ट।

महोदय,

मुझे क्षेत्रीय जैव प्रौधोगिकी केन्द्र के वर्ष 2023-24 के लेखों पर पृथक ऑडिट रिपोर्ट अग्रेषित करने का निर्देश हुआ है।

संसद के दोनों सदनों में प्रस्तुत करने से पहले वर्ष 2023-24 के वार्षिक लेखों को क्षेत्रीय जैव प्रौधोगिकी केन्द्र, फरीदाबाद द्वारा अपनाया जाए। प्रत्येक दस्तावेज जो संसद में प्रस्तुत किया जाए उसकी तीन प्रतियां इस कार्यालय तथा दो प्रतियां भारत के नियंत्रक एवम महालेखापरीक्षक को अग्रेषित की जाए। संसद के दोनों सदनों में प्रस्तुत करने की तिथि (या) भी इस कार्यालय को सूचित की जाए।

आपसे अनुरोध है कि पृथक ऑडिट रिपोर्ट का हिन्दी अनुवाद अपने कार्यालय में कराने के पश्चात सॉफ्ट कॉपी तथा हार्ड कापी दोनों में हमें भेज दें ताकि हिन्दी प्रति को शीघ्र अग्रेषित किया जा सके।

यह महानिदेशक महोदया द्वारा अनुमोदित है।

भवदीय,

संलग्कः यथोपरि।

उप-निदेशक (निरीक्षण)

Separate Audit Report of Comptroller and Auditor General of India on the accounts of Regional Centre for Biotechnology, Faridabad for the year ended 31 March 2024

We have audited the attached Balance Sheet of Regional Centre for Biotechnology (RCB), Faridabad as at 31 March 2024 and the Income and Expenditure Account/ Receipts and Payments Account for the year ended on that date under Section 19 (2) of the Comptroller and Auditor General's (Duties, Power and Conditions of Service) Act, 1971 read with section 32 (1) of Regional Centre for Biotechnology Act, 2016. These financial statements are the responsibility of the Regional Centre for Biotechnology's management. Our responsibility is to express an opinion on these financial statements based on our audit.

2.This Separate Audit Report contains the comments of the Comptroller and Auditor General of India on the accounting treatment only with regard to classification, conformity with the best accounting practices, accounting standards and disclosure norms, etc. Audit observations on financial transactions with regard to compliance with the Laws, Rules & Regulations (Propriety and Regularity) and efficiency-cum-performance aspects, etc., if any, are reported through Inspection Reports/ Comptroller and Auditor General's Audit Reports separately.

3.We have conducted our audit in accordance with auditing standards generally accepted in India. These standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatements. An audit includes examining, on a test basis, evidence supporting the amounts and disclosure in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of financial statements. We believe that our audit provides a reasonable basis for our opinion.

4.Based on our audit, we report that –

(i) We have obtained all the information and explanations except those stated in the report, which to the best of our knowledge and belief were necessary for the purpose of our audit;

(ii) The Balance Sheet and Income and Expenditure Account dealt with by this report have been drawn up in the format approved by the Government of India. However, the Receipts and Payments Account dealt with by this report has not been drawn up in the format approved by the Government of India;

(iii) In our opinion, proper books of accounts and other relevant records have been maintained by Regional Centre for Biotechnology, except those stated in this audit report.

(iv) We further report that –

A. LIABILITIES

A.1 Current Liabilities

A.1.1 As per Uniform Format of Accounts, amounts received as grant or assistance, or retained by the entity to be utilised for specific or earmarked purposes and remaining to be expended/utilised for the specific purpose for which these are intended, are required to be disclosed under the Schedule 3: 'Earmarked/Endowment Funds'.

Regional Centre for Biotechnology, however, booked balances of project grants and fellowships amounting to ₹8.85 crore under 'Schedule-7: Current Liabilities' instead of 'Schedule-3: Earmarked/ Endowment Funds'. This led to understatement of Earmarked Funds by ₹8.85 crore and overstatement of Current Liabilities by the same amount. It also led to insufficient disclosures of capital and revenue expenditure incurred under these projects which were required to be depicted in Schedule 3.

A.1.2 Regional Centre for Biotechnology did not depict outstanding bills for services rendered in 2023-24 amounting to ₹17.98 lakh[1] as its Current Liability. This resulted in understatement of its current liabilities and expenditure each by ₹17.98 lakh.

B. ASSETS

B.1. Fixed Assets

B.1.1 In Schedule 8, additions of assets during the year under the following heads was not correctly shown:

(in ₹.)

Head	Half year period	Amount shown in Sch. 8	Actual purchase as per Assets Register	Difference	Depreciation Rate in *per-cent*	Difference in depreciation
Lab Equipment	First	2,35,62,671	1,19,92,506	1,15,70,165	15	17,35,525
Lab Equipment	Second	16,19,81,367	13,43,75,347	2,76,06,020	7.5	20,70,452
Furniture and Fixture	First	3,10,188	78,000	2,32,188	10	23,219
Furniture and Fixture	Second	14,17,104	15,16,745	-99,641	5	-4,982
Office Equipment	First	6,44,707	82,954	5,61,753	15	84,263

[1] Voucher No. 205 dated 29 April 2024 for ₹5.96 lakh and Voucher No. 201 dated 29 April 2024 for ₹12.02 lakh.

Office Equipment	Second	11,78,124	47,083	11,31,041	7.5	84,828
Computer and Peripherals	First	35,75,918	46,01,454	-10,25,536	40	-4,10,214
Computer and Peripherals	Second	73,17,351	45,26,164	27,91,187	20	5,58,237
Total		**19,99,87,430**	**15,72,20,253**	**4,27,67,177**		**41,41,328**

This incorrect depiction of assets resulted in overstatement of assets by ₹3.86 crore (₹4.27 crore less ₹0.41 crore depreciation thereon), overstatement of liabilities by ₹4.27 crore and understatement of expenditure by ₹0.41 crore.

B.1.2 The Gross Block shown in the Schedule 8: Fixed Assets was not correct as instead of depicting the acquisition value of assets, it depicted the previous year's Net Block figures under the head 'Cost/Valuation as on 01 April 2023'. Similarly, the head 'Cost/Valuation as on 31 March 2024' was also incorrect as it depicted the acquisition cost of assets procured during 2023-24 plus net value of assets procured during previous years instead of acquisition cost of all the assets.

The heading 'Cost/Valuation as on 31 March 2023' in the Gross Block needs to be corrected to 'Cost/Valuation as on 31 March 2024'.

B.1.3 In the Depreciation Block, the head 'as at 01 April 2023' was required to show accumulated depreciation as on that date. However, this column was showing depreciation for the year 2023-24 on fixed assets as of 01 April 2023. Similarly, the head 'Total as on 31 March 2024' was also incorrect as it was showing total depreciation for the year 2023-24 only instead of total accumulated depreciation as of 31 March 2024.

B.1.4 An amount of ₹76.87 crore was shown to be deducted from the Capital Work in Progress. However, under the building head, an amount of only ₹26.59 crore was added. As the Assets Register for Buildings was not provided to audit, we are unable to ascertain the correctness of both the above figures and also the difference of ₹50.28 crore between these two figures.

B.1.5 Software amounting to ₹11.06 lakh was capitalised although annual license fee was being paid for these software and hence, these expenses were of revenue nature. This incorrect depiction resulted in overstatement of Assets by ₹6.64 lakh (₹11.06 lakh minus ₹4.42 lakh depreciation thereon) and understatement of Expenditure by the same amount.

C. INCOME AND EXPENDITURE ACCOUNT

C.1 Income

C.1.1 Deferred Income – Fixed Assets

It was reported in previous year's Audit Reports (for the year 2021-22 and 2022-23) that expenditure on account of depreciation charged on Fixed Assets was set off by booking as Deferred Income in Income and Expenditure Account, which was against the Uniform Format of Accounts prescribed by Government of India for Autonomous Bodies as it allows booking of deferred income only in case of grant received for specific fixed assets.

However, Regional Centre for Biotechnology again adopted same practice and an expenditure of ₹11.42 crore booked towards depreciation on Fixed Assets was set off by booking as Deferred Income in Income and Expenditure Account for 2023-24. This resulted in overstatement of income as well as of liabilities by ₹11.42 crore.

C.2 Expenditure

C.2.1 Other Administrative expenses etc.

Accounting policy adopted by Regional Centre for Biotechnology for chemicals, glassware, consumables and stationery was not in conformity with generally accepted accounting principles, as all purchases of chemicals, glassware, consumables and stationery were charged to consumption at the time of purchase.

Hence ₹9.55 crore[2] reported by Regional Centre for Biotechnology, as expenditure incurred on chemicals, consumables and stationery during 2023-24, is charged as expenses is against generally accepted accounting principal.

This issue was reported in previous years' Audit Reports (for the year 2021-22 and 2022-23) also.

D. RECEIPTS AND PAYMENTS ACCOUNT

Receipts and Payments Account was not as per Uniform Format of Accounts prescribed by Government of India for Autonomous Bodies as it contained various heads like 'Current liabilities', 'Current Assets', Fixed Assets'; which are not part of Receipt and Payment Account as per Uniform Format.

This issue was reported in previous year's Audit Report also.

[2] Consumables/chemicals – ₹9.26 crore, Printing and Stationery – ₹0.29 crore.

E. GRANTS-IN-AID

During 2023-24, Department of Biotechnology issued sanctions for release of core Grants-in-aid of ₹60 crore to Regional Centre for Biotechnology through account opened with Reserve Bank of India under Treasury Single Account system. An expenditure of ₹59.67 crore was incurred by Regional Centre for Biotechnology during 2023-24 and ₹0.33 crore were lapsed to Department of Biotechnology, leaving no unspent balance as on 31 March 2024.

Audit noticed that during 2023-24, Regional Centre for Biotechnology transferred a total amount of ₹5.34 crore from Treasury Single Account to its other commercial bank accounts for miscellaneous purposes, which was not permissible as per instructions. Regional Centre for Biotechnology utilised the transferred core grants-in-aid along with other funds (grants-in-aid received from other departments and income generated from internal resources) already available in commercial bank account. Hence, the possibility of parking of unspent amount of grant under this account cannot be ruled out.

This issue was reported in previous year's Audit Report also.

(a) *In so far as it relates to the balance sheet, of state of affairs of the Regional Centre for Biotechnology, Faridabad as of 31 March 2024; and*

(b) *In so far as it relates to the Income and Expenditure Account, of the surplus for the year ended on that date.*

For and on behalf C&AG of India

6.12.2024

Place: New Delhi
Date:

Director General of Audit, Central Expenditure
(Environment and Scientific Departments)

Annexure to Separate Audit Report

1. Adequacy of Internal Audit System

Internal Audit of the Regional Centre for Biotechnology is conducted by the internal audit wing of the Principal Pay and Accounts Office of the Ministry of Science and Technology, New Delhi which was completed up to March 2023. A total number of 28 paras pertaining to the period 2019-21 (two paras) and 2021-23 (26 paras) were outstanding to date.

2. Adequacy of Internal control system

Regional Centre for Biotechnology did not provide Assets Register for Buildings. Hence, we are not able to verify figures mentioned in the Schedule 8 relating to Building head (closing balance ₹54.89 crore as of March 2024) and Capital Work in Progress (closing balance ₹13.86 crore as of March 2024).

3. System of physical verification of assets and inventories

Physical verification of assets and inventories was conducted during the year 2023-24.

4. Regularity in payment of statutory dues

There were no outstanding statutory dues against Regional Centre for Biotechnology.

Deputy Director (Inspection)

INSTITUTIONAL GOVERNANCE

Photo Credit: Sahil Kumar

Board of Governors (BOG)

- **Dr. Rajesh Gokhale (Chairperson)**
  Secretary
  Department of Biotechnology,
  New Delhi - 110 003
- **Director (Ex-officio Member)**
  Rajiv Gandhi Centre for Biotechnology
  Thiruvananthapuram - 695 014, Kerala
- **Director (Ex-officio Member)**
  National Institute of Immunology,
  Delhi 110 067
- **Director (Ex-officio Member)**
  NIMHANS, Bangalore 560 029
  Karnataka
- **Director (Ex-officio Member)**
  UNESCO Delhi Office,
  New Delhi - 110 021
- **Chairperson, RCB PAC (Permanent Invitee)**
- **Dr. Richi V. Mahajan (Ex-officio Member)**
  Scientist-D, Dept. of Biotechnology
  Govt. of India, New Delhi
- **Dr. Arvind Sahu (Convenor)**
  Executive Director
  Regional Centre for Biotechnology,
  Faridabad - 121 001

Programme Advisory Committee (PAC)

- **Dr. Umesh Varshney (Chairperson)**
  Honorary Professor, IISc-Bangalore
- **Dr. Joel Sussman (Member)**
  Professor, Dept. of Structural Biology
  The Weizmann Institute of Science,
  Israel
- **Prof. Angelo Azzi (Member)**
  Tufts University, Medford, USA
- **Dr. Mohan Wani (Member)**
  Director, NCCS-Pune
- **Dr. Saumitra Das (Member)**
  Professor, IISc-Bengaluru
- **Dr. Krishnaveni Mishra (Member)**
  Professor, University of Hyderabad
- **Dr. Sabhyata Bhatia (Member)**
  Staff Scientist, NIPGR, New Delhi
- **Dr. Shrikumar Suryanarayan**
  Chairman, Sea6 Energy,
  Bengaluru
- **Dr. Vinay K. Nandicoori**
  Director, CCMB, Hyderabad
- **Dr. Alka Sharma (Member)**
  Scientist-H, Dept. of Biotechnology,
  New Delhi
- **Dr. Rakesh Mishra (Member)**
  Director, TIGS, Bengaluru
- **Dr. Richi V. Mahajan (Member, Ex-officio)**
  Scientist-D, Dept. of Biotechnology
  Govt. of India, New Delhi
- **Dr. Arvind Sahu (Ex-officio Member Secretary)**
  Executive Director
  Regional Centre for Biotechnology
  Faridabad 121 001

Executive Committee (EC)

- **Dr. Arvind Sahu (Chairman, Ex-officio)**
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- **Dean (Member, Ex-officio)**
  Regional Centre for Biotechnology
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- **Director (Member, Ex-officio)**
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- **Joint Secretary (Member, Ex-officio)**
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  Ministry Of External Affairs,
  Govt. of India, New Delhi 110 001
- **Registrar (Permanent Invitee)**
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- **Finance Officer (Permanent Invitee)**
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- **Controller of Administration (Member Secretary, Ex-officio)**
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Finance Committee (FC)

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- **Additional Secretary & Financial Advisor (Member, Ex-officio)**
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- **Finance Officer (Member Secretary, Ex-officio)**
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Scientific Personnel

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Dean
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Dr. Deepak T. Nair
Dr. Avinash Bajaj
Dr. Sivaram V. S. Mylavarapu
Dr. C. V. Srikanth
Dr. Vengadesan Krishnan
Dr. Tushar Kanti Maiti

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Dr. Deepti Jain
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Dr. Karthigeyan Dhanasekaran

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Dr. Arvind K Sahu
Dr. R.P. Roy
Prof. Sudhanshu Vrati

Wellcome Trust-DBT IA Intermediate Fellowships
Dr. Rajender Kumar Motiani

Wellcome Trust -DBT IA Early Career Fellowship
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Dr. Kesiraju Kartik
Dr. Lakshmikanthan P

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Ms. Navya Chauhan
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Management

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Dr. Arvind K Sahu

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Technical Assistant
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Controller of Administration
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Prof. Prasenjit Guchhait (Acting Registrar)

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Mr. C.B. Yadav
Mr. Rakesh Yadav

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Mr. Sudhir Kumar
Mr. Chakrawan Singh Chahar

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Dr. Reena Rani

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Ms. Leena

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Mr. Puneet Sharma

Multi-Tasking Staff
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Ms. Satuluri Sriharsha

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क्षेत्रीय जैव प्रौद्योगिकी केन्द्र
Regional Centre
for Biotechnology

REGIONAL CENTRE FOR BIOTECHNOLOGY

an Institution of National Importance for Education, Training and Research

Established by the Dept. of Biotechnology, Govt. of India

Under the Auspices of UNESCO

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