ncbs

National Centre for Biological Sciences
Tata Institute of Fundamental Research

Annual Report
2023-2024

Annual Report 2023-2024
National Centre for Biological Sciences

ncbs
National Centre for Biological Sciences
Tata Institute of Fundamental Research

Contents

Director's Note

LS Shashidhara
Director, NCBS

Dear Reader,

It is my pleasure and honour to present you the **annual report of NCBS-TIFR** for the year **2023-24.** We completed 25 years of functioning from the current campus. In these 25 years, NCBS has grown considerably in size and has made significant contributions to science across diverse fields of biological sciences. Fostering collaborations with scientists from within and outside the country, catalyzing establishments of new programs, institutions, connecting the history of science to the current times, connecting science to society and nurturing transdisciplinary ideas and facilitating free discussions should be hallmarks of any academic organization and NCBS passionately adheres to these principles.

What started as an idea in the 1980s led to the establishment of NCBS, which turned out to be an experiment in Indian science, not only in building a high-quality research institute but in building an entire S&T ecosystem, the Bengaluru Life Science Cluster (BLiSC). In addition to NCBS-TIFR, BLiSC comprises of Institute of Stem Cell Science and Regenerative Medicine (inStem; established in 2009), an autonomous body under the Department of Biotechnology, Government of India; The Centre for Cellular and Molecular Platforms (C-CAMP; established in 2009), a for-non-profit initiative of the Department of Biotechnology, Government of India and Tata Institute of Genetics and Society (TIGS; established in 2017) a for non-profit initiative of Tata Trusts.

BLiSC represents the best of fundamental and translational research with an excellent ecosystem for innovation and entrepreneurship. BLiSC is an ecosystem of diverse organisations and people with diverse ideas and skills. Constituent members of BLiSC employ diverse approaches to S&T governance with a vision to achieve greater impact, both individually and collectively. All research facilities, irrespective of their source and mode of procurement, are available for all researchers across the campus akin to BLiSC working as one single organization. This has enabled BLiSC members to establish a seamless pipeline for the propagation of an idea from fundamental to applied to translational research to innovative product development for the benefit of end users with a focus on scale, affordability, and excellence. The BLiSC ecosystem, therefore, is a major attraction for start-ups seeking support and mentorship. It is a well-connected ecosystem, whose function and services are benefiting the whole nation.

Researchers at NCBS have continued to do seminal work in their areas of interest and continue to be awarded and recognized by their peers. Highlights of some of the work carried out at NCBS include identification of neuronal correlatives of predictive neural computations in the cerebellum contributing to motor planning and faster behavioural responses in larval zebrafish by Vatsala Thirumalai's group; discovering a stepwise peptide-mediated signal relay that

*We completed **25 years** of functioning from the current campus. In these 25 years, NCBS has grown considerably in size and has made significant contributions to science across diverse fields of biological sciences.*

regulates the transition from defence to growth upon wounding in monocots such as rice by Shivaprasad's group; a new highly prevalent mechanism that mediates methylation-dependent DNA damage response in bacteria by Anjana Badrinarayanan's group; ways neurons identify different patterns in a stimulus by Upinder Bhalla's group; tracing the founders of five genetically diverse Indian elephants to as long back 70,000 years and analysing the impact of their past dynamics to their current status by Uma Ramakrishnan's group and collaborators etc.

This year, 3 of our faculty were elected to National Science Academies (Sanjay Sane, Sandeep Krishna and PV Shivaprasad); Uma Ramakrishnan was elected to the American Academy of Arts and Science; Madan Rao and Sowdhamini were recognised and awarded by Karnataka State Council for Science & Technology, Government of Karnataka.

"Reaching out" is a most important feature of humanity. The more we reach out, the more we learn, the more we experience and lesser the mistakes we make and the more productive we will be. Science progresses on the foundation of "reaching out" to collaborators, peers, stakeholders etc. In the past one year, NCBS has reached out and established active partnership with:

- NIMHANS and Rohini Nilekani Philanthropies to establish an advanced research centre – "Centre for Brain and Mind" to study psychiatric disorders;
- a large interdisciplinary team to develop a ultrasound device for imaging brains in low-resource settings;
- forest departments, forest research, educational and training institutes for collaborations, co-teaching advanced wildlife management and conservation science;
- a large number of hospitals to initiate translational clinical research on infectious diseases and cancer;
- various ICAR (NIVEDI, NISHAD and NFMDV) and CSIR (NCL and CCMB) institutes and Gujarat Biotechnology Research centre to develop methods and low-cost kits for epidemiology and environmental surveillance for viruses affecting livestock, poultry and wild birds;
- Max Plank Group of institutes for collaborative research in multiple areas of life sciences with specific focus on physics of life and history of science.

This year, Archives@NCBS has expanded by reaching out to a large number of individuals to donate archival material to members of their families, who have contributed to the growth of science in the country.

Over the years, NCBS has also anchored many special-purpose vehicles that enable members of the scientific community to reach out to each other. IndiaBioscience (connecting and networking the entire bioscience community in India) and Bengaluru Sustainability Forum (to bring all organizations working on various solutions for sustainable living in Bengaluru) are two such initiatives.

Organizations such as ours need effective ways of reaching out to potential partners, funders and other stakeholders and the general public needs excellent faculty and students, an enthusiastic and knowledgeable team of science communicators, people who proactively facilitate academic meetings and collaborations, research management experts, dedicated and skilled technical and administrative support personnel. NCBS is fortunate to have wonderful colleagues in all these sections.

Diversity and inclusivity on campus are critical for sustaining this vibrant ecosystem and its further growth. That is our commitment and pledge from us while thanking the leadership that made this institute what it is today.

NCBS Awards

★ **Prof. R. Sowdhamini,** Dr. Raja Ramanna State Award, Karnataka State Council for Science & Technology, Government of Karnataka, 2023.

★ **Prof. Madan Rao,** Sir M. Visvesvaraya Senior Scientist State Award, Karnataka State Council for Science & Technology, Government of Karnataka, 2023.

★ **Prof. Mahesh Sankaran,** RM Tulpule Chair Professorship for Global Change, TIFR.

★ **Dr. Soumyashree Das,** Werner Risau Early Career Investigator Award in Vascular Biology, American Heart Association, 2024.

★ **Prof. Deepa Agashe,** Mid-Career Excellence Award, Society for Molecular Biology and Evolution, 2024.

★ **Prof. Dimple Notani,** Associate Fellow, Indian National Science Academy, 2024.

★ **Prof. Sanjay Sane,** Elected Fellow, Indian National Science Academy, 2024.

★ **Prof. Deepa Agashe,** Elected Fellow, Indian Academy of Sciences, 2025.

★ **Prof. Krushnamegh Kunte,** Elected Fellow, Linnean Society of London and the Royal Entomological Society, UK, 2024.

★ **Prof. Uma Ramakrishnan,** Elected International Honorary Fellow, American Academy of Arts and Sciences, 2024.

★ **Prof. Rajesh Kumar Ladher,** Elected to the Board of Directors, International Society for Differentiation, 2024.

★ **Dr. Sufyan Ashhad,** Intermediate Fellow, DBT/Wellcome Trust India Alliance, 2024.

★ **Prof. Vatsala Thirumalai,** New Indian Express Devi Award, 2024.

★ **Dr. Rajesh Kumar Ladher,** Excellence in Teaching Award (Best Teacher Award) in Biology by TIFR, 2024.

Thanking the Deans

LS Shashidhara
Director, NCBS

Dear Faculty and Staff Colleagues,

As we prepare to welcome our new Deans and Associate Deans, I would like to take this opportunity to express my heartfelt gratitude to the current Deans—**Sanjay Sane, Raghu Padinjat,** and **Raj Ladher**—and the Head of Outreach and Communications, **Uma Ramakrishnan**, along with Associate Deans **Ranabir Das, PV Shivaprasad, Vatsala Thirumalai,** and **Deepa Agashe**. Their unwavering dedication has been instrumental in the growth of our Institute and the smooth functioning of its daily activities.

Sanjay Sane Sanjay played a pivotal role in identifying and recruiting exceptional young faculty from among hundreds of applicants over the past four years. I am very impressed with the breadth and depth of his understanding of biology and its interface with physics, mathematics and chemistry. Sanjay truly represents NCBS's USP - "Biology across scales". Beyond recruitment, he has dedicated immense effort to mentoring faculty through tenure processes and promotions, consistently prioritizing quality over expediency. Sanjay, your commitment to bringing in and nurturing outstanding talent is deeply appreciated. Sanjay never compromised on the quality in the interests of time or numbers. The same is true for his research. We look forward to your continued guidance.

Raghu Padinjat Raghu has been the go-to person for all matters, be it academic, administrative, finance or medical. It's amazing how he handles such a vast list of tasks and responsibilities–mentoring PhD students, publishing high-quality papers at regular intervals, crisscrossing between fly and human biology, steering ADBS and now CBM, institutional finance, administration, space (he would know the location of each freezer/centrifuge and sitting in his office can tell Ranjith where to place new ones!), purchase, dealing with the needs of faculty/staff and much more. There is nothing he doesn't know about NCBS/TIFR/DAE and nothing he has not done for the Institute.

His meticulous attention to detail and thoughtful problem-solving are qualities we all admire and strive to emulate. Raghu, thank you for your boundless support; I suspect I will still be reaching out to you often for advice!

Raj Ladher Graduate students would miss him a lot. Always patient, willing to listen, smiling and never failed to solve academic or non-academic problems of students. His dedication to organizing workshops, lectures, and activities aimed at enhancing students' skills and perspectives was truly commendable. Raj's passion for the history and philosophy of science, research ethics, and integrity sets an inspiring example for all of us. Raj, I am confident you will continue to be a guide and mentor for students and faculty alike.

Uma Ramakrishnan With Uma as Head of Outreach and Communications, the visibility of the quality, diversity and scale of our research is enhanced across all target groups - funders, policymakers, prospective faculty, students, and the general public. She handled every job with passion and emotion, which is visible in the quality of the outcome. Uma transformed the meetings office and science communication cell, brought in new partnerships for science popularisation, and contributed to Archives, Bengaluru Sustainability Forum, etc. The Annual Reports that came out under her guidance are of high quality in terms of content, organization and creativity.

Uma, your vision and dedication have left an indelible mark, and we will continue to seek your insights on science communication and outreach.

PV Shivaprasad Shiva handled campus safety/security, monthly reports to TIFR/DAE etc. He was always available to staff to handle any unforeseen situation, very frank and critical in matters that were not appropriate to NCBS or that deviated from the policies. Despite the additional work of administration, all his students have completed their PhD well within 5 years and have published well.

Many of us are unaware that Shiva is a gifted poet in Kannada and a passionate science communicator who frequently visits schools in remote areas to inspire young minds. Almost every weekend, Shiva spends some time with kids, discussing the excitement of observing the natural world using scientific methods. Shiva, your multifaceted contributions enrich our community in countless ways.

Ranabir Das Though often working behind the scenes, Ranabir has been indispensable in ensuring the seamless operation of our technical services. His ability to maintain high standards while earning the respect and admiration of the technical staff speaks volumes about his leadership. Ranabir, your commitment and dependability are deeply valued.

Vatsala Thirumalai Vatsala's meticulous approach to managing the student admission process and her dedication to introducing innovative graduate courses have been vital to the academic mission of NCBS.

Deepa Agashe Deepa has diligently overseen key aspects of the academic office, from recruitment to the welfare of campus fellows, PDFs, and externally funded faculty fellows. Her efforts have ensured that academic affairs are handled with precision and care.

Raj, Vatsala, and Deepa formed a remarkable team, driving NCBS's academic success. Their contributions to our PhD program—a cornerstone of our research institute—have been integral to our achievements.

On behalf of everyone at NCBS, I extend my deepest thanks to Sanjay, Raghu, Raj, Uma, Shiva, Rana, Vatsala, and Deepa. Your dedication and contributions have enriched the Institute, and we are profoundly grateful for all you have done. We also take this opportunity to welcome the new deans and associate deans. More about them next time!

Special Interest Section:

Reaching Out

M.Sc. Wildlife Biology and Conservation Programme

Centre for Brain and Mind

Alliance for Pathogen Surveillance Innovations (APSI)-India

Training Programs in Advanced Technologies by Research Facilities

Undergraduate Lecture Series

Monsoon School

The Master's Programme in Wildlife Biology and Conservation

Jayashree Ratnam

2024 has been a very special year for the Wildlife Biology and Conservation Program. It **marks two decades** since the program began in 2004. A milestone to celebrate and a time to reflect on what we have done, and what more we could be doing.

Around 150 graduates from 10 cohorts of our program are now spread across the country and beyond, engaged in conservation research and action across a range of species and ecosystems. These engagements are varied. They include, to name a few, fundamental research on endangered species and ecosystems, work with local communities to promote coexistence with wild megafauna, restoration of degraded forests and grasslands, conservation education, environmental journalism and natural resource management through forest departments. 80 of these alumni gathered at NCBS in June this year for our 20th year reunion, alongside faculty and resource persons from across the years. With students from all cohorts in attendance, we traveled down the memory lane, sharing stories, nostalgic video footage and some tongue-in-cheek roasting of long-time faculty and program traditions. Above all, there was a sense of camaraderie and homecoming in the air, as old bonds were renewed and new ones formed over a raucous game of water-polo and a lively dinner at the campus canteen. These enduring bonds and this sense of being part of a larger community with a shared purpose will be critical in the coming decades. With the amplifying climate crises and the accelerating losses of habitats and species, it will be more important than ever to work collaboratively, and at scale, to secure a future for our magnificent wildlife and natural ecosystems.

Taking the themes of reaching out and building community further, we also marked this year by organizing the first Indian Wildlife Ecology Conference. Right on the heels of our reunion, we welcomed nearly 500 professionals in the field of wildlife ecology and conservation from across the country onto our beautiful campus. With representation from more than 40 organizations, from senior professionals to young scholars, from academia to NGOs to independent practitioners, from formally trained ecologists to indigenous knowledge holders, the gathering was diverse. As were the topics covered, which ranged from the molecular and chemical ecology of wild populations to ecosystems and urban ecology, and covered the gamut from marine environments to high-altitude mountains. Participants presented their research, exchanged ideas, identified areas in urgent need of research and action, and proposed new collaborations. Given the excellent response and the need for such a forum, participants agreed that IWEC should convene regularly, perhaps every two years, at locations around the country.

But wildlife and nature know no boundaries. Snow leopards range across many countries in the high mountains of Asia, while elephants and tigers move across the forests of South and Southeast Asia. It makes sense to think of wildlife and nature conservation across the Asian geography – we share species and ecosystems across national boundaries, we share colonial histories that define our understanding and management of our natural ecosystems today, and we will share the vagaries of the changing Asian monsoon of the future. We will need a cohort of conservationists in the next generation who will work together across our shared geography. Towards this end, the program now welcomes 5 international students from developing Central, South and Southeast Asia in each cohort. We hope that this will enhance the capacity for regional-scale problem solving in the conservation of wildlife and natural ecosystems across the Asian tropics.

As always, our gratitude goes out to our partner organizations, our funders, our faculty, our resource persons and alumni, and our Academic and Administrative offices, who help us to deliver this program. Our program is very much a collaborative endeavour, and what we do is scaffolded by the inspiring work of our partners. We hope to continue growing together, so here's to the next two decades!!

Indian Wildlife Ecology Conference 2024 (IWEC '24): *A conference for Indian wildlife ecology researchers to discuss the science, share research, and network. June 2024, NCBS, Bangalore.*

Rohini Nilekani Centre for Brain and Mind

Raghu Padinjat

Severe mental Illness are a major source of disability in young adults with about 2-3% of the population at risk for developing these disorders both in India and across the world. These disorders are recognized as **one of the major non-communicable diseases (NCD) and a significant contributor to morbidity** as articulated by the World Health Organization's New Delhi call for action on combating NCDs in India. Given this huge disease burden, the development of novel ways to diagnose and treat mental illness will have important positive social and economic benefits. To achieve this goal, there is a pressing need to understand the mechanistic basis of these disorders; such discovery could form the basis for the development of novel diagnostic and therapeutic approaches.

In 2015, NCBS led the development of a research program to understand the genetic and cellular basis of severe mental illness through harnessing the power of modern human genetics and stem cell technology. The program was set up in 2015 as a collaborative initiative of three institutions from Bengaluru, India – the National Centre for Biological Sciences (NCBS), the Institute for Stem Cell Science and Regenerative Medicine (inStem), and the National Institute for Mental Health and Neurosciences (NIMHANS) supported between 2016-2022 by the Department of Biotechnology, Government of India, and the Pratiksha Trust. Since 2023 the program is funded through generous support from **Rohini Nilekani Philanthropies** as a collaborative effort between **NCBS** and **NIMHANS** as the **Rohini Nilekani Centre for Brain and Mind (CBM).**

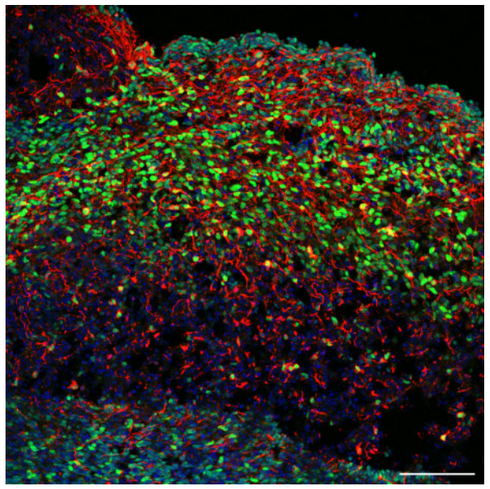
CBM studies **five major forms** of severe mental illness (SMI): schizophrenia, bipolar disorder, obsessive-compulsive disorder, substance dependence and dementia. All these disorders are known to have an inherited basis. However, despite their high heritability, to date, few genetic correlates that could account for this high heritability have been identified. To study these disorders, a prospective cohort of families with a strong family history of SMI is being studied. Three distinct but complementary lines of analysis are being pursued on these families:

(i) The families have been clinically studied to understand changes in structure and function at multiple levels of brain organization; they will continue to be followed over twenty years at 3-year intervals to define the temporal development of disease at multiple scales of brain function through regular and detailed clinical neuroscience analysis.

(ii) We have established ca. 120 induced pluripotent stem cell lines from affected individuals in these families and unaffected controls. CBM uses modern technology to create stem cells from human subjects with a strong history of severe mental illness and uses these to create "disease-in-a-dish" models of the human brain to study the mechanistic aspects of cellular neurobiology that lead to disease.

(iii) Next Generation Sequencing and neuroinformatics are being used to uncover the genetic basis of SMI.

The multiple types of data generated by the program are being assembled into an integrated database (CALM-BRAIN) to facilitate the application of sophisticated methods of data analysis to uncover new disease biology. The stem cell lines, other biomaterials and other datasets have been assembled into a biorepository that will allow the sharing and use of this resource to drive discovery biology around SMI. The program has instituted mechanisms to facilitate the sharing of data and resources generated through its activities. CBM is envisaged as a discovery platform that seeks to engage with scientists beyond the core partner institutions to leverage the most modern tools and methods of analysis and discover new biology that will lead to better solutions for treatment of severe mental illness in humans.



(A) 3D brain organoids after 120 days culture in vitro (DIV). (B) Cryosection of organoid stained to show the various cell types in the mini brain. Red: Glial Fibrillary Acidic Protein (GFAP)- marker of mature astrocytes; Green: NF1A a marker of glial precursor cells; DAPI(Blue). Glial cells are critical regulators of neuronal function in healthy brains and in disease conditions. The CBM program is using disease-in-a-dish models generated from human iPSC to discover the role of altered glial cell function in the pathogenesis of severe mental illness.

PUBLICATIONS

- Enhanced Notch dependent gliogenesis and delayed physiological maturation underlie neurodevelopmental defects in Lowe syndrome. Yojet Sharma, Priyanka Bhatia, Gagana Rangappa, Sankhanil Saha, Raghu P*. bioRxiv 2024.11.25.625332; doi: https://doi.org/10.1101/2024.11.25.625332.
- Saha S, H Krishnan H, Raghu P*. IMPA1 dependent regulation of phosphatidylinositol 4,5-bisphosphate and calcium signalling by lithium. Life Sci Alliance 2023 Dec 6;7(2): e202302425. doi: 10.26508/lsa.202302425. Print 2024 Feb.
- Raghu P*, Sharma S, Aswathy BS and Krishnan H. Challenges and opportunities for discovering the biology of rare genetic diseases of the brain. J. Biosciences. 2024. 49:26. Indian Academy of Sciences DOI: 10.1007/s12038-023-00408-5.
- Holla B, Mahadevan J, Ganesh S, Sud R, Janardhanan M, Balachander S, Strom N, Mattheisen M, Sullivan PF, Huang H, Zandi P, Benegal V, Reddy YJ, Jain S; cVEDA collaborators; ADBS-CBM consortium; iPSYCH OCD consortium; NORDiC OCD & Related Disorders Consortium; Purushottam M, Viswanath B. A cross ancestry genetic study of psychiatric disorders from India. medRxiv. 2024 Apr 27:2024.04.25.24306377. doi: 10.1101/2024.04.25.24306377.

  * Corresponding author

Alliance for Pathogen Surveillance Innovations (APSI)-India: A Model for Wastewater-based Epidemiology and Disease Surveillance

NCBS is a key partner to APSI consortium

Wastewater based epidemiology is an approach to environmental disease surveillance that offers a foundation for providing early warning signs for known and emerging infectious disease agents via cost-effective measures of health. Its significance has been reported during the SARS-CoV-2 pandemic where it proved to be an invaluable tool in detection of the circulating variants world-wide.

Advantages of wastewater surveillance include:

Comprehensive Disease Burden Assessment
Wastewater surveillance allows for a singular, comprehensive assessment of disease burden within a community, offering a more accurate reflection of both symptomatic and asymptomatic infections and the silent circulation of pathogens.

Early Prediction of Outbreaks
The ability to detect silent waves of pathogens circulating in the environment facilitates early prediction of disease outbreaks. This proactive approach is instrumental in timely public health responses.

Cost-Effective Population Testing
Measuring an infectious disease pathogen in wastewater (mostly from sewage treatment plants or open drains) provides a community-level estimate with a single test; hence presenting a cost-effective alternative to individual testing, enabling the testing of entire cities at a fraction of the cost as compared to traditional or individual testing methods.

Identifying Emerging Threats
Wastewater surveillance has been an important tool that has successfully identified emerging threats to public health beyond the SARS-CoV-2 pandemic. It can further help detect pathogens identified by the World Health Organization in the priority list of pathogens contributing to antimicrobial resistance (AMR), which is a global health threat.

In response to the second wave of COVID-19 and the critical need for an advanced pathogen genomics pipeline and enhanced data sharing, the Alliance for Pathogen Surveillance Innovations (APSI)-India, was initiated in 2021, with funding from The Rockefeller Foundation. The primary focus of APSI was to support the government's efforts to bolster SARS-CoV-2 genomic surveillance in India, with a special emphasis on viral genome sequencing from both clinical and wastewater-based detection systems and to complement the task of government initiatives like the Indian SARS-CoV-2 Genomics Consortium. The consortium (consisting of CSIR-Centre for Cellular and Molecular Biology in Hyderabad and its partners, TIFR-National Centre for Biological Sciences/Tata Institute for Genetics and Society in Bengaluru and their partners, Ashoka University/CSIR-Institute of Genomics and Integrative Biology in Delhi and partners, and Indian Institute of Science Education and Research/CSIR-National Chemical Laboratory /Pune Knowledge Cluster and partners in Pune) has worked towards setting up an advanced surveillance platform, incorporating viral genome sequencing and wastewater-based detection and surveillance as well as enhancing bioinformatics, data analytics and sharing pipelines. Since its inception, APSI has developed country-wide networks with many research and clinical partners as well as local administrations and municipal corporations, for accessing samples as well as epidemiological clinical data on disease outcomes. While the first phase of the consortium's efforts during 2021 was focused on detecting the then circulating SARS-CoV-2 variants, it has now expanded its wastewater surveillance program beyond SARS-CoV-2, employing a metagenomics-based approach for comprehensive identification of various other pathogens of public health concern including viruses such as influenza and respiratory syncytial virus as well as bacterial pathogens listed as priority pathogens contributing to AMR.

Significant milestones achieved by the consortium include:

Robust Sequencing Strategy
- Executed a two-pronged strategy encompassing prospective and retrospective sampling.
- Sequenced over 40,000 clinical samples detecting SARS CoV-2 variants since August 2021, 75% of the clinical sequences have been submitted to the Global Initiative on Sharing all Influenza Data promoting global data sharing.

Bioinformatics and Real-time Lineage Identification
- Expanded focus beyond sequencing to enhance bioinformatics capacity, data analysis, and sharing pipelines.
- Implemented a real-time lineage identification system, promptly notifying state authorities of novel variants through an in-house dashboard *(http://rock.igib.res.in/)* and dedicated website *(https://data.ccmb.res.in/apsi/)* .
- The dashboard allows for real-time tracking and visual exploration of data inflow from consortium partners.

Comprehensive Metadata Analysis
- Analysing metadata obtained from partnering hospitals, laboratories and testing centres.
- Focus on understanding the prevalence of vaccine breakthrough cases and reinfections, especially in the context of the Omicron wave.

Way Forward APSI's vision is to integrate environmental surveillance into existing surveillance programs in India with a focus to detect and predict disease outbreaks. This would significantly reduce costs associated with disease burden in India.

Training Programs in Advanced Technologies by Research Facilities

Deepti Trivedi

Over the years, **research facilities** have played a critical role in equipping scientists, both on and off campus, with skills in advanced and specialized technologies. By organizing **intensive training programs, hands-on workshops,** and **individualized training,** these facilities ensure that present and future researchers are adept in the latest methodologies and instruments essential to cutting-edge biological research. Here, we provide an overview of some of the training initiatives led by key facilities, showcasing their contributions to scientific development and technical expertise.

Bangalore Microscopy Course The Bangalore Microscopy Course, established in 2009, is a flagship training initiative, recently completing its 14th edition. Over 364 participants from around the world have been trained in diverse microscopy techniques, ranging from confocal to high-resolution methods like SIM and STED. A selective admission process ensures an optimal trainer-to-participant ratio, maximizing hands-on time with high-end equipment. Additionally, participants engage in independent projects and interact with experts from leading microscope companies, gaining comprehensive knowledge and practical skills in microscopy.

Sequencing, Genomics, and Mass Spectrometry Facility Since 2019, the Genomics and Mass Spectrometry Facility have jointly organized a bi-annual workshop titled "Integrated OMICS," focusing on hands-on training in omics technologies for external researchers. Excluding a brief hiatus during the COVID-19 pandemic (2020-2021), this program has successfully trained over 120 researchers across India in advanced genomics and mass spectrometry techniques. The Mass Spectrometry Facility also independently offers specialized training to internal students on proteomics, targeted metabolomics, and complex mass spectrometer handling, catering to both academic and industry participants.

Animal Facility The Animal Facility has been running bi-annual hands-on training sessions for external participants for the past five years, focusing on laboratory mice and rat care. Participants receive rigorous training in humane handling, identification, sampling methods, and euthanasia techniques. This workshop also includes an assessment phase to validate participants' proficiency, ensuring they meet high standards before certification.

Central Imaging and Flow Cytometry Facility (CIFF) CIFF offers an annual series of three Basic Flow Cytometry Courses in collaboration with BD, the Centre of Excellence in Cytometry. These sessions train about 10 students per course in fundamental principles, such as fluidics, optics, and data processing in flow cytometry. The CIFF also conducts specialized microscopy courses thrice a year, focusing on confocal and high-resolution techniques, benefiting graduate students, postdoctoral fellows, and facility staff.

NMR Facility The NMR Facility has been a hub for specialized training in nuclear magnetic resonance (NMR) for over eight years. Primarily serving BLiSC users, it has trained around 115 students in this period, focusing on hands-on experience with NMR. In addition, the facility collaborates with faculty to offer theoretical courses, such as "Protein NMR Spectroscopy," to PhD students, enhancing their understanding of NMR principles and applications.

Drosophila Facility The Drosophila Facility provides personalized training in fly genetics, transgenesis, and CRISPR-Cas9 genome engineering, enabling users to conduct precise genetic studies. The facility engages in outreach by training college students and lecturers in experiments suitable for biology education, promoting interest and proficiency in genetic research.

Research Collections Facility In 2023, the Research Collections Facility conducted two focused workshops on Insect and Squamata taxonomy, training 40 participants, including students, professors, and naturalists from 12 states. In addition, two B.Sc. students completed a two-month internship, gaining hands-on experience in taxonomy and specimen handling.

In summary, these facilities' concerted efforts demonstrate their commitment to advancing scientific capabilities in cutting-edge technology through intensive training and global collaborations, equipping researchers to address complex biological challenges.

Undergraduate Lecture Series

Dhananjay Chaturvedi *(Assistant Professor at CCMB)*

For the past ten years, Postdoctoral Fellows at NCBS have organized the **Annual Undergraduate Lecture Series**. The focus of this event is **problem-solving**, using the basics of any scientific theme covered that year. We recognize that knowledge is the ability to wield information. We equip undergraduate students from the Bangalore area and beyond to gather and assess relevant data, synthesise it into a useful framework and use it to make testable hypotheses and predictions. Many students who have gone on to pursue PhDs in prestigious institutions worldwide after this program have conveyed their gratitude for our efforts.

The lecture series starts with the convergence of postdocs eager to teach a subject in which each of us has complementary expertise. We then float an open-ended question with the advertisement, shared through social media and direct emails to college heads of Biology departments. Up to seventy students a year, from as far as Hassan and Chennai have been selected in the past based on their analytical abilities demonstrated in their responses to the question. The students then attend the lecture series in person at NCBS over eight Sundays chosen to exclude exam weeks. The first session of each Sunday has an interactive didactic class, and the second is devoted to solving problems and reading scientific papers. The latter two differ from textbook teaching, chiefly because, like in actual research and nature, no information presents as a pronouncement couched in a universal, ready-to-use form.

To prepare for these sessions, each postdoc goes through several iterations of a class to be tailored to undergraduate students, assuming no prior knowledge of the field. The emphasis is on eliciting the logical connection between facts from the students themselves. The non-trivial amount of time each participating Postdoc spends honing all individual classes greatly helps our own clarity of thought and communication.

This series is one of the most important activities in the Postdoc calendar at NCBS. We draw on what we felt were lacunae in our early training with hopes of filling them for students in attendance. We always regret having to turn away applicants, but we know fully well that this method cannot help everyone at that stage in their training. As with any teaching, the impact is only apparent years later if the students choose to acknowledge it. Thus far, we are satisfied with our contributions and hope to continue on this path.

Monsoon School

Mukund Thattai

NCBS has always been an interdisciplinary environment: over half of our faculty have their primary training in disciplines other than biology! In Obaid Siddiqi's original formulation of key research areas at NCBS, "Theory" had a prominent part. By the time I joined NCBS in 2004, there were already many groups engaged in research at the interface of biology and other disciplines: Madan Rao and Shivashankar looking at the physics of living matter; Satyajit Mayor using sophisticated measurements to understand the structure of biological membranes; Upinder Bhalla studying the molecular-level organisation of the synapse; Jayant Udgaonkar using super-sensitive techniques to study protein folding and unfolding. Soon Shachi Gosavi, Sandeep Krishna, and Madhu Venkadesan joined the faculty, opening up new research directions in protein structure, bimolecular networks, and biomechanics.

NCBS students, as well, were drawn from multiple disciplines. The NCBS entrance exam was designed so that students with training in any area of basic science or engineering could apply. Over the years we attracted several adventurous young scholars who wanted to take the plunge into biology.

Each of us, whether professors or students, had a different story about why we chose to enter a research area outside of our original training. We were inspired by our professors, by papers we read or by other researchers we met. In 2013, Sandeep Krishna suggested that we should "pay it forward". That is, just as we had been inspired by those who came before us, we should do something that could inspire the next generation of students across disciplines to study living systems. Thus did the **NCBS Monsoon School on the Physics of Life** get its start.

Our goal was to attract students from physics, chemistry, mathematics, computer science and engineering, and get them excited about **deep open questions in biology**.

It was Sandeep's idea to call it a "Monsoon School" rather than a "Summer School" to add some uniqueness to the program. (Though the actual start date varies from year to year, we have been rather lucky in the school coinciding with the first monsoon showers, giving the IMD a run for their money!)

The Monsoon School has a unique structure because it emphasises independent learning, with hands-on sessions and group projects. Scientists from across India generously give their time as instructors in the School. They are present throughout the program, and interact with students outside the lectures, helping them define and carry out projects. There are typically 40 participants, and they split into 8 groups on the first day of the program. Over the next 10 days, each of these groups must articulate and explore some question about living systems, even as they attend lectures and workshops. This challenge gets the students excited, and they make independent connections with labs and facilities across campus, not just defining a problem, but doing out-of-the-box experiments.

The School began as an ICTS workshop in 2013. From 2014 onwards it was funded through the Simons Centre for the Study of Living Machines, an interdisciplinary centre set up within NCBS with support from the Simons Foundation. The School has been running every year apart from a 3-year hiatus during the pandemic and has now completed its 9th iteration. Over 350 undergraduate students from across India have participated in the School. Many have gone on to PhD programs, and some of our early alumni are now independent researchers!

Physics of Life - 8th Annual Simons-NCBS Monsoon School
19th to 28th June, 2023

Physics of Life - 9th Annual Simons-NCBS Monsoon School
1st to 10th July, 2024

Our Research Interests

- Biophysics, Biochemistry, and Bioinformatics
- Genetics and Development
- Cellular Organization and Signalling
- Theory, Simulation, and Modelling of Biological Systems
- Neurobiology
- Ecology and Evolution

1 Biophysics, Biochemistry, and Bioinformatics

Adaptation, the Bacterial Way!
Aswin Seshasayee

Ubiquitin-Like Signaling in Host-Pathogen Interactions
Ranabir Das

Computational Approaches to Protein Science
R Sowdhamini

Deciphering Genetic and Molecular Alterations in Cancers
Sabarinathan Radhakrishnan

Active Living Material in Complex Environment
Tapomoy Bhattacharjee

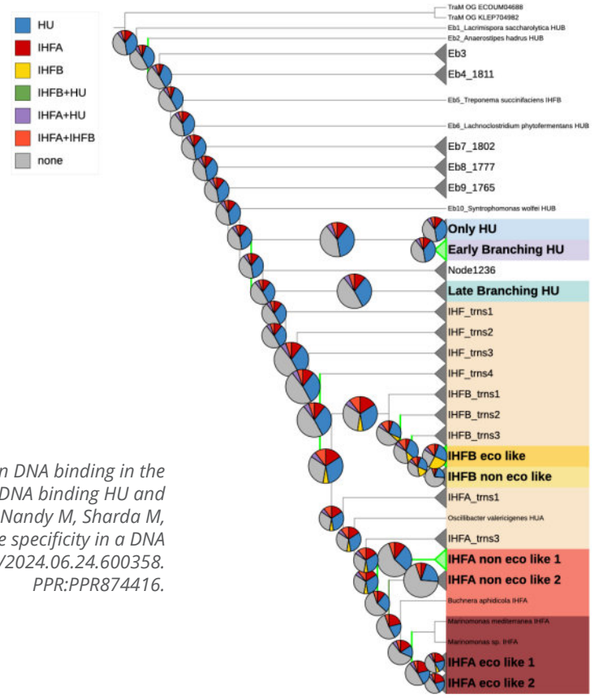
Structures of Macromolecules and Dynamics
VinothKumar KR

Aswin Seshasayee
aswin@ncbs.res.in

Adaptation, the Bacterial Way!

Bacterial adaptation is multipronged. Not only do bacteria regulate what molecules are produced when, they also adapt by changing their genotype. We ask how these phenomena operate and evolve using computation.

Regulation of transcription is a critical component of bacterial adaptation to their environments. We are interested in the structure and evolution of these networks. Our current work deals with the evolution of transcription factors, which are key proteins in gene regulation. Transcription factor activity is one among several nucleic acid binding functions, but unlike DNA compaction, is not absolutely essential for the existence of minimal cellular life forms. We ask how these transcription factors evolved, and how they might be evolutionarily related to other DNA binding proteins. We ask these questions in both bacteria as well as in eukaryotes which have elaborated their own unique set of transcription factor sequence families. We have identified evidence suggesting that a sub-family of sequence-specific binding, characteristic of transcription factors, might have evolved from a non-specific DNA binding relative in bacteria. In eukaryotes, large expansions of transcription factors appear to have happened in more recently diverged multi-cellular branches whereas most of their non-transcription factor relatives emerged earlier.



The emergence and loss of residues involved in DNA binding in the sequence family comprising the non-specific DNA binding HU and the specific transcription factor IHF. From Nandy M, Sharda M, Seshasayee ASN. The evolution of sequence specificity in a DNA binding protein family. doi:10.1101/2024.06.24.600358. PPR:PPR874416.

PUBLICATIONS

- Nandy M, Sharda M, Seshasayee ASN. The evolution of sequence specificity in a DNA binding protein family. doi:10.1101/2024.06.24.600358. PPR:PPR874416.
- Das M, Sreedharan S, Shee S, Malhotra N, Nandy M, Banerjee U, Kohli S, Rajmani RS, Chandra N, Seshasayee ASN, Laxman S, Singh A. Cysteine desulfurase (IscS)-mediated fine-tuning of bioenergetics and SUF expression prevents Mycobacterium tuberculosis hypervirulence. Sci Adv. 2023 Dec;9(50) eadh2858. doi:10.1126/sciadv.adh2858. PMID: 38091389; PMCID: PMC10848736.
- Shee S, Veetil RT, Mohanraj K, Das M, Malhotra N, Bandopadhyay D, Beig H, Birua S, Niphadkar S, Nagarajan SN, Sinha VK, Thakur C, Rajmani RS, Chandra N, Laxman S, Singh M, Samal A, Seshasayee AN, Singh A. Biosensor-integrated transposon mutagenesis reveals rv0158 as a coordinator of redox homeostasis in Mycobacterium tuberculosis. Elife. 2023 Aug;12 e80218. doi:10.7554/elife.80218. PMID: 37642294; PMCID: PMC10501769.

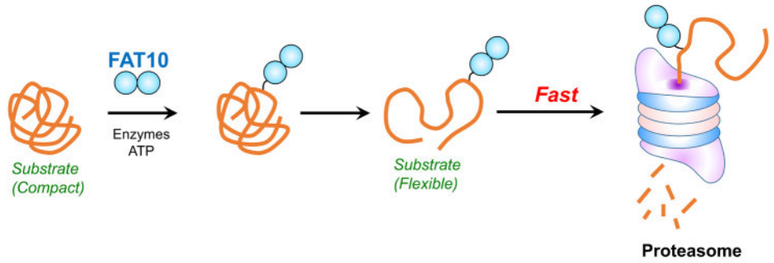
Ranabir Das
rana@ncbs.res.in

Ubiquitin-Like Signaling in Host-Pathogen Interactions

Post-translational modifications of substrate proteins with Ubiquitin-like small proteins regulate their function and lifetime. Studying the molecular interactions of these modifications reveals why and how they are crucial in host-pathogen interactions.

We study the relevance of the ubiquitin-proteasome pathway in host-pathogen interactions. Most substrate proteins are posttranslationally modified by a small protein ubiquitin for degradation. Recently, we studied an auxiliary proteasome-targeting protein known as Fat10 activated during infection.

Ubiquitin substrates need unfoldases like Cdc48 to unfold the substrate before it engages with the proteasome. Our studies showed that Fat10 substrates do not require unfoldases, suggesting that Fat10 significantly impacts the substrate's structure by unknown mechanisms. We find that Fat10 has a malleable native structure that unfolds rapidly, efficiently engages with the proteasome, and ensures fast substrate degradation. Moreover, Fat10 reduces the substrate's thermodynamic stability in cellular and in-vitro conditions. The thermodynamic coupling between the substrate and Fat10 increases partially disordered regions in the substrate-tag conjugate, ensuring rapid degradation. The quantum of Fat10's destabilizing effect is modulated by the substrate size, structure and the conjugation site. Further information on novel interactions of Fat10 will be interesting to understand host inflammatory response to microbial infection.



PUBLICATIONS

- Plasticity of the proteasome-targeting signal Fat10 enhances substrate degradation, Negi H, Ravichandran A, Dasgupta P, Reddy S, Das R, (2024), Elife. 13, e91122.
- The Thermodynamic Properties of Fat10ylated Proteins Are Regulated by the Fat10ylation Site, Ravichandran A, Das R, (2024), ACS Omega, 9(20), 22265-22276.

HONORS AND AWARDS

- Fulbright-Nehru Professional Excellence Fellowship.

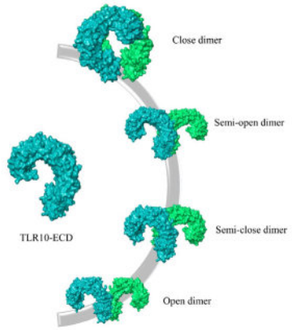
R Sowdhamini
mini@ncbs.res.in

Computational Approaches to Protein Science

We employ computational algorithms to enable efficient annotation of functions to unknown gene products. Our projects are geared towards modelling protein-protein/ligand interactions and plant genomics, aided by collaborative ventures.

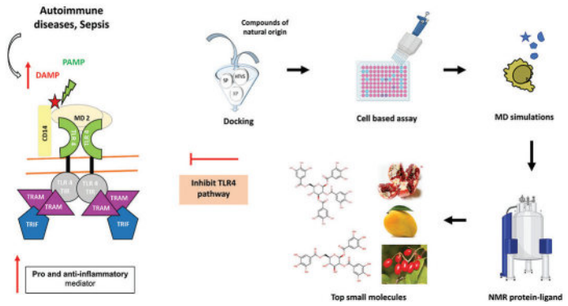
Genome sequencing projects have enormous potential to benefit human endeavours. However, just as acquiring a language's vocabulary does not enable one to speak it, databases that list the amino acid compositions of proteins do not directly tell us much about the higher-level structures and functions of these proteins. Functionally similar proteins may have <25% sequence overlap. Proteins with very similar amino acid sequences are 'no-brainers', but the real test——is to detect the "essential" similarities in proteins whose non-critical sections have experienced random rearrangements during evolution.

We seek to understand mechanism of action and to provide rationale for disease-causing mutations. Explicit computational pipelines have been devised to recognise parts of the genome that retain genic regions and applied in DNA or RNA assemblies of select medicinal plants. Finally, we have exploited the availability of structural information of small molecules of natural origin to identify potential inhibitors for target proteins. The efficacy of these inhibitors has been verified using *in vitro* assays and biophysical studies.



Three-dimensional modeling of full-length of Toll-like receptor 10 using multiple domain templates and dimer orientations (Tiwari and Sowdhamini, 2023 Structural modelling and dynamics of full-length of TLR10 sheds light on possible modes of dimerization, ligand binding and mechanism of action. Current research in structural biology, 5, 100097. https://doi.org/10.1016/j.crstbi.2023.100097).

[Figure created by Vikas Tiwari]



Virtual screening for potential inhibitors for TRAM adapter domain from around 0.3 million natural small molecules, followed by validation using in vitro assays and NMR studies (Shailya Verma, Purushotham Reddy and R. Sowdhamini (2023) Integrated approaches for the recognition of small molecule inhibitors for Toll-like receptor 4. Computational and Structural Biotechnology Journal, 21, 3680-3689 https://doi.org/10.1016/j.csbj.2023.07.026.)

[Figure created by Shailya Verma]

PUBLICATIONS

- Tiwari and Sowdhamini, 2023 Structural modelling and dynamics of full-length of TLR10 sheds light on possible modes of dimerization, ligand binding and mechanism of action. Current research in structural biology, 5, 100097. https://doi.org/10.1016/j.crstbi.2023.100097.
- Shailya Verma, Purushotham Reddy and R. Sowdhamini (2023) Integrated approaches for the recognition of small molecule inhibitors for Toll-like receptor 4. Computational and Structural Biotechnology Journal, 21, 3680-3689 https://doi.org/10.1016/j.csbj.2023.07.026.

Sabarinathan Radhakrishnan
sabari@ncbs.res.in

Deciphering Genetic and Molecular Alterations in Cancers

We are interested in understanding the genetic and molecular alterations responsible for cancer development and resistance to treatments, using computational and functional genomics approaches.

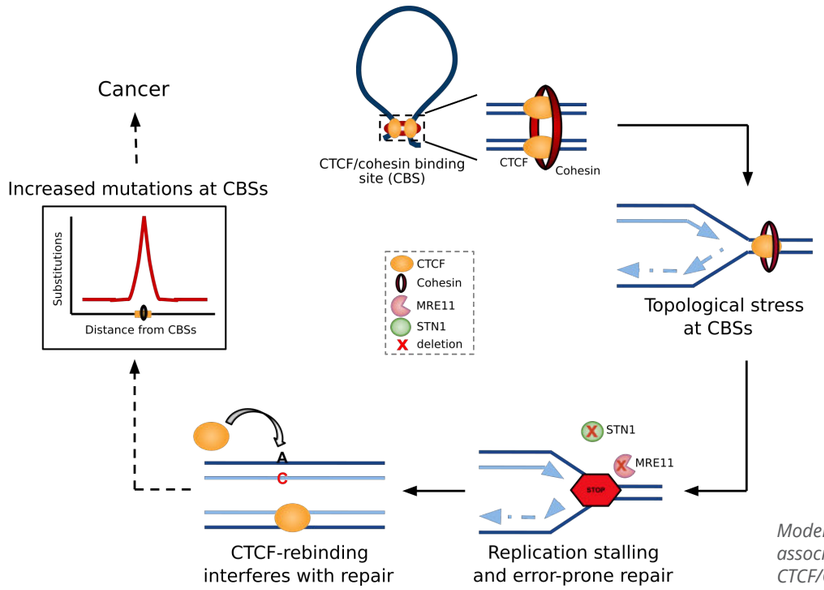
Our current research includes understanding of:

a) the impact of chromatin architecture on somatic mutational processes and gene regulation in cancer,
b) cancer driver mutations and their mechanism of action, and
c) tumor-immune cell interactions.

Key findings from our recent studies:

a) CTCF and Cohesin play a major role in forming chromatin loops, which are essential for gene regulation. In cancers, the CTCF/Cohesin-bound DNA regions are frequently mutated; however, the underlying mechanisms are unknown. Our findings suggest that these DNA-bound regions experience stress during DNA replication, leading to DNA breaks and genomic instability (Faseela et al., 2023) (Figure 1).

b) Integration of Human papillomavirus (HPV) in the nuclear genome is often detected in cervical cancers; however, the oncogene role of this integration is not yet fully understood. We identified that HPV integration affects host chromatin structure and gene expression both locally and long-range to drive the expression of oncogenes such as MYC/PVT1 (Singh et al., 2024).



Model depicting the replication stress associated genomic instability at CTCF/Cohesin-bound sites in cancers.

PUBLICATIONS

- Faseela EE, Notani D, Sabarinathan R. Replication stress underlies genomic instability at CTCF/cohesin-binding sites in cancer. bioRxiv, 2023.
- Singh AK, Walavalkar K, Tavernari D, Ciriello G, Notani D, Sabarinathan R. Cis-regulatory effect of HPV integration is constrained by host chromatin architecture in cervical cancers. Molecular Oncology, 2024.

HONORS AND AWARDS

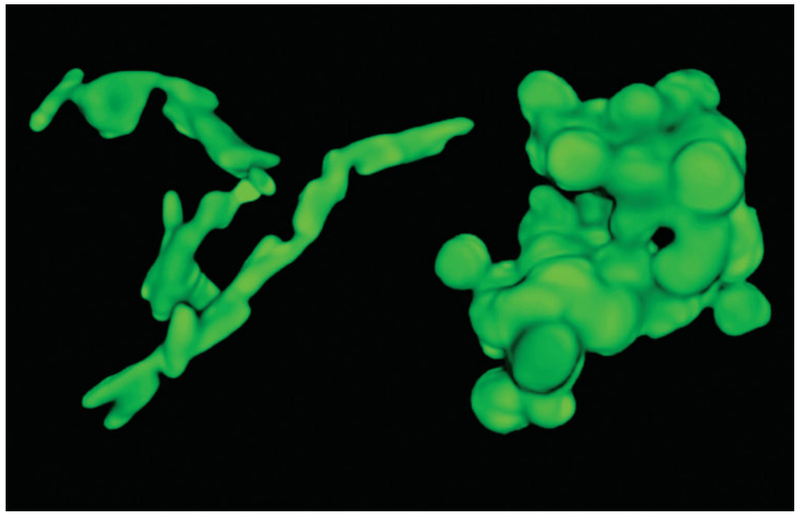
- DBT/Wellcome-Trust IA Intermediate Fellowship (2021-25).

Tapomoy Bhattacharjee
tapa@ncbs.res.in

Active Living Material in Complex Environment

We aim to discover new physical and biological principles emerging from the interactions between living organisms and their complex, three-dimensional microenvironments.

Our lab works in the broad area of active living matter in complex environments and aims to discover new physical and biological principles emerging from the interactions between mammalian cells, bacteria, and their microenvironments. We design and fabricate biomimetic 3D media to mimic the natural habitat of mammalian cells, bacteria and even worms. We fine-tune the material properties of the media to explore how living organisms respond to the change in their microenvironment. The lab uses bioprinting and a variety of microscopy techniques to probe multicellular systems at three-dimensional biological interfaces. More specifically, the lab is exploring a spectrum of areas that include characterizing the properties of biomimetic gels, understanding worm behavior in 3D environment, exploring bacterial growth and response to antibiotics in 3D, designing long-term cultures of 3D-printed tissues, studying the interaction between microbes and mammalian tissues in 3D, and investigating mechanically assisted maturation of tissues.



Bacterial growth under confinement selectively favours rod-shaped bacteria compared to spherical bacteria.

PUBLICATIONS

- M Sreepadmanabh, M. Ganesh, P. Sanjenbam, C. Kurzthaler, D. Agashe, T. Bhattacharjee*, Cell shape affects bacterial colony growth under physical confinement, Nature Communications, 2024. DOI : 10.1038/s41467-024-53989-6.
- N.K. Babu, M Sreepadmanabh, S. Dutta*, T. Bhattacharjee*, Interplay of geometry and mechanics in epithelial wound healing. Physical Review E, 2024.

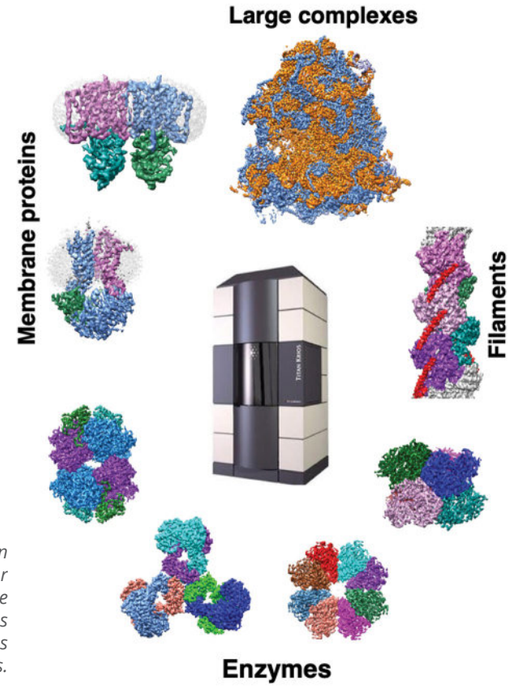
*corresponding author

Vinothkumar KR
vkumar@ncbs.res.in

Structures of Macromolecules and Dynamics

Our research is driven by the curiosity of how macromolecules function in the cell. We study macromolecules that function in the membrane, those that regulate translation and interesting microbial enzymes.

The lab's theme is 'Macromolecular Structure and Dynamics' and the research areas that we study include membrane proteins, microbial enzymes and large macromolecules such as ribosomes (Fig 1). Within the broad area of membrane proteins, we are working towards understanding the mechanism of peptide and antibiotic resistance in bacteria, cleavage of transmembrane proteins by intramembrane proteases and membrane receptors. We also work on select microbial enzymes that have interesting catalytic mechanisms and for their use as test samples for cryoEM (to understand the behaviour of specimens during freezing and also to optimize data collection) in particular at air-water interface (1). One of the projects that we have been working on for a while is the metabotropic glutamate receptor, mGlu, a class C G-protein coupled receptor. We have been interested in understanding how different ligands bind in the transmembrane domain to inhibit or promote signalling (2).



A gallery of macromolecules studied in our lab using cryoEM as the major technique. These include membrane proteins, enzymes, filamentous structures and large complexes such as ribosomes.

PUBLICATIONS

- Yadav, S & Vinotkumar, KR., Factors affecting macromolecule orientations in thin films formed in cryo-EM. (2024), Acta Cryst. D80, 535-550.
- Cannone, G., et al., Conformational diversity in class C GPCR positive allosteric modulation. bioRxiv 2023. DOI:10.1101/2023.11.07.565819.

Chromatin Dynamics in Gene Regulation
Dimple Notani

Control of Organ Size and Shape During the Differential Development of Drosophila Wing and Haltere
LS Shashidhara

Epigenetics and Small Silencing RNAs
PV Shivaprasad

Development and Morphogenesis of the Inner Ear
Raj Ladher

Investigating the Role of Endothelial Cells in Cardiovascular Regeneration
Soumyashree Das

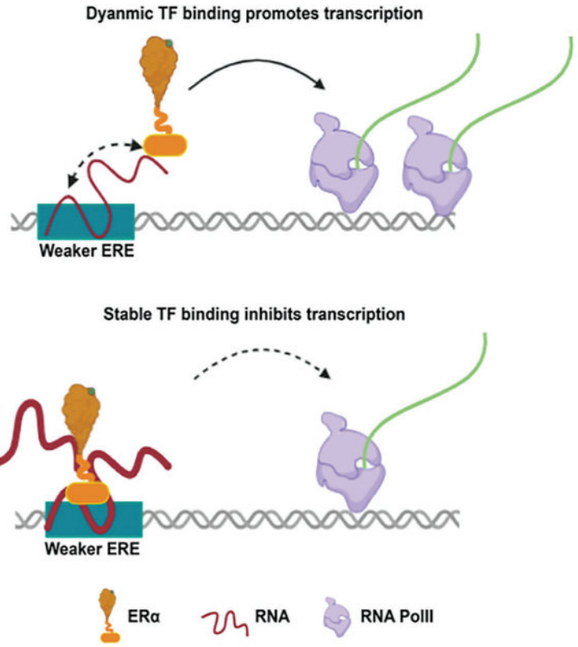
Dimple Notani
dnotani@ncbs.res.in

Chromatin Dynamics in Gene Regulation

My group is interested in understanding the dynamic interplay between regulatory elements, non-coding RNAs, and chromatin-architecture in gene regulation.

Expression of genes is controlled by DNA sequences that are distal from the promoters known as enhancers. They regulate target genes by establishing looping with the promoter in a cell-type specific manner. Although discovered over forty years ago, how enhancers regulate their promoters remains poorly understood. Further, the enhancers that drive cyclic signaling response, are reversibly dynamic as opposed to developmental enhancers, adding another layer of complexity to this conundrum.

Using genomic techniques that quantify the alterations in TF binding, nascent transcription, three-dimensional architecture during the course of estrogen signaling, our work has revealed that chromatin state under basal signaling is the key to signaling response. Further, these and other enhancer clusters do not function as sum-of-all but they rely on complex hierarchies that cannot be predicted. Furthermore, promiscuous transcription and mutations in these enhancers lead to patho-physiologies including cancer.



PUBLICATIONS

- Soota D, Saravanan B, Mann R, Kharbanda T, Notani D. RNA fine-tunes estrogen receptor-alpha binding on low-affinity DNA motifs for transcriptional regulation. EMBO J. 2024 Nov;43(21):5186-5210.
- Bohra d, Islam Z, Sundarraj N, Mazumder A, Notani D. Acute Activation of Genes Through Transcriptional Condensates Impact Non-target Genes in a Chromatin Domaine. 2024. eLife.13:RP1024174.

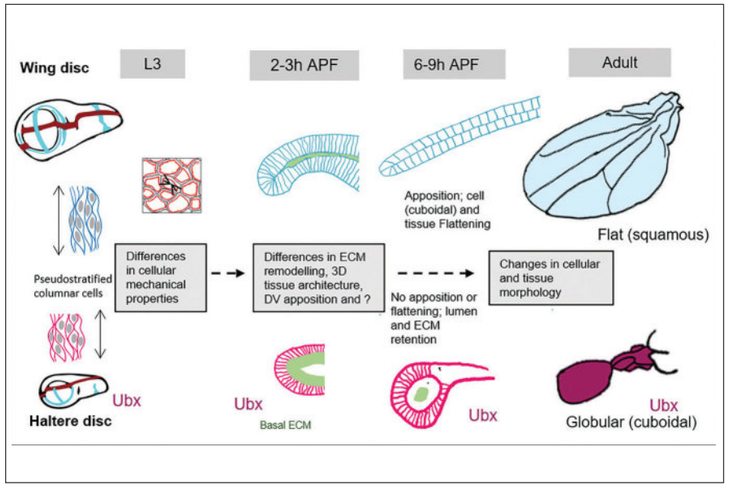
LS Shashidhara
lsshashidhara@ncbs.res.in

Control of Organ Size and Shape during the Differential Development of *Drosophila* Wing and Haltere

We study :
(i) how biomechanical properties of cellular components such as membrane, actin-myosin and microtubular complexes determine cell size and shape of individual cells

(ii) and their collective behaviour shaped by extracellular matrix and forces exerted on individual cells in specifying organ shape.

Diverse organ shapes and sizes arise from the complex interplay between cellular properties, mechanical forces, and gene regulation. *Drosophila* wing- a flat structure and the globular haltere are two homologous flight appendages emerging from a similar group of progenitor cells. The activity of a single Hox transcription factor, Ultrabithorax (Ubx), governs the development of these two distinct organs- wing and haltere with different cell and organ morphologies. We have observed that localisation and abundance of actomyosin complexes, apical cell contractility, properties of extracellular matrix, and cell size and shape, which is a result of various cell intrinsic and extrinsic forces, plausibly influence the flat vs. globular geometry of these two organs. We have followed the three-dimensional architecture of developing wing and halteres during early pupal morphogenesis, indicating the role of the above-mentioned factors in force generation and in driving differential morphogenesis, leading to different organ shapes. We have also developed simulated scenarios based on computational modelling that propose key ingredients required for producing wing- or haltere-like morphologies in *Drosophila.*



Schematic showing various developmental steps regulated by Ubx during the wing and haltere morphogenesis in Drosophila.

PUBLICATIONS

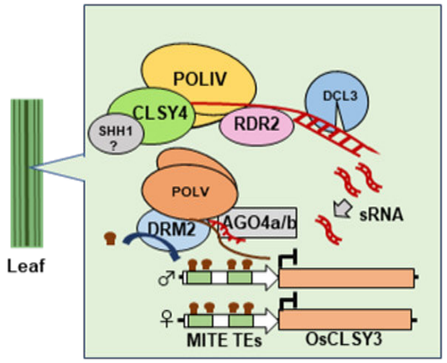
- Asokan et al. (2024). Immunogenicity of SARS-CoV-2 vaccines BBV152 (COVAXIN®) and ChAdOx1 nCoV-19 (COVISHIELD™) in seronegative and seropositive individuals in India: a multicentre, non-randomised observational study. LANCET Regional Health Southeast Asia. 22, 100361, DOI:https://doi.org/10.1016/j.lansea.2024.100361.
- Khan S, Pradhan SJ, Giraud G, Bleicher F, Paul R, Merabet S, Shashidhara LS. (2023). A Micro-evolutionary Change in Target Binding Sites as a Key Determinant of Ultrabithorax Function in Drosophila. J Mol Evol. 91(5):616-627. doi: 10.1007/s00239-023-10123-2.

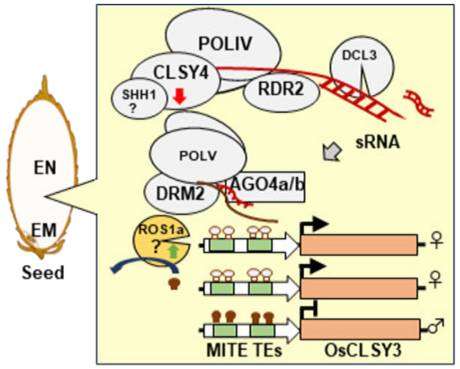
PV Shivaprasad
shivaprasad@ncbs.res.in

Epigenetics and Small Silencing RNAs

A number of epigenetic regulatory layers are superimposed on the genome. We study mechanisms of small (s)RNA-mediated epigenetics and other signalling pathways, focusing on the functional significance of these regulatory layers.

sRNAs are a group of key molecules resulting from RNA silencing pathways. They regulate transcription and translation of their target RNAs by associating with Argonaute protein effectors. sRNAs are also important factors in initiating and maintaining heritable changes in gene expression without changes in DNA sequence ('epigenetics'). sRNAs and epigenome modifications impact every aspect of eukaryotic development and disease. Our laboratory is interested in understanding the pathways and mechanisms that generate sRNAs and epigenome modifications in plants. We use various biochemical, genetic, bioinformatic and whole-genome approaches in a wide variety of model organisms. During the reporting period, we have discovered a cascade of peptide mediated signalling operating in rice upon wounding (Harshith et al., 2024). We also identified a chromatin remodeler named CLSY3 that is an upstream player regulating genomic imprinting in rice endosperm *(Pal et al., 2024).*





CLSY3 chromatin remodeler is an upstream player in rice genomic imprinting and endosperm development

CLSY3 is a new player in rice endosperm development. Using a well-resolved spatial transcriptomics coupled with genetic data, this study identified rice CLSY3 chromatin remodeler as an upstream player in endosperm development. OsCLSY3 is imprinted, endosperm-specific and under the control of small RNA directed DNA methylation. From Pal et al., Nature Communications. 2024.

PUBLICATIONS

- Avik Pal, Vivek Hari Sundar G, Amruta Nair, and P.V. Shivaprasad (2024). Upstream regulator of genomic imprinting in rice endosperm is a small RNA-associated chromatin remodeler. Nature Communications. 15:7807.
- Harshith, C.Y., Avik Pal, Monoswi Chakraborty, Ashwin Nair, Steffi Raju, and P. V. Shivaprasad (2024). Wound induced small-peptide mediated signalling cascade regulated by OsPSKR dictates balance between growth and defense in rice. Cell Reports. 43:114515.

HONORS AND AWARDS

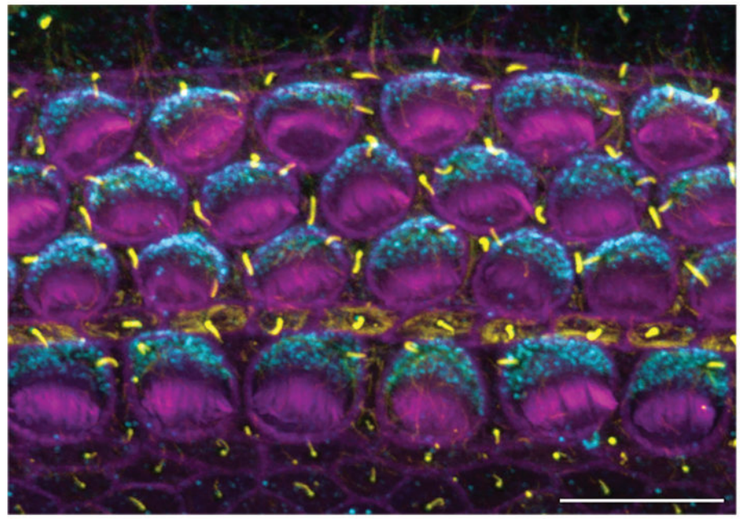
- Elected Fellow of Indian Academy of Sciences, Bangalore (IAS), 2023.
- Member, Technical Expert Committee (TEC), Biological Sciences, DBT-India (2024-onwards).
- Elected Fellow of Indian National Science Academy (INSA), 2023.

Raj Ladher
rajladher@ncbs.res.in

Development and Morphogenesis of the Inner Ear

We are using the inner ear to understand the changes in cell biology as cells and tissues become ordered during development.

The inner ear is a complex structure that is generated from a relatively simple group of cells. These cells should have become skin, yet receive a series of instructions that change their potential and their shape. A subset of these cells form inner ear hair cells that covert the mechanical vibrations associated with sound into electrochemical impulses that are sent to the brain. How do development programmes instruct these changes to the cell ? Using molecular, cellular, imaging, and computational approaches, our aim is to understand the morphogenesis of the inner ear.



A mutant mouse Organ of Corti, stained with actin (Magenta), part of the trimeric G-protein complex (Cyan) and cilia (Yellow).

PUBLICATIONS

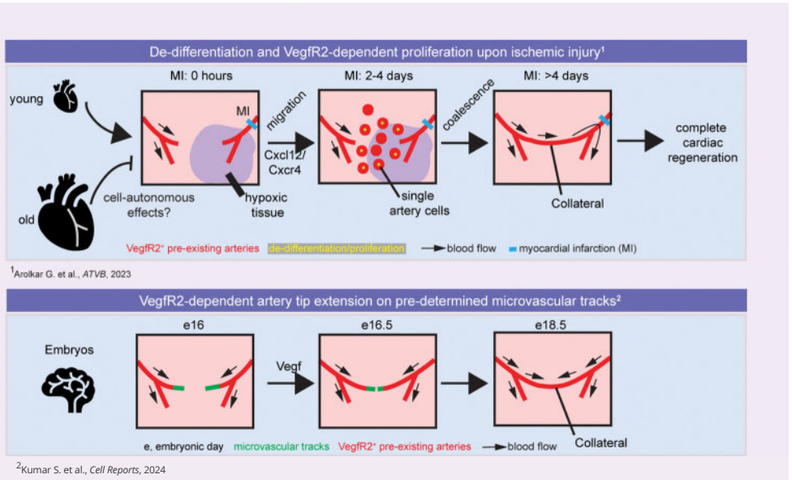
- Singh, N., Kaushik, R., Prakash, A., Saini, S. S., Garg, S., Adhikary, A. and Ladher, R. K. (2024). Mosaic Atoh1 deletion in the chick auditory epithelium reveals a homeostatic mechanism to restore hair cell number. Developmental Biology 516, 35–46.
- Chakravarthy, S. R., Zanten, T. S. van and Ladher, R. K. (2024). Initiation and Formation of Stereocilia during the Development of Mouse Cochlear Hair Cells. BioRXiv 10.1101/2024.03.23.586377.

Soumyashree Das
soumyashree@ncbs.res.in

Investigating the Role of Endothelial Cells in Cardiovascular Regeneration

We investigate mechanisms by which arteries are built, maintained and remodeled in response to biological cues. We also study how formation of new arteries contribute to tissue regeneration.

Our group studies how arteries develop, sustain and remodel. Specifically, we investigate cellular mechanisms, molecular drivers and physiological triggers which facilitate the *de novo* formation of collaterals. Collateral arteries are life-savers during myocardial infarction or stroke where an artery is occluded. Using mouse genetics, single cell RNA sequencing analyses and whole heart confocal imaging at single-cell resolution, we show that young mouse artery cells can de-differentiate and proliferate in response to myocardial infarction; a phenomenon absent in older hearts. Using *in vivo* live imaging of mouse embryos, we show that artery cells extend on pre-determined microvascular tracks to build pial collaterals in brain. Our study reveals that Vegf/VegfR2 axis facilitates pial artery-tip extensions in the developing brain, but drives coronary proliferation in injured hearts. Thus, while developmental pathways reactivate in response to injury, their mode of action may be distinct. Together, our work suggests organ-specific mechanisms drive collateral formation in the heart and brain.



Organ-specific mechanisms drive collateral formation

PUBLICATIONS

- Kumar S, Ghosh S, Shanavas N, Sivaramakrishnan V, Dwari M, Das S. (2024). Development of Pial Collaterals by Extension of Pre-existing Artery Tips. Cell Reports. doi: 10.1016/j.celrep.2024.114771.
- Arolkar G*, Krishna Kumar S*, Wang H, Gonzalez KM, Kumar S, Bishnoi B, Rios Coronado PE, Woo YJ, Red-Horse K, Das S#. (2023). Dedifferentiation and Proliferation of Artery Endothelial Cells Drive Coronary Collateral Development in Mice. Arterioscler. Thromb. Vasc. Biol. 2023; 43(8):1455-1477. doi: 10.1161/ATVBAHA.123.319319. (* equal contribution).

HONORS AND AWARDS

- 2024 Werner Risau Early Career Investigator Award in Vascular Biology.
- Arolkar et al, 2023 received the award of most outstanding vascular biology paper (out of 355 articles published in 2023 by ATVB), American Heart Association.
- (2024) SERB Core Research Grant.

Amey Redkar
aredkar@ncbs.res.in

Genetic Determinants of Fungi for Plant Root Associations

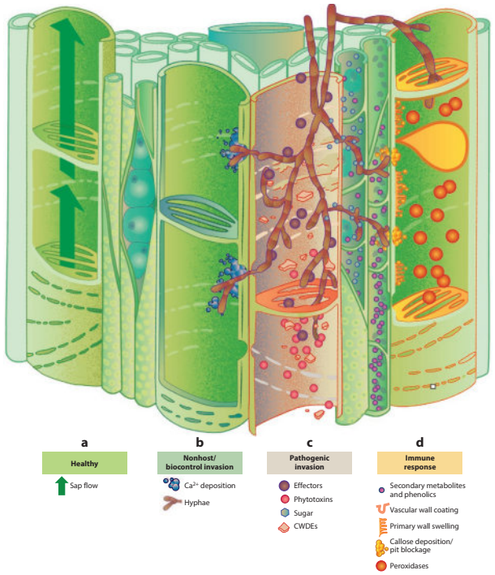
We aim to understand the regulatory mechanisms in fungal-plant associations, focusing on the pathogenic effectors as probes, and the plant processes that they modulate to promote endophytic and pathogenic outcomes during plant interaction.

Our work addresses a central question in plant-microbe interactions: how soil-inhabiting fungi establish compatibility with plant roots and form associations leading to varied interaction outcomes- pathogenic and/or mutualistic. We are interested in understanding how root immunity functions to differentiate diverse microbial interaction outcomes and aim to identify regulatory mechanisms in fungi, that establish plant compatibility. As vast majority of plant-microbe interactions occurs belowground, we use the root-infecting fungal model *Fusarium oxysporum* (Fo) that causes vascular-wilt disease in crops.

To understand how fungal phytopathogens have been so successful, we decode the fungal genomes to map their effectorome and use these candidate secreted proteins as probes to decipher the plant processes that are modulated for promoting disease occurrence. Current major projects in the lab on effectors of *F. oxysporum* aim to understand:

a) Similarity and diversity of *F. oxysporum* effectors by structure-guided comparative analysis and evolution of structurally similar effector families for host-specific adaptation.

b) To gain insights into the effector-mediated adaptation strategies and genome plasticity in *F. oxysporum* for infection on evolutionarily distant non-vascular and vascular plant lineages.



Progression of xylem colonization upon Fusarium oxysporum infection. Schematic representation of the xylem vessel in a healthy state showing (a) conduction of water and nutrients (sap) upward. (b) Endophytic interaction of F. oxysporum on alternative hosts results in the colonization of primarily the cortical cell layers and triggers a strong defense response, with rare events of invasion of the xylem vessel. (c) Invasion of the xylem vessel in F. oxysporum interaction involves the secretion of effectors to suppress host immunity, induction of cell wall–degrading enzymes (CWDEs) to loosen host cell walls, and production of phytotoxins. (d) Host defense responses of an infected xylem vessel show structural changes produced by the cell wall to combat infection that deter fungal growth. This figure is from Srivastava et al., 2024.

PUBLICATIONS

- Srivastava V, Patra K, Pai H, Aguilar Pontes MV, Berasategui A, Kamble A, Di Pietro A, Redkar A*(2024). Molecular dialogue during host manipulation by the vascular wilt fungus Fusarium oxysporum. Annual Review of Phytopathology, 62(1) : 97-126. https://doi.org/10.1146/annurev-phyto-021722-034823.
- Kamble A, Michavila S, Gimenez-Ibanez S, Redkar A* (2024). Shared infection strategy of a fungal pathogen across diverse lineages of land plants, the Fusarium example. Current Opinion in Plant Biology 2024, 77:102498 https://doi.org/10.1016/j.pbi.2023.102498.

**corresponding author*

Anjana Badrinarayanan
anjana@ncbs.res.in

Microbial Genome Plasticity: Molecular Mechanisms and Regulation

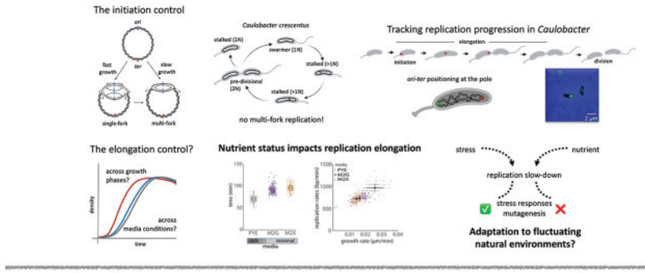
The overall objective of our work is to understand fundamental regulatory mechanisms that govern the activity of genomic error-correction pathways, and how this can drive genome evolution under genotoxic stress.

While DNA damage repair is important for the faithful propagation of life, pathways of repair can also be sources for mutagenesis. Mutations during repair most often arise due to error-prone repair or tolerance mechanisms. For example, repair can sometimes be inaccurate due to the participation of stress-induced error-prone DNA polymerases (translesion polymerases). Apart from their impact on evolution, such inducible mutagenesis can lead to genetic defects and cancer in human cells as well as antibiotic and stress resistance in bacteria. Thus, the modulation of these pathways can have a significant impact on cellular adaptation and survival. This becomes particularly relevant in organisms such as microbes that live in constantly fluctuating environments.

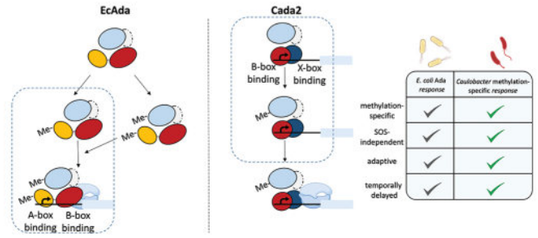
We primarily use imaging approaches, in combination with other interdisciplinary tools, to understand how DNA damage response repair is regulated in microbial systems. Presently, we have focused our efforts on understanding how specific steps of response and repair are regulated *in vivo*, under the following themes:

A. To change or not to change: regulation of mutagenic and non-mutagenic mechanisms of DNA repair

B. Co-evolution of genomes and their error-correction mechanisms



A. Live cell tracking reveals nutrient-mediated control of DNA replication



B. Specificity in bacterial DNA damage responses

PUBLICATIONS

- Zhang C, Joseph A, Casini L, Collier J, Badrinarayanan A, Manley S, Chromosome organization shapes replisome dynamics in Caulobacter crescentus, Nature Communications. Apr 24;15(1):3460. 2024.
- Kamat A, Tran N, Sharda M, Sontakke N, Le T, Badrinarayanan A. Widespread prevalence of a methylation-dependent switch to activate an essential DNA damage response in bacteria., PLoS Biology, 22, 3, e3002540, 2024 Mar 11.

Raghu Padinjat
praghu@ncbs.res.in

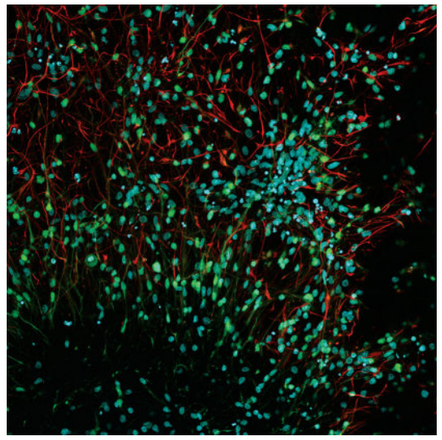
Phosphoinositide Signalling in Cell Biology

Chemical messengers derived from phosphatidylinositol are an evolutionarily conserved mechanism of signalling. They regulate key cellular and biological processes. We study the logic underlying lipid signalling and its relevance to biomedical science.

Our long-term scientific interest is to understand cellular communication mediated by lipid molecules generated by the metabolism of phosphatidylinositol. Phosphoinositide signals provide molecular control for key subcellular processes such as membrane remodelling, cytoskeletal function, transcription, and translation. Through these processes, this signalling pathway orchestrates basic cellular behaviours such as cell division, shape changes, polarised movement, and cell death; and these behaviours play key roles in a number of physiological processes including early embryogenesis, lymphocyte development and function, as well as neuronal activity.

The overall goal of our work is to understand how the architecture in this signalling cascade is designed to optimally deliver physiological outputs. The work is multidisciplinary and done using a combination of Drosophila and human disease models. Over the last year, we have uncovered the function of key enzymes that regulate lipid signalling and provided a molecular mechanism by which they control cellular processes. These include the mechanism by which lipid molecules are exchanged between cellular compartments, the control of membrane turnover and receptor activity by lipids, and a quantitative model of the turnover of lipids during critical cell signalling reactions important for brain function.

We also study the function of phosphoinositides in neuronal cell biology and brain disorders using human iPSC-derived neural cells in cell culture. The goal of this work is to uncover the function of altered phosphoinositide signalling in brain disorders.



Confocal image of human forebrain cortical neural culture differentiated from induced pluripotent stem cells. Images shown are from cultures differentiated for 30 days in vitro and show the glial cells in the culture; DAPI (blue) marks nuclei, GFAP:Glial fibrillary acidic protein (red) marks mature astrocytes and S100B (green) marks immature astrocytes. Work in the Padinjat lab is exploring the role of glial cells in regulating neuronal function in the context of the biology of bipolar affective disorder.

PUBLICATIONS

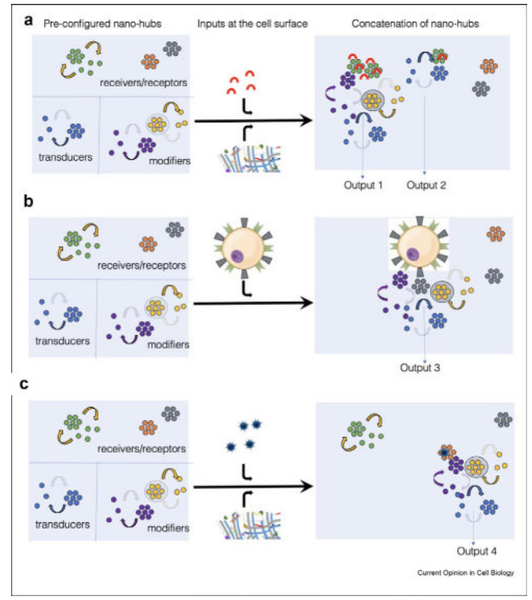
- Saha S, H Krishnan H, Raghu P*. IMPA1 dependent regulation of phosphatidylinositol 4,5-bisphosphate and calcium signalling by lithium. Life Sci Alliance 2023 Dec 6;7(2):e202302425. doi: 10.26508/lsa.202302425. Print 2024 Feb.
- Ghosh A, Venugopal A, Shinde D, Sharma S, Krishnan M, Mathre S, Krishnan H, Saha S, Raghu P*. PI3P-dependent regulation of cell size and autophagy by phosphatidylinositol 5-phosphate 4-kinase. Life Sci Alliance. 2023 Jun 14;6(9):e202301920. doi: 10.26508/lsa.202301920. PMID: 37316298.

Satyajit Mayor
mayor@ncbs.res.in

Mechanisms of Membrane Organization and Endocytosis

Our laboratory studies physico-chemical rules that govern local organisation of cell membrane components in a living cell and connects this to cellular and organismal physiology. In this context we explore how functional signalling complexes and responsive endocytic platform are built.

The plasma membrane that demarcates the boundary of a cell is a macromolecular assembly teeming with activity and local heterogeneities. It is the site where information transfer and endocytic activities take place modulated by the local organization and structure of the membrane. Our laboratory has provided a new understanding of the membrane as an active composite of a lipid bilayer in conjunction with a dynamic cytoplasmic cortical actin scaffold [1]. This is mediated by generating nanoscopic clusters which in turn organize as mesoscopic domains of liquid-ordered lipid species, resulting in active emulsions in the cell membranes. This provides control over the local composition of the membrane creating sites necessary for cell migration and signalling. In parallel we have discovered that a specific clathin and dynamin-independent endocytic process that is involved in regulating global composition and tension in the membrane, is also involved in developmental patterning. It is responsible for robust inference of the Wingless morphogen position during morphogenesis in Drosophila wing imaginal discs [2]. This endocytic process serves to create multiple tiered gradients by promoting the internalizing of the Wingless morphogen via a non-signalling receptor.



Nano-hubs as logic gates. At the cell surface, receptors (as receivers) may be pre-assembled nanoclusters or those that are assembled at the cell surface by multiple means both active and passive. Co-receptors and adaptor proteins (modifiers) and different signalling components (transducers) are also organize as nano-hubs. Receptor nanoclusters interact with diverse inputs such as small molecules or soluble protein-ligands (a), ligands presented at cell surfaces (b), or virus particles (c), in the presence (a, c) or absence (b) of independent mechanical and chemical inputs from the extracellular matrix. Nano-hubs: i) they concentrate molecules in a hub; ii) they have unique identity (they normally contain only one type of molecule); iii) they have a specific function (like logic gates). These features resemble functional circuits where nano-hubs may be "interconnected" to diversify and perform different functions, or trigger different signalling pathways. The flexible concatenation of the receiver nano-hubs with modifier (co-receptors or adaptors) and transducer (signalling assemblies) nano-hubs lead to a variety of outputs based on the nature of the concatenation. Concatenation between different nano-hubs may be achieved by using different strategies such as by colocation of active emulsions due to dynamics of the actin cytoskeleton, phase separation resulting in ordered domains, specific lateral interactions augmented by the generation of nano-hubs, and many others.

PUBLICATIONS

- Solvatochromic reporter to image plasma membrane order leaflet by leaflet reveals a highly asymmetric bilayer locally modulated by transbilayer interactions. Chandrima Patra, Muzamil Samad, Thomas van Zanten, Maninder Singh, Ram A Vishwakarma, Parvinder Pal Singh, Satyajit Mayor. bioRxiv 2024.07.23.604763; doi: https://doi.org/10.1101/2024.07.23.604763.
- The ubiquitous nanocluster: A molecular scale organizing principle that governs cellular information flow Maria F. Garcia-Parajo and Satyajit Mayor. Current Opinion in Cell Biology, Volume 86, 2024, 102285, https://doi.org/10.1016/j.ceb.2023.102285.

HONORS AND AWARDS

- JC Bose National Felowship (DST) 2023-2028
- Leverhulme International Professorship (to be held at University of Warwick).

Swadhin C Jana
swadhin@ncbs.res.in

Organelle Biology: in Physiology and Diseases

The Organelle Biology Laboratory (OBL) investigates mechanisms for building, diversity, evolution and maintaining organelles, primarily Cytoskeleton, Centrosome, and Cilium (i.e., 3Cs), in various organisms (grow in distinct environmental conditions) using a multifaceted approach.

Essential eukaryotic structures, the cytoskeleton, centrosome, cilium, mitochondria and lysosome, are implicated in numerous human diseases, including degenerative diseases, cancer and ciliopathies (combined affect one in every three individuals). Despite these organelles' importance to human health, **our knowledge of their roles in pathologies is limited.**

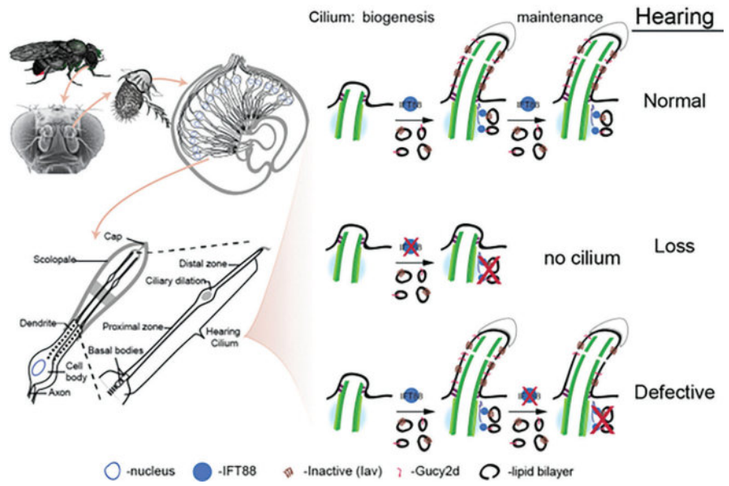
The OBL primarily focuses on the Cytoskeleton, Centrosome and Cilium (3Cs) and their involvement in numerous signalling processes vital for organism development and homeostasis. We, for example, ask:

1) What controls the organisation of several critical building blocks of 3Cs?

2) How are different portions of these structures assembled?

3) How are these vital structures maintained and go wary with pathological conditions?

We have been applying various approaches/techniques/ tools (including bio-physics, -chemistry and -informatics, genetics, transcriptomics, proteomics, advanced imaging, electrophysiology and animal behaviour) in various organisms (prevail in distinct environmental conditions).



Summary of our findings reported in Werner S et al, 2024. LSA.

PUBLICATIONS

- Active EB1 surges promote tubulin influx into the growing outer segments of the bipartite olfactory cilia in Drosophila. Agarwal RG, Iyer D, Barbora A, Gadgil Y, Jana SC*, Ray K*. Preprint. DOI: 10.1101/2024.09.10.612170.
- IFT88 maintains sensory function by localising signalling proteins along Drosophila cilia. Werner S, Okenve-Ramos P, Hehlert P, Zitouni S, Priya P, Mendonça S, Sporbert A, Spalthoff C, Göpfert MC, Jana SC*, Bettencourt-Dias M*. Life Science Alliance. 2024-05 DOI: 10.26508/lsa.202302289. * Lead Corresponding authors.

HONORS AND AWARDS

- Principal Investigator, Mechanisms of maintenance of cilia and their consequences on the organism's homeostasis, Funder: FCT (Portugal, Horizon 2020). Completed: 2024.
- Principal Investigator, Deciphering the roles of yet underappreciated ciliopathy-related proteins in centrosome-cilium assembly and homeostasis in *Drosophila*, Funder: CEFIPRA (Indo-French), Ongoing.

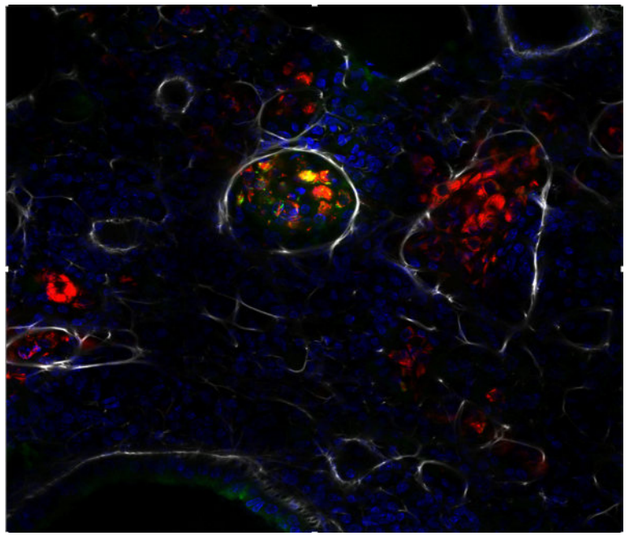
Varadharajan Sundaramurthy
varadha@ncbs.res.in

Host-Pathogen Interactions

The broad goal of our lab is to understand the interactions between the intracellular pathogens and host cells at multiple levels (molecular, cellular, tissue) and exploit this knowledge for host-directed therapeutics against infectious diseases.

When an intracellular bacteria encounters a host cell, variety of outcomes are possible. The cell can get infected, or not; once inside the cell, the bacteria can proliferate, or remain dormant, or escape the cell, or succumb to the immune pressures and die; the host cell can undergo cell death due to bacterial proliferation. These events are not mutually exclusive, and often occur in the same non-perturbed cell population, underlining the cellular heterogeneity in responses to infection. Yet population level responses are largely robust. Ongoing projects in the lab aim to understand the cause and consequences of such heterogeneity in host-pathogen encounters, and relate them to phenotypic diversity in bacterial physiological states.

We study this in the context of *M. tuberculosis* infection in cells and tissues and aim to understand the drivers of heterogeneity from both the host and bacterial sides and their influence on each other. An important off-shoot of these efforts is the identification of different sub-populations of infected cells that harbour *Mtb* of distinct phenotypic states. Ongoing and future projects aim to pharmacologically impact host heterogeneity to modulate *Mtb* phenotypic diversity. These efforts could help identify and specifically target *Mtb* sub-populations with differing antibiotic susceptibilities.



Lung section of mouse infected with Mtb expressing mCherry and immunostained with LC3 (green). Adjacent infected regions in the same tissue show differential association with the host marker. DAPI is in blue, phalloidin is in gray.

PUBLICATIONS

- Immunogenicity of SARS-CoV-2 vaccines BBV152 (COVAXIN®) and ChAdOx1 nCoV-19 (COVISHIELD™) in seronegative and seropositive individuals in India: a multicentre, nonrandomised observational study. Asokan, Mangaiarkarasi S. et al. The Lancet Regional Health - Southeast Asia, Volume 22, 100361.
- Bhatt T, Dam B, Khedkar SU, Lall S, Pandey S, Kataria S, Ajnabi J, Gulzar S-E-J, Dias PM, Waskar M, Raut J, Sundaramurthy V, Vemula PK, Ghatlia N, Majumdar A and Jamora C (2023) Niacinamide enhances cathelicidin mediated SARS-CoV-2 membrane disruption. Front. Immunol. 14:1255478. doi: 10.3389/fimmu.2023.1255478.

4 Theory, Simulation, and Modelling of Biological Systems

Emergence and Control in Development and Evolution
Archishman Raju

Theoretical Approaches in Cell Biology: Physics of Active, Evolving Systems
Madan Rao

The Whats, Hows and Whys of the Eukaryotic Cell Plan
Mukund Thattai

Non-equilibrium Dynamics of Living Systems across Scales
Sandeep Krishna

Computational Dynamics of Biomolecular Self-Assembly
Shachi Gosavi

Quantitative Cell Biology: Oscillations and Proliferation in Development and Disease
Shaon Chakrabarti

Living Metamaterials: Towards a Synthetic Biology from a Physical Perspective
Shashi Thutupalli

Integrative Structural Biology of Large Macromolecular Assemblies
Shruthi Viswanath

Archishman Raju
archishman@ncbs.res.in

Emergence and Control in Development and Evolution

Our lab is interested in the theoretical modeling of developmental dynamics to make minimally parameterized models of data and conceptually clarify the link between development and evolution.

Our lab continues to work on modeling developmental systems using mathematical models that are emergent descriptions of the dynamics.

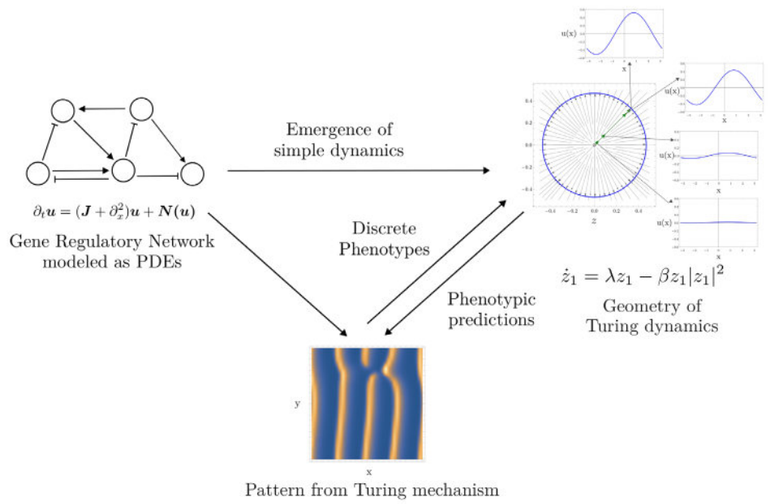
Over the past year, we have worked on using a mathematical technique called normal form theory to understand the behaviour of Turing patterns. We have shown that the behaviour of Turing patterns does not depend on the nature of the reaction-diffusion equations of the morphogens but only on two emergent parameters.

We have also investigated how these patterns change when they are coupled with a morphogen field which has positional information.

We are also close to finishing collaborative work aimed at understanding non-genetic memory i.e. the inheritance of phenotypic states for genetically identical cells. We have developed a novel algorithm to identify "memory genes" that have slow time-scales of fluctuation from single-snapshot measurements and no lineage information.

We continue to work on genetic assimilation and its consequences for evolution and cell fate specification in the mouse blastocyst.

Turing patterns are conventionally understood using partial differential equations that describe morphogen dynamics. Recent work shows that the signaling and regulatory networks that create Turing patterns can be complex. However, we have shown that irrespective of the complexity of the network, the dynamics of Turing patterns can be understood simply using a few emergent parameters combined with a time-independent map from this emergent space to the spatial pattern.



PUBLICATIONS

- Raju, A., Xue, B., & Leibler, S. (2023). A theoretical perspective on Waddington's genetic assimilation experiments. Proceedings of the National Academy of Sciences, 120(51), e2309760120.
- Raju, A., & Siggia, E. D. (2024). A geometrical model of cell fate specification in the mouse blastocyst. Development, 151(8).

Madan Rao
madan@ncbs.res.in

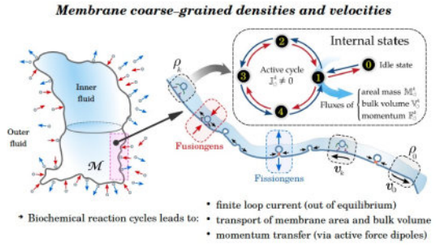
Theoretical Approaches in Cell Biology: Physics of Active, Evolving Systems

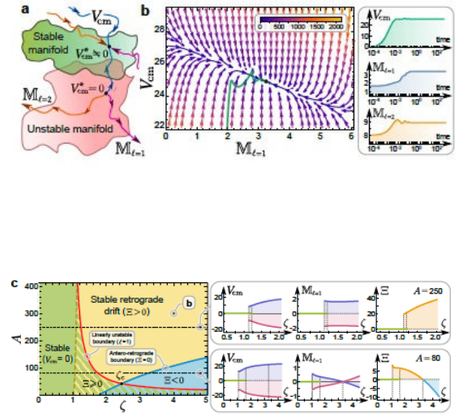
We look for new physical principles underlying the nonequilibrium organisation of the living state, arising from the interplay between active mechanics, molecular organisation, geometry, information processing and control in diverse cellular contexts such as the cell surface, cytoskeletal patterning, chromatin organisation, organelle biogenesis, and tissue morphogenesis.

How do living systems, driven far from equilibrium, self-organise (evolve) to perform, "engineering tasks", such as information processing, computation, and control? We explore new physical principles underlying biological organisation across scales, from functional biomolecules, to subcellular, cellular and tissue scale organisation. We study the mesoscale organisation at the cell membrane driven by active stresses arising from the actomyosin cortex, leading to active segregation and active emulsions. We are interested in the emergence and inheritance of intracellular patterning, e.g., the nonequilibrium assembly and morphodynamics of a system of organelles, such as the Golgi. We work on the dynamics of the active cytoskeleton and cellular force patterning. We have been studying the morphogenesis, patterning, excitability, and homeostatic control in epithelial tissues, driven by an interplay between active mechanics and geometry. A recent focus has been cellular inference and control in the context of tissue development. In addition, we study the unusual mechanical response, segregation and pattern formation in active soft matter, that exhibit non-reciprocity, enhanced memory and fragile elasticity. Our theoretical studies are often supported by collaborations with experimental groups.

Nonlinear analysis shows stable anterograde and retrograde motion of organelles

Active Hydrodynamics of Golgi Membrane





PUBLICATIONS

- Krishnan S Iyer, Chaitra Prabhakara, Satyajit Mayor and Madan Rao, Cellular compartmentalisation and receptor promiscuity as a strategy for accurate and robust inference of position during morphogenesis, eLife 12:e79257 (2023).
- S. Alex Rautu, Richard G. Morris, and Madan Rao, Active morphodynamics of intracellular organelles in the trafficking pathway, arXiv:2409.19084 [cond-mat.soft], https://doi.org/10.48550/arXiv.2409.19084.

HONORS AND AWARDS

- Sir M. Visvesvaraya Senior Scientist State award for the year 2023, Government of Karnataka.

Mukund Thattai
thattai@ncbs.res.in

The Whats, Hows and Whys of the Eukaryotic Cell Plan

We use the membrane traffic system as a window to study the mechanistic and evolutionary origins of the eukaryotic cell plan, using tools from mathematics, physics, and computer science.

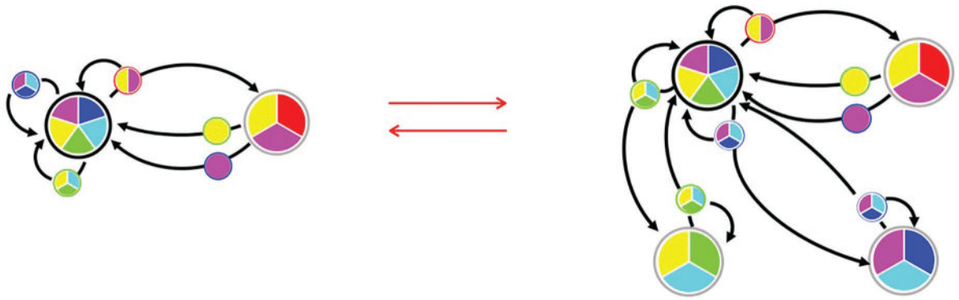
As a physicist practising biology, I am interested in how cellular complexity emerges from molecular rules. My group is based within the Simons Centre for the Study of Living Machines at NCBS. We use biophysical, mathematical and computational principles to understand how cells work. We have been deeply involved in developing evolutionary cell biology as a rigorous field of study.

We ask:

• What? We study the evolution of proteins involved in membrane traffic, to shed light on the natural history and diversity of this system across species and time.

• How? We use mathematical and computational methods to understand how the global structure of the membrane traffic system emerges from local molecular interactions.

• Why? We explore the selective advantage of having intracellular organelles and intra-organellar transport, with particular focus on the structure and function of the Golgi apparatus.



The eukaryotic endomembrane traffic consists of membrane-bounded compartments that exchange matter via transport vesicles. These systems can be abstractly represented and analysed as directed graphs, with different colours corresponding to different types of molecular cargo. We study how new compartments and exchange fluxes can be added to these systems over evolutionary time, driven by the duplication and diversification of vesicle traffic regulatory genes.

PUBLICATIONS

- Joshi, P., Satyajith, A., Panda, D., Thattai, M., & Balasubramanian, N. (2024). Cell-surface glycans are quantitative reporters of Golgi dysfunction in single cells. bioRxiv, 2024-06.17.599374.
- Daniel, S., & Thattai, M. (2024). Coexistence of self-compatible and self-incompatible alleles in a plant metapopulation via spatial rock-paper-scissors dynamics. bioRxiv 2024-01.31.578129.

HONORS AND AWARDS

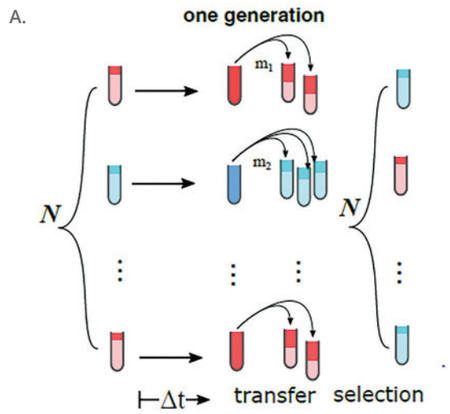
- Infosys Prize in Physical Sciences, 2023.
- Fellow, Indian Academy of Sciences, 2024.

Sandeep Krishna
sandeep@ncbs.res.in

Non-equilibrium Dynamics of Living Systems across Scales

I study the complex, far-from-equilibrium dynamics of biological systems, ranging from gene networks to cells to populations.

At the sub-cellular level, I use a combination of experimental data and mathematical models to study the dynamics of gene regulatory networks, metabolic networks and oscillatory signalling pathways. At a cellular level, I examine decision making, such as the lysis-lysogeny decision in bacteriophage infections. Finally, at an ecosystem level, I have been studying infectious diseases and microbial communities to understand phenomena related to cooperation, communication and symmetry breaking in populations.



Minimal ingredients for a Darwinian population of growing and dividing protocells. Ref [1] studies the conditions under which a population of growing and dividing "protocell" entities containing autocatalytic chemical reaction systems can exhibit heredity of their chemical compositions. We show how a simple serial dilution experiment (A) can test whether a specific autocatalytic chemistry can provide such heredity and delineate the conditions under which this can combine with natural sources of variation to produce a "Darwinian population" that exhibits evolution under natural selection (B).

PUBLICATIONS

- YJ Matsubara, S Ameta, S Thutupalli, P Nghe, S Krishna (2023) Robustness of compositional heredity to the growth and division dynamics of prebiotic compartments, arXiv:2211.03155.
- Mozaffer F, Cherian P, Krishna S, Wahl B, Menon GI (2023) Effect of hybrid immunity, school reopening, and the Omicron variant on the trajectory of the COVID-19 epidemic in India: a modelling study. Lancet Reg Health Southeast Asia 8:100095.

HONORS AND AWARDS

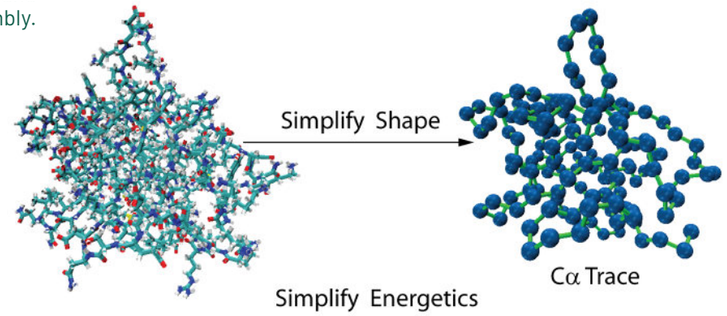
- Elected as Fellow of the Indian National Science Academy, 2023 and the Indian Academy of Sciences, 2024.

Shachi Gosavi
shachi@ncbs.res.in

Computational Dynamics of Biomolecular Self-Assembly

My group uses computational methods, specifically molecular dynamics simulations of coarse-grained and structure-based models, to understand the dynamics of protein folding and self-assembly.

Natural proteins fold robustly because of a funnel-shaped energy landscape. This funnel shape arises because native interactions dominate the folding landscape, while interactions not present in the native state (i.e. non-native interactions) contribute only in an average way. Structure-based models (SBMs) of proteins ignore non-native interactions by encoding only the folded structure of the protein into the energy function. This energy function can then be used to perform molecular dynamics (MD) simulations. The advantage of using SBMs is that they simplify the energy function such that long time-scale biomolecular motions such as protein folding, large conformational transitions and protein self-assembly can be easily sampled. We have been using and developing SBMs to understand mechanisms of biomolecular self-assembly, including those of multimerization and domain-swapping in viral proteins and how pieces of a protein (self-peptides) interact with the whole protein.



Cartoon of a structure-based model coarse-grained to a single Cα bead per residue.

PUBLICATIONS

- DL Prakash, S Gosavi, "The diversity of protein-protein interaction interfaces within T= 3 icosahedral viral capsids", Frontiers in Molecular Biosciences 9, 967877, 2022.
- S Yadahalli, LP Jayanthi, S Gosavi, "A Method for Assessing the Robustness of Protein Structures by Randomizing Packing Interactions", Frontiers in Molecular Biosciences 9, 849272, 2022.

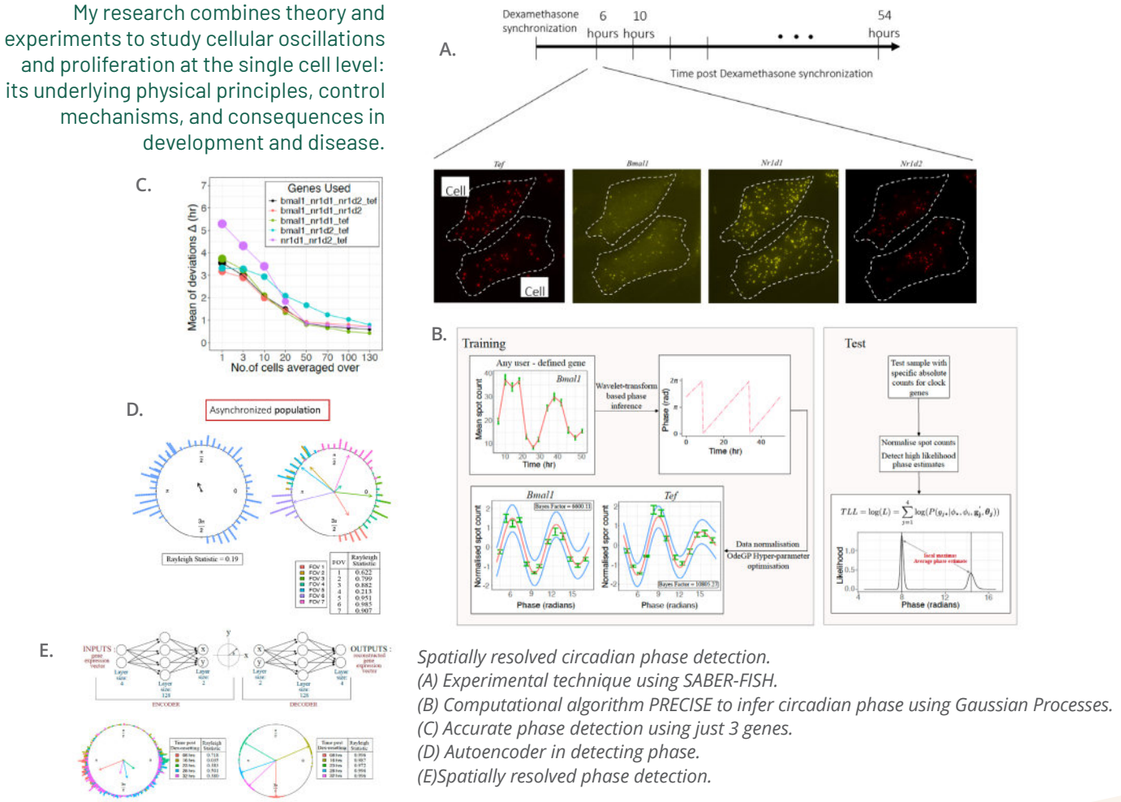
Shaon Chakrabarti
shaon@ncbs.res.in

Quantitative Cell Biology: Oscillations and Proliferation in Development and Disease

My research combines theory and experiments to study cellular oscillations and proliferation at the single cell level: its underlying physical principles, control mechanisms, and consequences in development and disease.

My lab continues to explore a variety of research directions with cell proliferation and oscillations forming the unifying element within somewhat disparate cell-biology questions.

We have successfully established single molecule FISH protocols to quantify circadian phase in a spatially resolved manner. We have imaged multiple circadian clock genes and demonstrated how circadian phase inference can be made from as low as 20 cells (see Figure below). We have established a simple theoretical framework for understanding how population growth laws emerge in cancer cells during treatment with anti-cancer therapies, from fluctuations (non-genetic heterogeneity) at the single cell level. These fluctuations induce a variety of lineage correlation patterns which we are using as probes to understand how the circadian clock drives cell proliferation, and also to infer the phase of the circadian clock in single cells.



Spatially resolved circadian phase detection.
(A) Experimental technique using SABER-FISH.
(B) Computational algorithm PRECISE to infer circadian phase using Gaussian Processes.
(C) Accurate phase detection using just 3 genes.
(D) Autoencoder in detecting phase.
(E)Spatially resolved phase detection.

PUBLICATIONS

- S. Sahay, S. Adhikari, S. Hormoz and S. Chakrabarti*, "An improved rhythmicity analysis method using Gaussian Processes detects cell-density dependent circadian oscillations in stem cells", Bioinformatics, 39 (10), 2023.
- A. Singh and S. Chakrabarti*, "Diffusion controls local versus dispersed inheritance of histones during replication and shapes epigenomic architecture", PLOS Computational Biology, 19 (12), 2023.

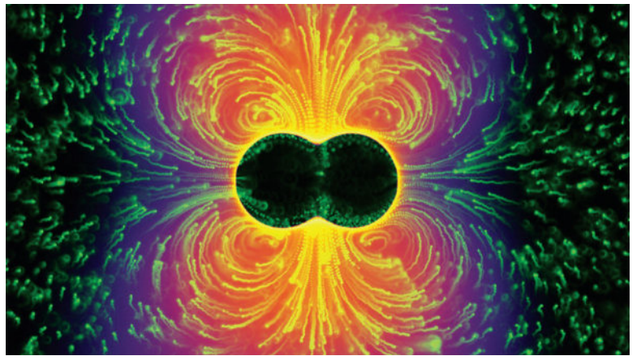
*corresponding author

Shashi Thutupalli
shashi@ncbs.res.in

Living Metamaterials: Towards a Synthetic Biology from a Physical Perspective

We are interested in the underlying principles of emergence and organization in living systems — towards this goal, we develop quantitative experiments combined with conceptual frameworks.

A key highlight from this year is our work on synthetic active systems, led by a postdoc, Manoj Kumar, in the group. A lot of research in synthetic active matter has concentrated on developing point-like, interacting entities. However, the inspiration for active systems, biology, is replete, not only with examples of point-like active units, but also higher order (hierarchical) assemblies of active units that form extended objects. These assemblies display remarkable emergent dynamics and self-organization, be it the mechanical consequences of active polymers such as actin and microtubules, the folding and function of coded polymers such as proteins or organismal shape arising from embryonic tissues. These biological instances may be viewed as self-morphing matter—assemblies of (chemically) active subunits—the dynamical traits of which are an intricate choreography between mechanics and other self-generated guiding fields, such as chemistry. The work led by Manoj focussed on designing freely jointed active assemblies from autonomously powered components; creating such assemblies in a hierarchical, functional manner has remained a challenge in the field. Using self-propelled droplets, our work created freely-jointed linear polymers and studied their emergent dynamics. The monomeric unit that we use is already a well established tunable model experimental system that we developed many years ago and has inspired much experimental and theoretical advance. The linking or "bonding" method that we use is generic and widely compatible for the creation of both multivalent and multi-flavoured assemblies. Altogether, we envision these as initial steps towards a kind of synthetic active matter capable of emergent self-morphic dynamics. This is an ongoing collaboration with the groups of Rajesh Singh at IIT Madras and Zorana Zeravcic at ESPCI, Paris.



Experimentally measured hydrodynamic flow fields (green streaks) and chemical fields (red to blue colour contours) for a dimer.

PUBLICATIONS

- Emergent dynamics due to chemo-hydrodynamic self-interactions in active polymers. M Kumar, A Murali, AG Subramaniam, R Singh, S Thutupalli. Nature Communications 15 (1), 4903, 2024.
- Constrained dynamics of DNA oligonucleotides in phase-separated droplets. A Singh, S Thutupalli, M Kumar, S Ameta. Biophysical Journal, 2024.

Shruthi Viswanath
shruthiv@ncbs.res.in

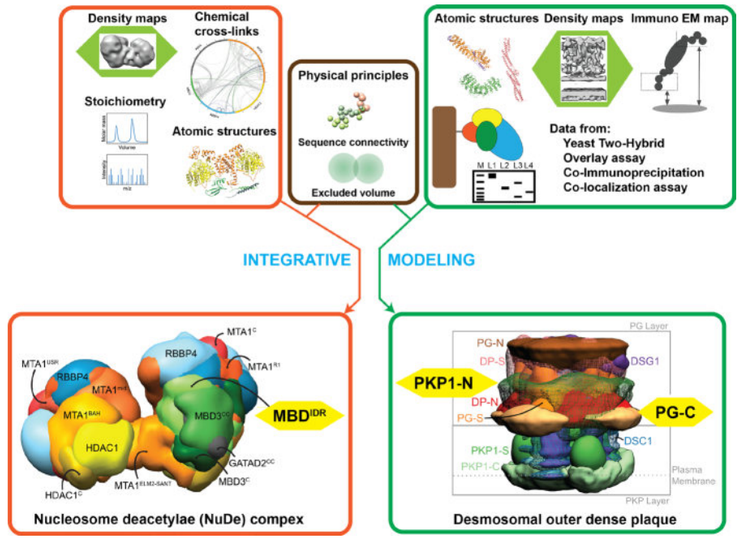
Integrative Structural Biology of Large Macromolecular Assemblies

Using an integrative approach, we develop and apply methods to determine protein organization in cells by characterizing their structures in binary complexes, macromolecular assemblies, and nanoscale architectures.

Large macromolecular assemblies, such as the ribosome or proteasome, contain tens to hundreds of proteins. The structures of these assemblies are key to understanding mechanistic details of biological processes. For example, how do these molecular machines work? How did they evolve? How are they assembled and regulated in the cell?

We use an integrative approach for structure determination, combining data from biophysical, biochemical, and cell biology experiments, with statistical inference, physical principles, and prior models. We are currently characterizing assemblies involved in chromatin remodeling, assemblies at cell-cell junctions, and mitochondrial assemblies, all in close collaborations with experimentalists.

We noticed two recurrent modeling challenges across a range of studies. One was the need to develop methods for incorporating disordered regions in these assemblies and another was to better utilize information from cryo-electron tomography, a timely challenge as structural biology is moving towards in situ characterization. We are currently focusing our method development in these two areas.



Frontiers in integrative structure determination.

Schematic describing integrative structure determination for the nucleosome remodeling and deacetylase complex (orange box) and the desmosomal outer dense plaque (green box) combining data from multiple sources. Low-resolution cryo-EM and cryo-ET maps (green) and intrinsically disordered regions (yellow) in both complexes are highlighted as emerging areas for method development.

PUBLICATIONS

- Majila, K., Arvindekar, S., Jindal, M., Viswanath, S. Frontiers in integrative structural biology: modeling disordered proteins and utilizing in situ data. Quarterly Reviews in Biophysics Discovery, in press, 2024.
- Liu, X. et. al, An Integrated Structural Model of the DNA Damage Responsive H3K4me3 Binding WDR76:SPIN1 Complex with the Nucleosome, PNAS, in press, 2024.
- Arvindekar, S., Pathak, A.S., Majila, K., Viswanath, S. Optimizing representations for integrative structural modeling using Bayesian model selection, Bioinformatics, 2024.
- Pasani, S., Menon, K.S., Viswanath, S., The molecular architecture of the desmosomal outer dense plaque by integrative structural modeling, Protein Science, 2024.

5

Neurobiology

Regulation of Electrical Synapse Formation
Abhishek Bhattacharya

Brain Homeostasis and Neuroinflammation
Hiyaa Ghosh

Physics, Neurobiology, and Ecophysiology of Insect Flight and Insect Architecture
Sanjay P Sane

Neural Mechanisms Underlying Breathing Rhythms
Sufyan Ashhad

Brain Computation and Memory: from Molecules to Behavior
Upinder Bhalla

Development, Modulation, and Function of Motor Systems
Vatsala Thirumalai

Abhishek Bhattacharya
abhishek@ncbs.res.in

Regulation of Electrical Synapse Formation

We are investigating the fundamental principles regulating formation and function of electrical synapses, a conserved, critical, yet much understudied feature of the nervous system.

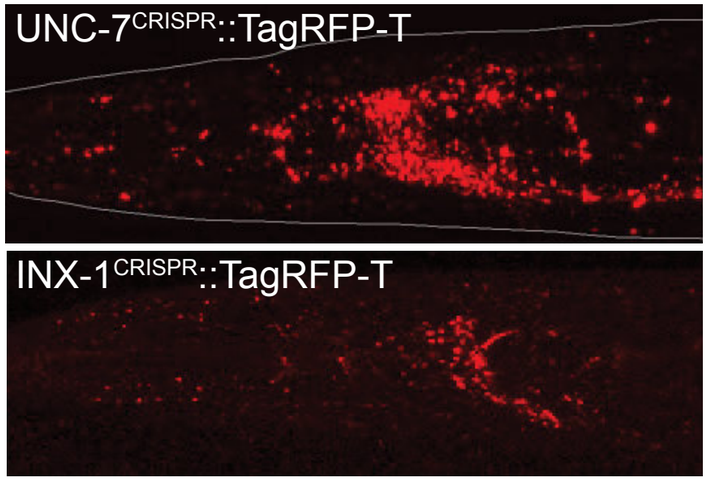
Understanding how an individual neuron finds a specific synaptic partner (synaptic specificity) and connects with different partners using synapses that bear distinct properties (functional diversity), have remained pivotal questions in neuroscience. While the complex biology of chemical synapses has been widely studied, electrical synapses remained much understudied, despite playing conserved and critical roles in the establishment and functioning of the neural circuit. The overall research goal of our lab is to understand the fundamental molecular principles regulating the diversity, assembly and functioning of the electrical synapse connectome, areas that are still very poorly understood. We are working to understand:

a) how individual neurons form molecularly and functionally distinct synapses with different synaptic partners,

b) electrical synapse accessory proteins that regulate trafficking of synaptic components and synapse formation,

c) how plastic changes in the electrical synapse network is achieved in response to intrinsic and extrinsic cues and

b) function of gap junctions on glial cells.



Endogenous tagging of two broadly expressed electrical synapse channel components in C. elegans using CRISPR/Cas9 revealed broad utilization of these proteins in electrical synapses present in the head of the worm.

PUBLICATIONS

- Reddy, V.[§], Bhattacharya, A.[§], and Baker, N. E.* The Id protein Extramacrochaetae restrains the E-protein Daughterless to regulate Notch, Rap1, and Sevenless within the R7 equivalence group of the Drosophila eye. Biology Open. 2024 Aug 15; 13(8): bio060124. PMID:39041866. (§: Equal contribution)

Hiyaa Ghosh
hiyaa@ncbs.res.in

Brain Homeostasis and Neuroinflammation

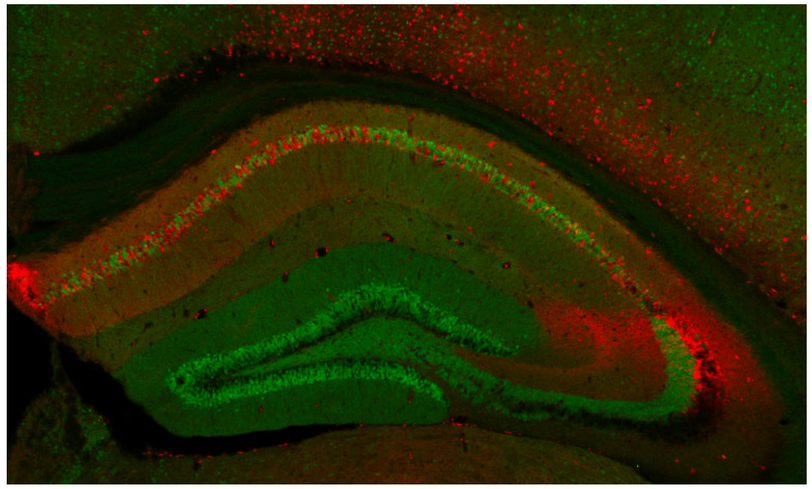
We seek to decipher inbuilt compensatory mechanisms in neuronal and glial cells that allow for brain plasticity and adaptability during healthy and pathological conditions.

Our goal is to uncover fundamental mechanisms of adaptability in the adult brain. For this, we study structural and functional programs that allow compensatory changes in neurons and glial cells. Our studies have revealed that adult brain cells, including neurons, retain the flexibility to change their structure and function. We have also established mouse models of physiological perturbations that cause cognitive deficit and rescue over time. Using these models, we examine how the retained structural and functional flexibility in neuron and glia potentially contribute to compensatory changes to enable cognitive rescue. We also study cellular heterogeneity in the context of adaptive advantage for plasticity and homeostasis in the adult brain. Using a suite of high-throughput and high-resolution tools, we investigate:

a) mechanisms of dendritic structural plasticity in neurons and its functional relevance in aging and neuro-pathologies,

b) microglia and astrocyte heterogeneity, and

c) the role of adult neurogenesis and neural stem cells in mechanisms of stress resilience.



Mouse brain hippocampus showing virally transduced Designer Receptors Exclusively Activated by Designer Drugs (DREADD) receptors on select projection neurons (red) in the CA1 region of hippocampus. CamK2a+ve CA1 neurons (green) can be seen interspersed with mCherry-DREADD (red) expressing CA1 projection neurons. This allows manipulation of the specific neuronal subsets in a localized manner by switching on or off neuronal activity in a reversal and acute manner.

PUBLICATIONS

- Cx3Cr1-Cre induction leads to microglial activation and IFN-1 signaling caused by DNA damage in early postnatal brain. Sahasrabuddhe V, Ghosh HS.Cell Rep. 2022 Jan 18;38(3):110252. doi: 10.1016/j.celrep.2021.110252.
- Adult brain neurons require continual expression of the schizophrenia-risk gene Tcf4 for structural and functional integrity. Sarkar D, Shariq M, Dwivedi D, Krishnan N, Naumann R, Bhalla US, Ghosh HS.Transl Psychiatry. 2021 Sep 25;11(1):494. doi: 10.1038/s41398-021-01618-x.

HONORS AND AWARDS

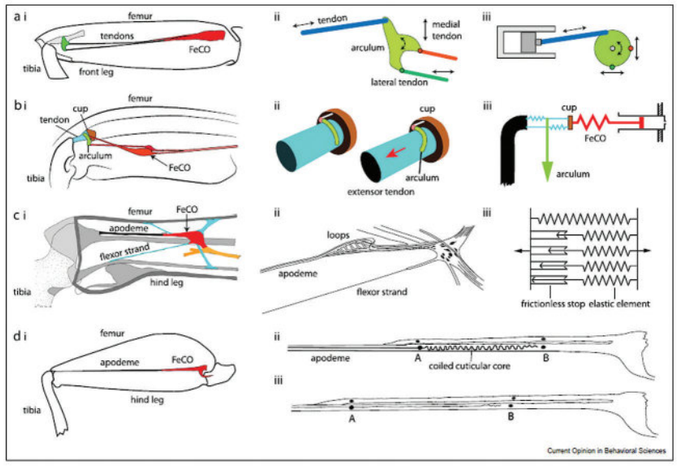
- Wellcome Trust-DBT Senior Fellowship, 2024.
- EMBO Global Investigator.

Sanjay P Sane
sane@ncbs.res.in

Physics, Neurobiology, and Ecophysiology of Insect Flight and Insect Architecture

We study the physics, neurobiology, and ecophysiology of insect flight and insect architecture, including flight-related behaviours such as aerial manoeuvers, territorial chases, short/long-distance navigation, and individual or collective nest-building.

The spectacular evolutionary success of insects owes largely to the evolution of flight. Across various scales of size and neural complexity, insects fly with exquisite speed, control, and maneuverability. Their wings flap several hundred times per second - each wingstroke finely controlled by a sensorimotor system that rapidly acquires and processes information. Sensory input from various organs is transmitted to the brain, which generates motor responses, resulting in coordinated movements of the head, legs, and wings. Understanding the mechanisms underlying even mundane observations about flying insects (e.g. flies chasing other flies, moths hovering on flowers, etc.) requires a multi-disciplinary study of the chain of events from sensory input to motor output and flight force generation. My laboratory integrates physics, engineering, biomechanics, neurobiology, muscle mechanics, and behaviour to address diverse flight-related phenomena. Using a similar approach, we also study complex nest-building behaviours in insects which involve intricate coordination of their movements at individual and collective levels. Our approach is broadly comparative, and encompasses diverse insect systems.



Comparative structure and biomechanics of the Femoral Chordotonal Organ (FeCO) in insects. FeCo is an important mechanosensory organ that monitors the femoro-tibial movements in diverse insects. This figure displays the structure and mechanics of FeCO in the fly Drosophila melanogaster (a i-iii), beetle Lethrus apterus (b i-iii), locust Schistocerca gregaria (c i-iii) and cricket Acheta domesticus (d i-iii). (reproduced from Virdi and Sane (2024))

PUBLICATIONS

- Sane, S. P.*, Manjunath, M., & Mukunda, C. L. (2023). Vestibular feedback for flight control in hawkmoths. *Trends in Neurosciences 46 (8), 614-616.*
- Virdi, S., & Sane, S. P. (2024). Form, function and mechanics of femoral chordotonal organs in insects. *Current Opinion in Behavioral Sciences, 60, 101459.*

HONORS AND AWARDS

- Ramanujan Fellowship.
- Fellow of the Indian Academy of Sciences, 2018 and the Indian National Academy of Sciences, 2024.
- Japanese Society for Promotion of Science Fellowship
- Editor of the Journal of Experimental Biology

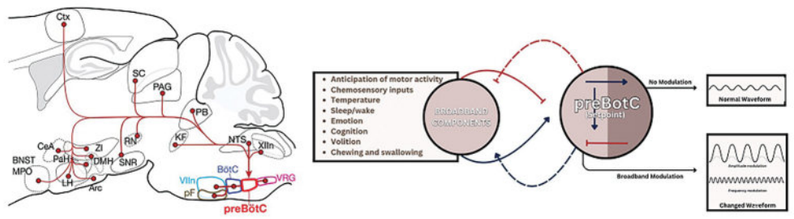
Sufyan Ashhad
sufyan@ncbs.res.in

Neural Mechanisms Underlying Breathing Rhythms and Breathing-Modulated Behaviors

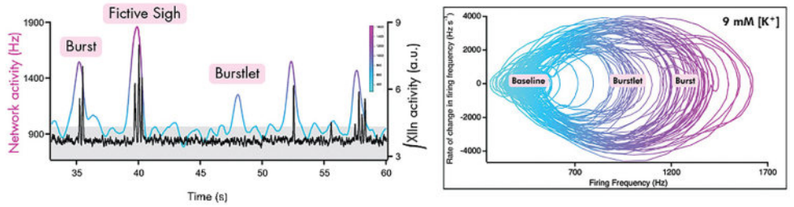
We investigate the neuronal mechanisms underlying breathing rhythm generation and its control, employing an integrative and interdisciplinary approach spanning computational and experimental neuroscience.

Breathing is a motor behavior that must persevere throughout one's life, and its pattern must be modulated to maintain homeostasis. Breathing rhythms are remarkably resilient yet highly adaptable, allowing instant modulation to meet physiological demands. Various behavioral states exhibit a phasic relationship with breathing. From "higher-order" brain functions such as cognition and memory to motor behaviors like locomotion and orofacial movements, many activities demonstrate phasic entrainment with breathing. This requires, among other things, that the ventilation control module be equipped with robust mechanisms to sense changes, deploy the appropriate motor responses, and sense changes due to this motor output.

We employ *in vitro* and *in vivo* electrophysiological recordings in rodents, computational modeling, and psychophysical experiments in humans to understand the mechanism of breathing rhythm generations, regulation, and breathing-modulated behaviors.



Diverse inputs to the breathing central pattern generator and modulation of its oscillatory dynamics.



Multi-stable dynamics in the preBötzinger Complex endows the system with the twin traits of robustness and flexibility.

HONORS AND AWARDS

- India Alliance DBT/Welcome Intermediate Fellowship, February 2024.

Upinder Bhalla
bhalla@ncbs.res.in

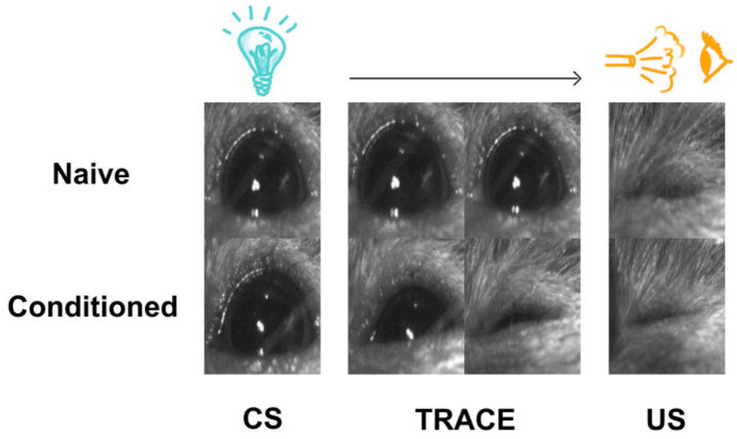
Brain Computation and Memory: from Molecules to Behavior

We study how pattern recognition and memory formation emerge from molecular, electrical and mechanical signaling in neurons. We use computer models and experiments including optical recordings, optogenetics, and electrophysiology.

In vivo, we use 2-photon imaging of hippocampal activity in mice to see how time is encoded during rhythmic stimuli and time-separated stimuli. We find that time is encoded through sequences of activity but is highly dependent on the task demands.

In vitro, we use optogenetics in mouse brain slice to deliver precise patterned stimuli to the hippocampal network while monitoring responses. We find remarkable heterogeneity in how synapses learn, even as cells maintain balance between excitatory and inhibitory inputs over complex pulse trains.

In silico, We build a range of models of synapses in health and disease using an array of tools we have developed to manage, access, and analyze the data. We are developing a synaptic signaling atlas using high-throughput mass-spectrometry data to measure the time-course of responses of thousands of proteins following stimulation. We use data and models to examine what processes underlie the overlapping cell and network dysfunction in aging, psychiatric disease, and neurodevelopmental disorders.



Mouse learns to associate an LED flash with future arrival of an air-puff to the eye. Upper row: Before training, the mouse doesn't blink its eye till the air-puff. Lower row: After learning, the mouse closes its eye shortly after the LED flash, so that it is shut before the air-puff arrives. We record from the mouse brain while it learns this association, to see how brain cells keep track of the time between events. (Credit: Hrishikesh Nambisan)

PUBLICATIONS

- Understanding molecular signaling cascades in neural disease using multi-resolution models. NA Viswan, US Bhalla. Current Opinion in Neurobiology 83, 102808, 2023.
- Discriminating neural ensemble patterns through dendritic computations in randomly connected feedforward networks. BP Somashekar, US Bhalla. eLife 2024.

HONORS AND AWARDS

- Team Science Grant, DBT-Wellcome Trust India Alliance, 2022.
- Kavli Foundation Open Source Software grant: Enhancing Interoperability, UI and Documentation of MOOSE. (With Subhasis Ray, CHINTA, Kolkata).

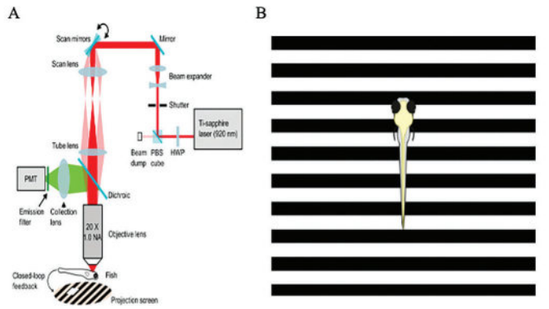
Vatsala Thirumalai
vatsala@ncbs.res.in

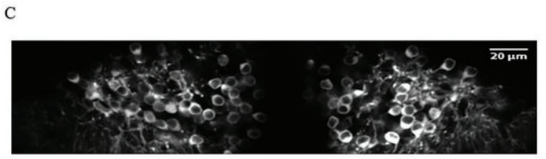
Development, Modulation, and Function of Motor Systems

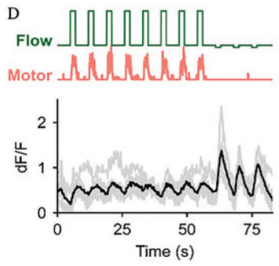
In vertebrates, locomotion is generated by multiple circuits in the brain and spinal cord acting in a coordinated fashion. We study how these circuits assemble and how they function at all stages of life.

My lab focuses on the function and development of brain circuits that control locomotion using the small freshwater fish zebrafish as our model system. Our work aims to understand how disparate circuits in the optic tectum, cerebellum, hindbrain, and spinal cord work together to generate appropriate locomotor behaviour. We also examine how locomotory circuits are assembled de novo, quite early in development when much of the nervous system is immature.

We use a range of techniques to probe how single neurons compute, how such computations are integrated circuit-wide and how behavior is generated. Some of the tools we use include genome editing, whole cell patch clamping, calcium imaging and high speed videography of larval swim kinematics. Lately, we have also forayed into building models of neurons to ask how their activity patterns are generated.







A: Custom built set-up to image neuronal activity and larval zebrafish behavior simultaneously, while providing visual stimulation.

B: Zebrafish larva being stimulated by the tail to head movement of gratings to trigger swims(optomotor response).

C: In vivo image of Purkinje neurons in larval zebrafish expressing the genetically encoded calcium indicator, GCaMP6s.

D: Simultaneous acquisition of visual stimulus ('Flow', top), larval swims ('Motor', middle) and Purkinje neuron activity ('dF/F', bottom).

PUBLICATIONS

- Aalok Varma, Sathvik Udupa, Mohini Sengupta, Prasanta Kumar Ghosh, Vatsala Thirumalai, A machine-learning tool to identify bistable states from calcium imaging data. J Physiol. 2024 Apr;602(7):1243-1271. doi: 10.1113/JP284373.
- Narayanan S, Varma A, Thirumalai V. Predictive neural computations in the cerebellum contribute to motor planning and faster behavioral responses in larval zebrafish. Sci Adv. 2024 Jan 5;10(1):eadi6470. doi: 10.1126/sciadv.adi6470. Epub 2024 Jan 3.

HONORS AND AWARDS

- Distinguished Alumni Award -2023, AC College of Technology, Anna University, Chennai.
- Co-organizer, Zebrafish Neurobiology Meeting 2023, CSHL, NY, USA.
- Discussion Leader, GRC Neuroethology Meeting 2023, Mount Snow, Vermont, USA.

6
Ecology and Evolution

The Remarkable Lives of Honey Bees
Axel Brockmann

Genetic and Ecological Factors Underlying Adaptive Evolution
Deepa Agashe

Speciation, Adaptation, and Morphological Diversification in the Tropics
Krushnamegh Kunte

Terrestrial Ecosystems and Community Ecology
Mahesh Sankaran

Understanding Human Impacts on Biodiversity and Facilitating Future Survival through a Genetic Lens
Uma Ramakrishnan

Axel Brockmann
axel@ncbs.res.in
(Retired, 2023)

The Remarkable Lives of Honey Bees

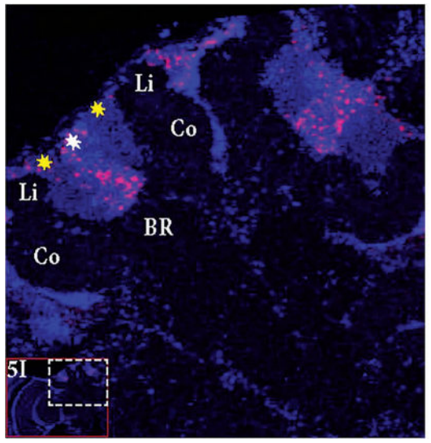
Our research focuses on two major themes: (a) the behaviour and ecology of Asian honey bees, and (b) cellular and molecular processes involved in time-memory in honey bees.

In the last two years we started three projects that have the potential to have a strong impact on honey bee research in the future.

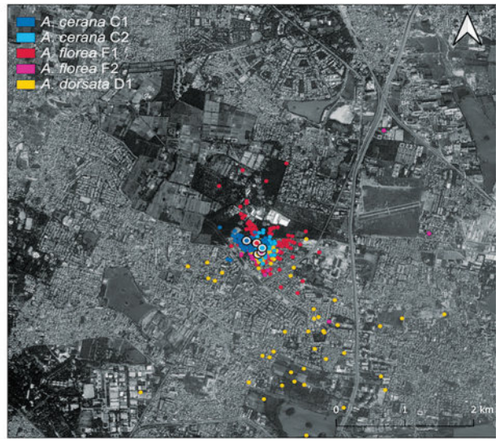
1. We surveyed the number of nesting sites of *Apis dorsata* colonies in Bangalore and recorded seasonal dynamics of colony occupancy. This is the first quantitative study on the distribution of *Apis dorsata* colonies worldwide.

2. We started to explore differences in the distance communication of *Apis cerana* populations in common garden experiments. Our current results are very promising, and we plan to use population differences as a starting point to identify genetic variation involved in the behavioural differences.

3. We continued our research on time memory using laser capture microdissection together with RNAseq transcriptomics and in situ hybridisation to identify cellular and molecular connections between the circadian clock and the major memory systems in the honey bee brain. Our study will open research on the molecular and cellular basis of time memory in insects.



Time-trained honey bee foragers show Egr-1 expression in mushroom body neurons in anticipation of leaving the colony for foraging.



Foraging map of A. florea, A. cerana, and A. dorsata colonies in the urban landscape of Bengaluru.

PUBLICATIONS

- Young A.M., Kodabalagi S., Brockmann A., and Dyer F.C. (2021) A hard day's night: Patterns in the diurnal and nocturnal foraging behavior of Apis dorsata across lunar cycles and seasons. PLoS ONE. 16(10): e0258604. https://doi.org/10.1371/journal.pone.0258604.
- Chatterjee A., Bais D., Brockmann A., and Ramesh D. (2021) Search behavior of individual foragers involves neurotransmitter systems characteristic for social scouting. Frontiers in Insect Science 1:664978. doi: 10.3389/finsc.2021.664978.

HONORS AND AWARDS

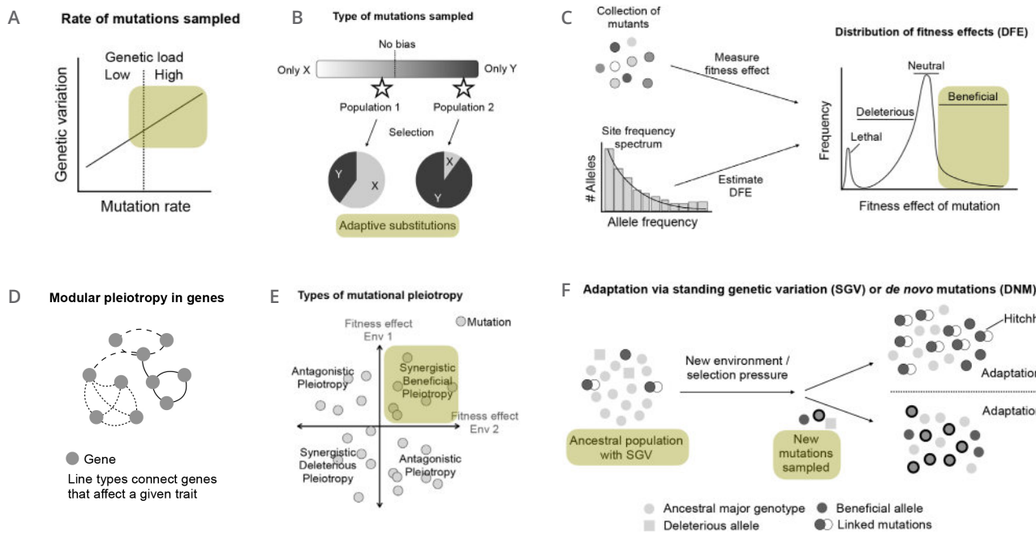
- Associate Editor, Frontiers in Insect Sciences - Section Insect Neurobiology.

Deepa Agashe
dagashe@ncbs.res.in

Genetic and Ecological Factors Underlying Adaptive Evolution

We aim to understand evolutionary processes, focusing on the genetic and ecological drivers and consequences of adaptation to new niches.

The role of genetic variation during adaptation is a major focus in evolutionary biology. However, the foundations of the field were laid before we understood the organization of the genetic code, the provenance of genetic variation, and how such variation influenced the phenotypes on which natural selection acts. The 2022 Vice Presidential symposium of the American Society of Naturalists highlighted examples of recent insights into the role of genetic variation in adaptive processes. Our introductory article for the resulting special issue reviewed some recent insights into the generation and maintenance of genetic variation, its impacts on phenotype and fitness, its fate in natural populations, and its role in driving adaptation. The nature and rate of introduction of new genetic variation via mutations remains poorly explored in natural populations, especially for multicellular eukaryotes. In contrast, analyses of the role and fate of genetic variation in wild populations are largely focused on plants, animals and pathogenic microbes. These are important avenues for further research.



Key concepts and terms for understanding the adaptive impacts of genetic variation. Shaded boxes indicate mutations that are expected to be most relevant for adaptation.

PUBLICATIONS

- Agashe D, Sane M and Singhal S (2023). Revisiting the role of genetic variation in adaptation. American Naturalist 202(4):486–502.
- Sanjenbam P and Agashe D (2024). Divergence and convergence in epiphytic and endophytic phyllosphere bacterial communities of rice landraces. mSphere 9:e00765-24.

HONORS AND AWARDS

- Faculty Excellence Award from the Society for Molecular Biology and Evolution, 2024.
- DBT/Wellcome Trust India Alliance Senior Fellowship, 2024.

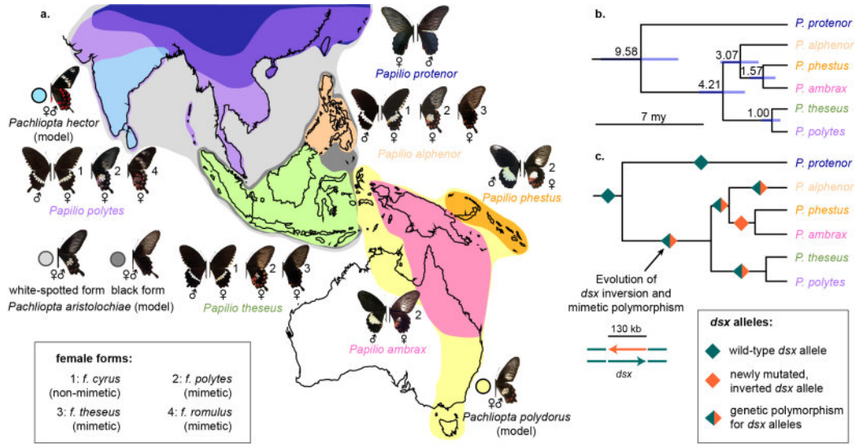
Krushnamegh Kunte
krushnamegh@ncbs.res.in

Speciation, Adaptation, and Morphological Diversification in the Tropics

Diversity is the cornerstone of life on earth. We are evolutionary biologists who study the origins and mechanisms that underlie the proliferation of biodiversity in tropical regions such as India.

I have a broad interest in evolutionary biology, ecology and genetics, encompassing the fields of natural selection theory, evolutionary genetics, population and community ecology, and conservation biology. Specifically, we study ecological, sexual and population genetic underpinnings of why populations and traits diverge, and why they often result in new species or sexually dimorphic and polymorphic adaptations. This provides a larger perspective on the evolution of biodiversity.

Our main study system is Batesian mimicry, which is a phenomenon in which unprotected prey species (called 'mimics') gain protection from predators by mimicking toxic or otherwise protected species (called 'models'). Predators learn to avoid models based on prior experience, and subsequently avoid eating mimics due to misidentification. Hundreds of mimetic insects (especially butterflies) are known from tropical forests. There is tremendous variation in Batesian mimicry: mimicry can be sexually monomorphic, polymorphic, or sex-limited within and across species. Our research aims to understand selective pressures that favour such variations in mimetic colour patterns, and uncover its genetic basis.



Speciation, wing pattern evolution and mimetic polymorphism in the Papilio polytes species group. a. Species distributional ranges and wing colour pattern polymorphism in the female forms of the polytes species group, along with their Batesian models. Although the minute details of mimetic wing colour patterns and the presence/absence of tails vary across species and populations, the form names apply to multiple species. b. A secondary fossil-calibrated, dated phylogeny of the polytes species group, showing mean with 95% Highest Posterior Density of each split in million years. c. Evolution of mimetic polymorphism and doublesex inversion in relation to speciation events. Diamonds on branches show fixation or polymorphism of female wing patterns and the evolution of accompanying dsx inversion. [reproduced from Figure 1 in Deshmukh et al. 2024. DOI: https://doi.org/10.7554/eLife.101346.1]

PUBLICATIONS

- Deshmukh, R., S. Baral, A. G. Kizhakke, M. Kuwalekar, K. Kunte. 2024. Evolution of novel mimicry polymorphisms through Haldane's sieve and rare recombination. eLife, 13:RP101346.
- Condamine, F. L., R. Allio, E. L. Rebouda, J. R. Dupuis, E. F. A. Toussaint, N. Mazet, S.-J. Hue, D. S. Lewis, K. Kunte, A. M. Cotton, F. A. H. Sperling. 2023. A comprehensive phylogeny and revised taxonomy illuminate the origin and diversification of the global radiation of Papilio (Lepidoptera: Papilionidae). Molecular Phylogenetics and Evolution, 183:107758.

Mahesh Sankaran
mahesh@ncbs.res.in

Terrestrial Ecosystems and Community Ecology

Can our ecosystems cope with the challenges of ever-expanding human activities? We work on understanding the dynamics of mixed tree-grass ecosystems, their responses to changes in climate—particularly drought—and what this means for their future distribution and functioning.

Current research in the lab is grouped around the following broad themes that examine:

(a) how interactions and feedbacks between climate, bio-geochemistry, fires, and herbivory influence the structure, composition, and stability of ecosystems and the cycling and sequestration of nutrients.

(b) how projected changes in climate, such as increasing variability of rainfall, frequency of droughts, aridity in the tropics, nitrogen and phosphorus deposition, and rising CO_2 levels will impact ecosystem function, stability, and services.

Most of our research is carried out across a range of systems, from savannas and grasslands to tropical forests, in India and Africa. Our current and planned future work will employ both long and short-term experiments, as well as targeted field surveys to address the above questions across the gamut of natural ecosystem types of the Indian subcontinent, with the goal of bringing a comprehensive understanding of biome-scale vegetation and nutrient dynamics in the Indian subcontinent.

One of our montane grassland study sites
Photo: Aaroha Malagi

PUBLICATIONS

- Joshi, A. A., Ratnam, J., Paramjyothi, H., & Sankaran, M. (2024). Climate and vegetation collectively drive soil respiration in montane forest-grassland landscapes of the southern Western Ghats, India. Journal of Tropical Ecology, 40, e16.
- Pratzer, M., et al (including M. Sankaran)(2024). An actor-centered, scalable land system typology for addressing biodiversity loss in the world's tropical dry woodlands. Global Environmental Change, 86, 102849.

Uma Ramakrishnan
uramakri@ncbs.res.in

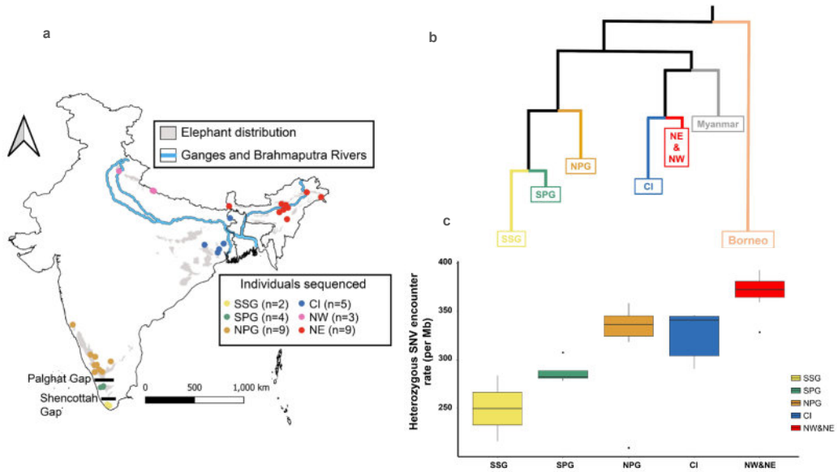
Understanding Human Impacts on Biodiversity and Facilitating Future Survival through a Genetic Lens

India has over a billion people, yet harbours incredible biodiversity. How are we impacting this diversity, and can we facilitate its survival? My research attempts to address this question.

Indian biodiversity: tracking its history, conserving its future. In my group, we use genetic information to better understand wild populations. We aim to use these insights to suggest strategies for the conservation of threatened species, or to minimize zoonotic spillover in the Indian subcontinent.

How isolated are populations of endangered species today? What determines connectivity? Are individuals in isolated populations inbred? How has human-induced fragmentation impacted the probability of zoonoses? We use field-collected samples (invasive at times, but mostly non-invasive), generate genomic (or genome-wide) data, and use computational tools to analyze this data to answer these questions.

This last year, we worked detailed landscape scale connectivity in two ungulates in the central Indian landscape. Further, our analyses of elephant genomes revealed a north-south divergence, gradient of diversity and serial colonization in India. Elephant populations show deep divergences in India, as old at 70,000 years. We also identify five management units of Asian elephants in India, given their history. These five populations retain distinct genetic load, with southernmost populations characterized by low diversity and high genetic load.



(a) elephants and their genomes sampled across India;
(b) the most likely model of population divergence and
(c) pattern of genetic diversity from north to south: higher heterozygosity in the north versus the southern populations.

PUBLICATIONS

- Khan A, Sil M, Thekaekara, T, Sinha, I, Khurana, R, Sukumar, R and Ramakrishnan, U (2024) Divergence and serial colonization shape genetic variation and define conservation units in Asian elephants. Current Biology, 34 (20), 4692-4703. e5.
- Tyagi, A, Yadav, N, Pandit, A and Ramakrishnan, U (2024) On the road to losing connectivity: Fecal samples provide genome-wide insights into anthropogenic impacts on two large herbivore species in central India. Molecular Ecology, https://doi.org/10.1111/mec.17461.

HONORS AND AWARDS

- Obaid Siddiqui award, Sastra University.
- Elected International Honorary Fellow, AAA&S.

Understanding the Principles of Cognitive-Motor Flexibility across Organismal Lifespan
Abhilasha Joshi

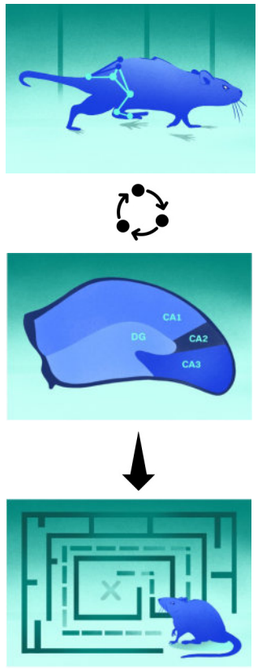
The Community and Functional Ecology (CaFE) Lab: from Individuals to Ecosystems
Meghna Krishnadas

Abhilasha Joshi
abhilasha@ncbs.res.in

Understanding the Principles of Cognitive-Motor Flexibility Across Organismal Lifespan

We aim to understand how internal cognitive computations dynamically engage with ongoing actions during complex behaviors and how these interactions alter with age. We use an interdisciplinary approach to address this challenge, combining insights from neuroscience, behavior, biomechanics, and computational methods.

As animals move in complex environments, higher-order cognitive computations in the hippocampus—a brain region critical for navigation—reflect an internal map of the external world. This map is represented by the population firing rhythmically at ~8Hz and corresponds to sequential spatial representations at, behind, or ahead of the actual location of the animal. At the same time, other multidimensional behavior-relevant variables are computed and represented elsewhere in the brain. To navigate efficiently, the nervous system must appropriately connect these representations, and a malfunction of this coordination is a hallmark of aging-associated cognitive impairments. Our prior work (Joshi et al., 2023) found that the forelimb stepping cycle in freely behaving rats is rhythmic and peaks at around 8Hz during movement, matching the approximately 8Hz modulation of hippocampal activity and spatial representations during locomotion. Our group will investigate the extent of the synchronization between locomotor steps and hippocampal spatial representations to study their impact on cognition across organismal lifespan.



Schematic representing the focus areas of the lab to investigate the interactions between locomotor stepping and hippocampal dynamics and study their impact on cognitive function.

PUBLICATIONS

- Joshi, A., Denovellis, E., Mankili, A., Meneksedag, Y., Davidson, T., Gillespie, A. K., Guidera, J. A., Roumis, D. and Frank, L. M. (2023). Dynamic Synchronization between Hippocampal Representations and Stepping. PMID: 37046088, Corresponding author.
- Ding, S.*, Fox J.*, Gordus, A.*, Joshi, A.*, Liao J.* and Scholz, M.* (2024). Fantastic beasts and how to study them: rethinking experimental animal behavior. PMID: 38372042 *equal contribution.

HONORS AND AWARDS

- 2023 The Peter and Patricia Gruber International Research Award, Society for Neuroscience.
- 2022-2027 Simons Collaboration on Plasticity and Aging Brain Transition to Independence Award.

Meghna Krishnadas
meghnak@ncbs.res.in

The Community and Functional Ecology (CaFE) Lab: from Individuals to Ecosystems

We seek to understand the processes that allow species to coexist and thus maintain diversity in ecological communities.

We are driven by a curiosity to understand biodiversity. Why are some species common but most species rare? What makes rare species persist? Further, in a world overwhelmingly shaped by humans today, we want to know how human influence impacts the mechanisms that maintain diversity. To this end, we combine ecological theory, experiments and observational field research with advanced statistical models. In particular, we use functional traits—heritable characteristics that mediate species' response to different conditions—to understand patterns and processes that shape biodiversity in different ecosystems. We use plant communities as model systems, but the concepts apply across ecological communities. Ultimately, our lab is driven by theory and curiosity.

Our work broadly focuses on the following cross-cutting themes:

1. The role of biotic interactions in shaping and maintaining diversity across multiple scales.
2. How intra- and interspecific trait variation mediate species distributions and performance.
3. How climate and disturbance shape assembly of communities and biomes.

Field team at work censusing seedlings. This work on long-term regeneration dynamics of tree communities in a humid tropical forest is in the Western Ghats. From right to left: Ebeneesh, Rashmi, and Athulya. These champs keep our field station and fieldwork going.

PUBLICATIONS

- Ahmad M, Rathee S, Krishnadas M*. 2024. From low to high elevations, flowers adapt traits and phenology to climate, but phenology-trait relationships weak. Functional Ecology (in press).
- Jhaveri R, Cannanbilla L, Bhat KSA, Sankaran M, Krishnadas M*. Anatomical traits explain drought response of seedlings from wet tropical forests. Ecology and Evolution 14 (9), e70155. 2024.

HONORS AND AWARDS

- Elected to serve as councilor (and co-chair of Grants Committee) in the Association for Tropical Biology and Conservation.

Distinguished Emeritus Faculty

Intracellular Ca^{2+} Signaling and the Regulation of Neuronal Function
Gaiti Hasan

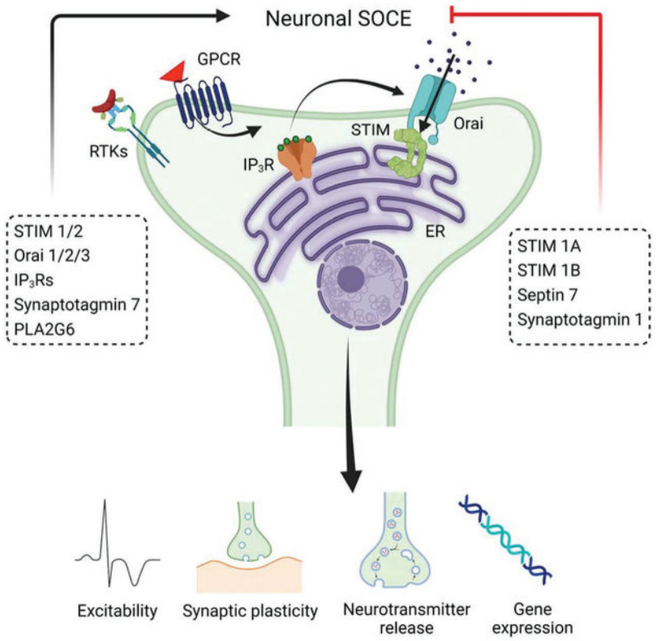
Development of Neural Circuits, Muscles, and the Emergence of Behaviour
K VijayRaghavan

Gaiti Hasan
gaiti@ncbs.res.in

Intracellular Ca^{2+} Signaling and the Regulation of Neuronal Function

We study how signalling through neuromodulator stimulated ER-Ca^{2+} release and Ca^{2+} entry through STIM and Orai impacts neuronal health in *Drosophila*, a human neuronal cell line and human stem cell derived neurons.

My group studies how intracellular Ca^{2+} signaling, through the IP_3R and the store-operated Ca^{2+} channel (STIM/Orai) impacts neuronal function. Ca^{2+} release through the intracellular ER-membrane localised IP_3R activates STIM and leads to extracellular Ca^{2+} entry through Orai referred to as SOCE. Work from our group in human neuronal cells demonstrates a new role for the IP_3R in regulating SOCE. Ligand-bound IP_3Rs enhance association of STIM1 and Orai1 in neuronal cells even in the absence of Ca^{2+} release from the ER. Convergent regulation of SOCE by IP_3Rs may tune neuronal SOCE to respond selectively to membrane receptors that generate IP_3 (1). Our current interest is to understand how Ca^{2+} signaling through IP_3Rs and SOCE impacts neuronal health in the context of Parkinson's Disease and Spinocerebellar Ataxias. We are studying this in *Drosophila* dopaminergic neurons and human patient derived iPSCs.



Store-operated Ca^{2+} entry in neuronal cells is regulated by both positive (left) and negative regulators (right).

PUBLICATIONS

- Chakraborty, P and Hasan, G (2024). ER-Ca^{2+} stores and the regulation of Store-operated Ca2+ entry in neurons. J. Physiol 602, 1463-1474. DOI: 10.1113/JP283827.
- Hasan, G (2024). Septin regulation of Orai-mediated Ca^{2+} entry - a novel target for neurodegeneration. Cell Calcium, 123, 102929.

HONORS AND AWARDS

- Invited to deliver the Michael Berridge Keynote Lecture at the European Calcium Society meeting held at Cambridge, UK, September 2024.

K VijayRaghavan
vijay@ncbs.res.in

Development of Neural Circuits, Muscles, and the Emergence of Behaviour

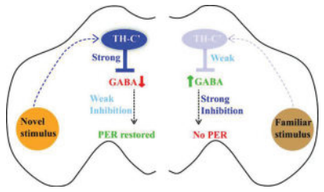
Our laboratory studies how the birth, morphogenesis, and connectivity of neurons and muscles translate into behaviour. We approach this complex problem by focussing on the olfactory, gustatory and motor system of *drosophila melanogaster*.

We endeavour to understand the principles of development culminating in behaviour. Muscles, the nervous system and their interplay at cellular, molecular and organismal scales remain our focus.

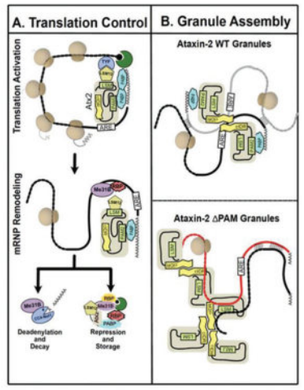
Animals can become habituated to persistent stimuli and stop responding, which can be overridden by other stimuli. Recent work, in collaboration with Mani Ramaswami's group at Trinity College, Dublin, shows that the override is regulated by subsets of dopaminergic neurons (Fig. 1). Other work with the Ramaswami laboratory also provided insights into the role of Ataxin-2, a protein important in the function of neuronal synapses and regulating mRNA stability and translation. One domain of Ataxin-2 mediates cellular toxicity, while another is protective (Fig. 2).

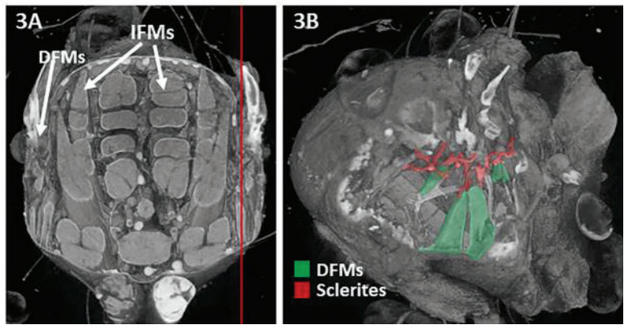
We have initiated studies to decipher how the flight steering mechanism of Drosophila is put in place. The neural control of variously oriented muscles attached to the wing hinge and their regulation of wing kinematics offers an unmatched system for understanding how the capacity for complex movement is put in place during development (Fig. 3).

1



2





3A: Transverse section through the thorax showing the locations of the IFMs and DFMs. The red line represents the plane which is shown in the lateral view of the thorax in 3B: Lateral view of the thorax showing the plane that is represented by the red line in 3A. Some of the DFMs (green), and sclerites (red) are shown. The sclerites are exoskeletal epidermal structures which connect the DFMs to the hinge region through attachment sites.

PUBLICATIONS

- Petrauskas A, Fortunati DL, Kandi AR, Pothapragada SS, Agrawal K, Singh A, Huelsmeier J, Hillebrand J, Brown G, Chaturvedi D, Lee J, Lim C, Auburger G, VijayRaghavan K, Ramaswami M, Bakthavachalu B. Structured and disordered regions of Ataxin-2 contribute differently to the specificity and efficiency of mRNP granule formation. PLoS Genet. 2024 May 20;20(5):e1011251.
- Trisal S, VijayRaghavan K, Ramaswami M. Habituation of Sugar-Induced Proboscis Extension Reflex and Yeast-Induced Habituation Override in Drosophila melanogaster. Bio Protoc. 2023 Dec 5;13(23):e4891.

Administration, Academics and Facilities

Administration, Procurement and Finance

RDO

Research Support Facilities

Research Facilities

Library

Administration, Procurement and Finance

G. Ravi Shankar

NCBS-TIFR was established as a Centre of TIFR in 1991. In the three decades since its establishment, NCBS-TIFR has grown into an exceptional Centre of Excellence in the disciplines of biological sciences. The **role of administration** in a research institution such as NCBS is **helping the faculty to carry out research and representation of the institute's interests** in the ever-growing complexity, changing economic conditions and needs of society.

Administration

The administration at NCBS is involved in coordinating the dissemination and implementation of policies, processes, guidelines and facilitating inter and intra-department coordination within NCBS. The Administration at NCBS is comprised of three divisions (Establishment, Procurement, and Finance), which include distinct operations with 22 permanent employees involved in various assessment activities that each unit has undertaken. The strength of the NCBS-TIFR administration division continues to be hard work, punctual performance and delivering a wide range of services throughout the campus.

Over the past year, the Administration Division has demonstrated strong teamwork, an outstanding service approach, resourcefulness in enhancing services, and a positive attitude in interactions with students, faculty, and staff. The details of personnel at NCBS as on March 2024 are as follows:

Particulars	Sanctioned Positions	Filled in Positions	No. of Vacancies	Deputation	Pachmarhi Field Station
Academics	42	35	07	1	0
Scientific	28	21	07	0	1
Technical	21	19	02		0
Administrative	32	22	10	0	1
Auxiliary	05	02	03	0	6
Total	**128**	**99**	**29**	**0**	**8***

**These are positions sanctioned for TIFR and loaned to NCBS. Their salaries are being paid by NCBS.*

Procurement

A remarkable model of cooperative effort in the procurement support system. NCBS procurement responsibilities include procurement of Lab consumables, Equipment, Furniture, Highend sophisticated laboratory equipment, managing Service and Labour Contracts (Canteen, Security, Lab Kitchen, Animal House, maintenance of buildings etc.), AMC, Import/Export, Live shipments, disposal and finalizing agreements. The responsibility of mentoring the procurement and contract procedural system for the Institute for Stem Cell Science & Regenerative Medicine (inStem) and Centre for Cellular and Molecular Platform (C-CAMP) as part of Bangalore Life Science Cluster (BLiSC).

NCBS procurement division handles 40% to 50% of NCBS's total annual expenditure, with a small team. The growth in infrastructure and facilities on our campus has posed the purchase division new challenges with the increased complexity of handling multiple tasks, by individuals and the Unit Head. The strategic way forward taken by the division was to sustain the growth path with the appropriate alignment of all resources, most importantly the human resources.

The procurement division deals with not only routine procurements but also specialized procurements of expensive capital equipment for biological and other scientific research, and the finalization of contracts and agreements. In the discharge of these multifarious and complex functions, displays excellent knowledge of the rules & procedures, a great deal of initiative in dealing with the unexpected and an abiding commitment towards providing effective services, to our researchers to achieve scientific excellence.

Finance

Expenditure (Amount in Millions)

S.No.	Particulars	2021-22	2022-23	2023-24
1	Research & Development	328.10	393.86	301.97
2	Extra Mural Grants	445.93	447.88	549.64
3	Salaries & Fellowships	292.92	352.91	385.37
4	Operational Expenditure	253.84	305.01	317.54
5	Construction	0.01	6.53	6.07
	Total	**1320.80**	**1506.19**	**1560.59**

During the year, 14 new grants were added to the ever-growing list of extramural support. The Department of Biotechnology, Science and Engineering Research Board, Department of Science and Technology, Wellcome Trust-DBT India Alliance, Wipro Foundation, Simons Foundation, The Human Frontier Science Program, University of Edinburgh, Bill & Melinda Gates Foundation, and HUDCO, were the major contributors in the extramural category. CCMB-Hyderabad for supporting SARS-COV-2 CORONAVIRUS GENOMIC SURVEILLANCE. Also, our special thanks to M/s TNQ Technologies Pvt. Ltd., Rohini Nilekani Philanthropies Foundation for their major support.

NCBS extends its sincere gratitude and appreciation to all supporters—financial, moral, and intellectual-for their ongoing generosity, trust, and confidence in the institution. Their continued support plays a crucial role in advancing NCBS's mission and objectives.

Research Development Office

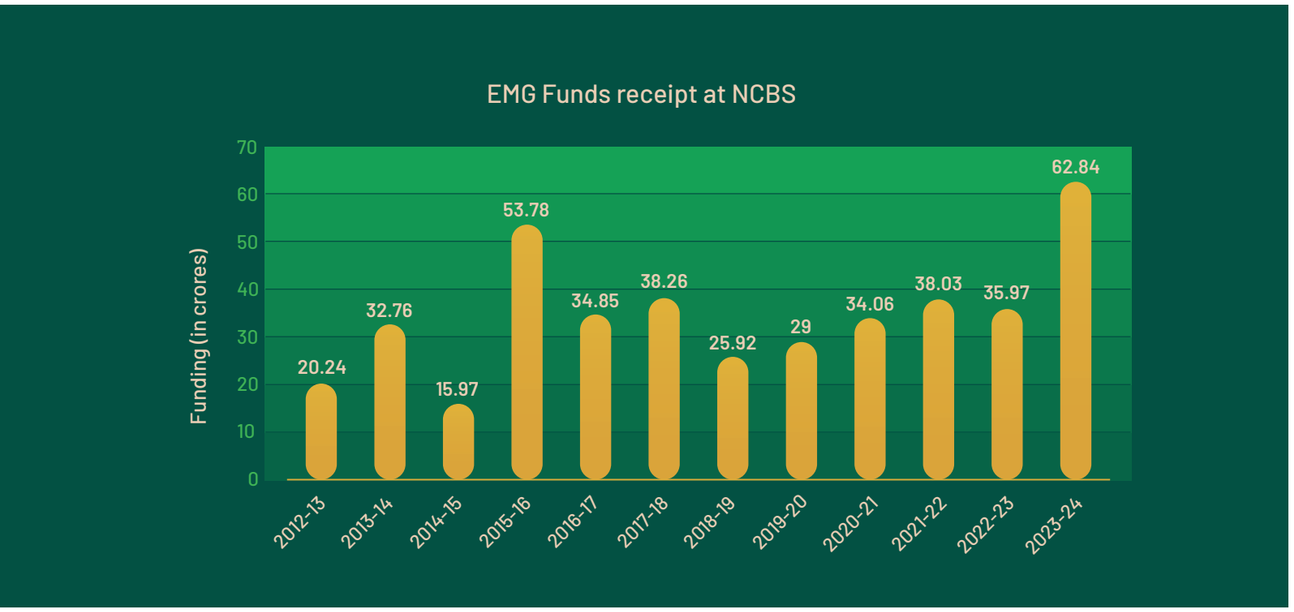
Malini SP

The Research Development Office (RDO) fa**cilitates research and training** on campus via research funding and collaborations. The RDO offers several key services at the boundaries of science, management, resource development and outreach.

A few key highlights of research funding at NCBS include the receipt of the prestigious Intermediate Research Fellowship and Senior Fellowships from DBT/ Wellcome Trust India Alliance, awarded to NCBS faculty members- Dr. Sufyan Ashhad, Dr. Deepa Agashe, and Dr. Dimple Notani, respectively. A significant funding highlight in this period was the award of a grant by Bill and Melinda Gates Foundation to Prof. Shashidhara at NCBS-TIFR for undertaking a multi-institutional consortium project to create a low-cost, sentinel-based environmental surveillance model for priority pathogens. Another recent highlight is the funding secured from the Global Environment Facility, World Bank, to implement the Fonseca Leadership Program (FLP) at NCBS-TIFR to support capacity building in conservation through the training of future leaders from developing countries and countries with economies. This project, led by Dr. Jayashree Ratnam, Director of the Wildlife Biology and Conservation Program at NCBS-TIFR, aims to train international students from Central, South, and Southeast Asia in the field of wildlife and ecosystem conservation science, adhering to international standards. Faculty at NCBS-TIFR have also been successful in securing research funding from other International agencies including Kavli Foundation, USA.

Private and philanthropic funding supports specific initiatives at NCBS. Under its corporate social responsibility (CSR) initiative, Housing and Urban Development Corporation Ltd (HUDCO) extended its support for setting up a biobank/bio-repository as part of large-scale translational health research using genomics and advanced cell biology. Additionally, Hindustan Unilever Limited (HUL) has sponsored NCBS-TIFR to establish fellowships in STEM for women researchers at NCBS-TIFR for pursuing research in the areas aligned with the four Sustainable Development Goals (SDGs) — Health & Hygiene; Clean Water & Sanitation; Nutrition & Fortification and Climate Action & Sustainability. Two PhD graduate students at NCBS - Aparna Krishnan (Professor Mahesh Sankaran's Lab) and Disha Kshirsagar (Dr. Sabarinathan Radhakrishnan Lab), have been selected this year for this prestigious fellowship.

The RDO continues to support the establishment of national and international collaborations. Recent highlights include the MoU signed between NCBS-TIFR and Max Planck Gesellschaft (MPG) to facilitate and promote increased scientific collaboration, cooperation and interaction between the institutions in the fields of natural sciences. During this period, NCBS has also signed MoUs with ICAR institutions including National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), National Institute on Foot and Mouth Disease (NIFMD) and National Institute of High Security Animal Diseases (NIHSAD) to collaborate to develop robust and cost-effective molecular surveillance (both environmental and clinical) for animal pathogens.



Research Support Facilities

PC Gautam

Running a dynamic institute like NCBS requires **a seamless integration of diverse range of support services** that ensure the campus operates efficiently and effectively. From maintaining critical infrastructure and fostering innovation to ensuring the functionality of every corner of the campus, these services form the backbone of the institution.

Architect The Architect's role on campus extends beyond building design. It includes site feasibility studies, detailed architectural and interior drawings, and integrated service plans. The team also supports campus activities like event setups, furnishings, tree-planting ceremonies, and more. Additionally, they contribute to designing and upgrading TIFR buildings, ensuring functionality and aesthetics.

Civil The Civil Department plays a vital role in campus infrastructure development and provides excellent support to all teams and end users even during emergencies. Special focus is given to maintaining water supply and sewerage networks, including raw and grey water treatment. While the team is optimal in size and handles general maintenance, most modifications are executed through external agencies via competitive quotations.

IT The IT team provides exceptional support by managing the computers and network infrastructure. The team supports a diverse range of client systems—Windows, Linux, and Mac. They use open-source technologies. The team looks after website development and manages lab servers, peripherals, CCTV systems, and FM200 gas suppression systems. IT Services oversees the wireless networks, periodic backups, and technical support for the public internet gateway, campus-wide WiFi, the scientific computing cluster facility, and centralized storage.

Instrumentation The Instrumentation team ensures the repair, operation and maintenance of training and calibration of instruments. They develop prototype instrument setups to support research activities. The team oversees the efficient operation of AV systems, access control, centralized gas lines, telephone services and bio-metric attendance system ensuring seamless functionality across the campus.

Electrical The Electrical Team, comprising highly trusted professionals, ensures 24/7 operation and maintenance of two 11kV substations and electrical systems. The team manages around 150 UPS units, ensuring uninterrupted power supply for critical equipment and critical systems. Their responsibilities include the operation and maintenance of fire alarm systems, firefighting motors and controls, and elevators. The team also takes care of infrastructure upgrades, executed modifications to existing facilities.

HVAC The HVAC team operates a 24/7 HVAC system and ensures optimal conditions for critical spaces like biosafety labs, animal facilities, and imaging rooms. They handle general maintenance, and modifications, and provide tailored solutions, including temperature-controlled rooms and alarm systems for critical failures. The team is managing 22,000 sq.m of AC space, 175 AHUs, 9 cold rooms, and 8900 BMS points, they ensure seamless operations with reduced reliance on external agencies.

Workshops The Electronic, Carpentry and Mechanical Workshops play a vital role in supporting campus infrastructure and innovation. The Carpentry Workshop focuses on crafting, repairing, and maintaining wooden structures, furniture, and fixtures, while also handling additions and alterations for new lab setups. The Mechanical Workshop caters to the campus's mechanical needs by fabricating advanced hardware components and sheet metal structures. It also undertakes product design and development, including CAD modeling, technical analysis, and manufacturing, ensuring high-quality and functional outcomes. The Electronic Workshop primarily help to develop the electronic circuit and setup for Prototype development.

Research Facilities

Deepti Trivedi

Research facilities at NCBS are **essential catalysts for bringing our researchers' innovative ideas to fruition**. In addition to offering cutting-edge equipment and technology, the facilities offer invaluable experience and expertise and have trained a large number of scientists aiding in generating a pool of well-trained scientists in India and worldwide. These facilities foster collaboration among researchers from diverse fields, encouraging the cross-pollination of ideas and innovative problem-solving. Research facilities also facilitate access to funding sources, especially by providing the credibility associated with reputable facilities providing the services to facilitate proposed research. Currently, there are **20 facilities helping researchers with their various needs,** including sophisticated biological manipulations at tissue and organismal levels and in-depth knowledge in operating and using new technology at atomic and molecular levels.

Facilities Coordination Committee

Raghu Padinjat, Arvind Ramanathan, Deepti Trivedi, Latha Chukki, Dimple Notani, Shivaprasad P V, Taslimarif Saiyed, Vinothkumar Kutti Ragunath, Arjun Guha.

01 Animal Care and Resource Centre

Animal Care and Resource Centre (ACRC) is a unique state-of-the-art high barrier Specific Pathogen Free (SPF) health status laboratory animal facility which provides services and resources to accomplish animal research objectives while ensuring optimal animal welfare conditions and animal ethics regulations.

Achievements in 2023-24
- Maintained 460 strains/lines of mice, 22 lines of rats and 60 lines of zebrafish.
- Used by 37 labs and handled over 96 projects.
- Trained 129 scientists in various aspects of lab animal management.
- Acknowledged in 15 publications.
- Enhanced ACRC outreach activities - training workshops & customized training for 62 external scientists.
- Providing animal resources and veterinary services to 6 external research projects at ACRC.

Crew Mohan G H, Roopa N, Sreenivasulu T, Manjuntha A M, Dinesh Kumar, Janarthanan, Jeevameena, Prasad G, Jagdish P T, Padmavathi G V, Himakar T, Laxmankumar N A, Akash R, Aravind N, Mahesh M, Babu P, Gopi P, Kumar R, Amarnath, Manjunath A, Nagaraju V, Nagaraju M C, Rohina, Srikanth R, Madhu H and Mahesh M V

Faculty Advisory Committee Raj Ladher, Colin Jamora, Vatsala Thirumalai, Soumyashree Das, Dhandapany P

02 Biosafety Facility

Biosafety Facility at NCBS comprises dedicated BSL-2 and BSL-3 laboratories. The Biosafety Level-3 (BSL-3) facility is certified for the regulatory BSL-3 compliance by the Review Committee on Genetic Manipulation (RCGM), DBT-GOI in 2022. It has two independent workspaces for viral and bacterial work. In addition, a small partition is also available in the bacterial lab for in vivo experiments (ABSL-3). Biosafety Level-2 (BSL-2) facilities on campus are multi-user facilities, in which different specimens containing known risk group-2 agents are handled. BSL2 laboratories are equipped with biosafety cabinets, CO2 incubators, centrifuges, fluorescent microscopes, refrigerators/freezers and storage units.

Achievements in 2023-24
- 40 users were trained for BSL2 and BSL-3 facilities.
- 63 users used these facilities.
- 3 publications acknowledged the contribution of the facility.

Crew Akshay Tharali, Chaitra Jagannathrao

Faculty Advisory Committee Varadharajan Sundaramurthy, Dimple Notani, Sabari Radhakrishnan, Diya Binoy Joseph, Sudarshan Gadadhar, Tapomoy Bhattacharjee

03 C. Elegans Facility

***C. elegans* facility** trains new users in regular *C. elegans* work, maintains *C. elegans* strains in frozen and growing conditions and supply *C. elegans* cultures. The facility provides services in making new transgenic C. elegans strains through germline microinjection, CRISPR/Cas-9 based knock-out and knock-in alleles.

Achievements in 2023-24
- 1 user was trained in microinjection.
- 16 users used the facility.
- Generated > 100 transgenics and 5 knock-in CRISPR *C. elegans* lines.

Crew Selvanayaki E

Faculty Advisory Committee Abhishek Bhattacharya, Raghu Padinjat

04 Central Imaging and Flow Cytometry Facility

Central Imaging and Flow Cytometry Facility (CIFF) is equipped with 20 state-of-the-art high-end microscopes and 12 flow cytometers.

Achievements in 2023-24
- The CIFF was used for 20,212 hours by 1,554 users in this period.
- CIFF organized 3 microscopy courses, 5 flow cytometry courses and 1 Bangalore Microscopy Course. We have trained 123 researchers coming from all over India and abroad in these 9 courses.
- We have trained 182 internal students/researchers on microscopy and flow cytometry.
- The CIFF was acknowledged in 16 papers in peer-reviewed journals.
- We have analysed 15421 plant samples.

Crew Venkatesan Iyer, Raksha K, Anil Kumar HV, Chandana S, Shraddha Sharma, Apoorva Shetty, and H Krishnamurthy

Faculty Advisory Committee Anjana Badrinarayanan, Minhaj Sirajuddin, Sudarshan Gadadhar, Shaon Chakrabarti

05 Cryoelectron Microscopy

The **National Electron Cryo Microscopy Facility** houses Titan Krios (Thermo Fisher Scientific) - a 300 kV FEG Transmission Electron Microscope equipped with an autoloader. On the pre-GIF position, a general purpose CETA (CMOS) camera and a CMOS direct electron detector, Falcon 3 are housed. The instrument also has a Volta Phase plate. In addition, the microscope is also equipped with a Quantum energy filter and a K2 direct detector. Thus, the instrument is equipped for high-resolution single-particle data collection as well as tomography.

Achievements in 2023-24
- 2 users trained and 27 users used the facility for multiple projects across the country.
- Acknowledged in 4 publications.

- The facility's prominent achievement is its capacity to generate high-resolution macromolecular structures, serving a diverse user community nationwide, and fostering collaborative partnerships spanning academia and industry.

Crew Sucharita Bose

Faculty Advisory Committee Vinothkumar Kutti Ragunath, Minhaj Sirajuddin, Ranabir Das

06 Electron Microscopy

Electron Microscopy Facility is equipped with high-end electron microscopes including Transmission Electron Microscope (Talos F 200 C G2 and Techni T12 G2 Spirit) and Field Emission Scanning Electron Microscope (Merlin Compact VP) for high-resolution imaging along with an X-ray source Micro-Computed Tomography (Skyscan 1272, Bruker Instruments) scanner machine. RMC cryo ultramicrotome, gatan plasma cleaner, gatan terbo pumping station, gatan cryo transfer holder, FEI vitrobot, and sputter coater are also available in the facility for electron microscopy sample preparations.

Achievements in 2023-24

- 5 users were trained and 50 users used the facility.
- The facility is acknowledged in 14 publications.
- Industrial users are also showing interest to the EM Facility.

Crew Angshuman Ray Chowdhuri, Sunil Prabhakar, Chandrani Samadder and Malavika Prabhakaran

Faculty Advisory Committee Vinothkumar Kutti Ragunath, Swadhin Chandra Jana, and Sanjay P Sane

07 Fly Facility

Fly Facility provides services in Drosophila stock maintenance, and genomic manipulations in Drosophila melanogaster including molecular cloning of DNA constructs, and generation of transgenic and CRISPR-based mutants. It is the only facility worldwide that provides a complete CRISPR service in *Drosophila melanogaster.*

Achievements in 2023-24

- Generated 137 transgenic and CRISPR flies.
- Maintained ~7000 fly stocks.
- Catered to projects from 216 internal and external users.
- Acknowledged for contribution in 11 publications.

Crew Deepti Trivedi, Anitha V A, Devika TK, Hemavathy C, Kishore V, Nataraj N, Smrithi V Yashwantha K

Faculty Advisory Committee Tina Mukherjee and Swadhin Jana

08 Genomics Facility

Genomics Facility is equipped with a state-of-the-art 48-capillary Sanger sequencing machine, two high-throughput next-generation sequencing platforms (NovaSeq 6000 and Hiseq2500), one bench-top next-generation sequencing platform (Miseq) and one Single Cell Genomics platform (10x Genomics).

Achievements in 2023-24

- 103 internal and external users trained.
- Acknowledged in 21 published papers.
- 20539 samples sequenced for Sanger Sequencing.
- Sequenced 13743 libraries for different applications of NGS i.e. Covid, 16s metegenomics, PCR amplicon, exome, mRNA and whole genome DNA, ddRAD, ATAC, small RNA etc.
- Improved the existing (Peterson et al, 2014; Diversity) Genotyping by Sequencing (GBS) method by modifying sequencing read primers (Read-1 and Read-2) to start the sequencing from the insert rather than restriction digested site to get high-quality sequenced data and also designed primers that allow multiplexing of more number of samples as compared to existing method *(https://onlinelibrary.wiley.com/doi/full/10.1111/mec.17461).*

Crew Awadhesh Pandit, Lakshminarayanan C P, Suresraj Y

Faculty Advisory Committee Dimple Notani, Dasaradhi P, Sabarinathan Radhakrishnan, Diya Binoy Joseph

S.No.	Name of the course/workshop	Duration (Year)	No. of Participants
1	4th Hands on workshop "Integrated OMICS"	28th Aug - 2nd Sep 2023	22
2	Next generation sequencing and genomics to understand species ecology	22nd Aug - 26th Aug 2023	30
3	5th Hands on workshop "Integrated OMICS"	4th Dec - 8th Dec 2023	22
4	Core Research Facilities Day - Technology Platforms for Advancing Biological Research	3rd May 2024	89

09 Greenhouse Facility

Greenhouse Facility has 7 greenhouses that allow researchers to maintain pure/transgenic strains of plants and insects and study plant-animal interactions. The greenhouses are equipped with adjustable and fully automated climatic control systems to control light, temperature, and humidity levels using special lights, shading screens, evaporative pads, fan cooling systems, heaters, humidifiers, and dehumidifiers. Several model plants (Arabidopsis, tobacco, rice, Nerium) are grown in the greenhouses.

Achievements in 2023-24

- 28 users used the facility

Crew Ranjith PP, SK Munegowda, Narasimha Raju, and Parvathamma

Faculty Advisory Committee Shivaprasad PV, Mahesh Sankaran, Amey Redkar

10 High-Performance Computing Facility

High-Performance Computing Facility caters to the ever-increasing demands from our scientific community. The facility at NCBS is a symbiosis of computing, network, graphics, and visualization. The facility is a functionally distributed super-computing environment and shared memory systems with open-source software packages all of which are inter-connected via an Infiniband network.

Achievements in 2023-24

- 250 users used the facility(Helpdesk data) plus user requests via email.
- Migrated all the labs and facilities from old centralized storage to New Dell storage and configured quotas. Successfully migrated data to new Storage.

Crew Rajshekar KS

Faculty Advisory Committee Shruthi V, Sabarinathan R, Vinothkumar KR

11 High Throughput Screening

High Throughput Screening Facility is equipped with state-of-art automated liquid handlers, multimode plate readers, automated imaging platforms, and multiplexing systems to quantify multiple analytes from a single sample while housing collection of RNAi libraries, small molecules and cell lines. The facility assists users in adaptation of both biochemical and cell-based assays in HTS/HCI formats through miniaturization and automation.

Crew Latha Chukki

Faculty Advisory Committee Varadharajan Sundaramurthy, Arjun Guha, Dimple Notani

12 Insectary

Insectary is a state-of-the-art research hub for mosquitoes that supports cutting-edge studies on insecticides, repellents, attractants, vector development, physiology, disease transmission, host-parasite/pathogen interactions, life history traits, population dynamics, behavioral genetics, ecological interactions, and related areas. It consists of three key components: (a) mosquito rearing facility, (b) parasite culture facility, and (c) transformation facility.

Achievements in 2023-24

- Published 5 research articles.
- Successfully trained 35 users from various institutes and the BLiSC campus.
- Actively participated in outreach programs.
- Organized a workshop on mosquito-rearing techniques, offering hands-on training to 24 students and faculty members.

Crew Sunita Swain, Chaitali Ghosh, Naveen Kumar, Soumya M, Soumya Gopal Joshi, Chethan Kumar R, Joydeep Roy

Faculty Advisory Committee Sanjay Sane, Varadharajan Sundaramurthy, Tina Mukherjee, Sonia Sen

13 Mass Spectrometry Facility

Mass Spectrometry Facility is equipped with advanced Mass spec (MS) technologies and established workflows to characterize biological and chemical molecules such as Metabolites, Glycans, Lipids, Proteins, Biosimilars, Antibodies and synthetic lab molecules. It also provides post-translation identification and quantitation of biomolecules using labelled and label-free workflow. The facility has now established untargeted metabolomics workflows for Mass Spectrometry Imaging using AP-MALDI UHR (ng) Ion Source and orbitrap Fusion (Thermo Fisher Scientific). The facility has developed advanced workflows for SWATH/DIA based proteomics and Phosphoproteomics.

Achievements in 2023-24

- Trained ~60 researchers in different LC-MS/MS technologies, such as lipidomics, proteomics, metabolomics, and glycomics.
- Conducted 4 national workshops and 1 symposium for researchers across industry and academia.
- Conducted a short talk on Applications for Advanced Mass Spectrometry in unravelling Organellar Proteome.
- Contribution of the facility is acknowledged in several publications.

Crew Ankit Jain, Nirpendra Singh, Pallavi HU, Amrutha Nair

Faculty Advisory Committee Arvind Ramanathan, Ranabir Das, and Raghu Padinjat

14 Mouse Genome Engineering Facility

Mouse Genome Engineering Facility is a well-equipped state-of-the-art functional facility for the generation of transgenic and gene-edited mouse models. The MGEF facility caters to 32 different services in the domain of mice model generation and assisted reproductive technologies to academic and non-academic institutions all over India.

Achievements in 2023-24

- A total of 217 projects (internal and external) including genome editing, sperm cryo, embryo cryo, and rederivation been carried out this year with a substantial amount of revenue generation toward achieving self-sustainability.

  Model Generation: 16, novel mouse models generated using CRISPR technologies.

  Sperm Cryopreservation: 111

  Rederivation: 35

  Embryo cryopreservation: 16

  Media and kits: 21

  Training: 46 candidates were trained on Genome editing and Assisted reproductive technologies in Mice models

Crew Mahesh Sahare, Rakshana, Gamyashree, Utkarsh Nikahde, Mahima, Reena V, Shilpa Kumari BA

Faculty Advisory Committee Raj Ladher, Arjun Guha, Dhandapani P, Soumyashree Das

15 Microfluidics and Microfabrication Facility

Microfluidics and Microfabrication Facility has a Class 10000 (ISO 7) cleanroom that is equipped with state-of-the-art fabrication and characterization tools to design, manufacture, and test PDMS and other polymer-based microfluidic devices and microstructures. The facility supports research activities in the campus by offering services in designing, fabricating and optimization of experiments that require micron-scale precision.

Achievements in 2023-24

- 52 researchers, students, and innovators were trained in various aspects of microfluidics.

Crew Karthik Mahesh

Faculty Advisory Committee Shashi Thutupalli, Tapomoy Bhattacharjee, Praveen Vemula

16 Field Station Facility

Field Station Facility provides support for field research in frontier areas of ecology, evolution and conservation genetics. It hosts long-term monitoring programs of diverse natural habitats, flora and fauna and supports science education and public outreach.

Achievements in 2023-24

- 168 citizens were trained in the field station.
- 12 users used the facility.
- 2 publications acknowledged the facility's contribution to their work.
- Pachmarhi field station was actively involved in the outreach events, participated in moth–week and butterfly month documenting moths and butterflies on the campus and was engaged with a larger audience through social media and citizen science.

Crew Yeshwanth HM, Savitha Chib

Faculty Advisory Committee Uma Ramakrishnan, Sanjay Sane, Mahesh Sankaran and Shivaprasad PV

17 Collection Facility

Collection Facility is a state-of-the-art facility for biodiversity-related work and serves as a national repository of type specimens and other specimens of research importance to NCBS and the broader global community of biologists. It facilitates networking with museums worldwide, and museum-based collaborations with taxonomists and biodiversity experts. Provides science education and public outreach through the museum and collections facility.

Achievements in 2023–24

- An insect and squamata taxonomy workshop was organized for students.
- Organized outreach programs to engage school and college students, as well as forest department staff from various states, by showcasing research collections and fostering discussions on different aspects of research and conservation across various taxa.
- 60 people were trained in various workshops and 22 users used the facility.
- The facility was acknowledged in 17 publications.

Crew Pritha Dey and Tarun Karmakar

18 Nuclear Magnetic Resonance (NMR) Facility

Nuclear Magnetic Resonance (NMR) Facility is equipped with two machines (800 MHz and 600 MHz) with cryo-probes for very sensitive ^{1}H, ^{13}C, ^{15}N signal detection at the liquid state along with the capability of variable temperature experiments from 40º C to -20º C. Also, the auto sampler at the 600 MHz NMR system offers automatic multi-sample analysis. The facility aids in studies focusing on de novo structure determination of macromolecules such as proteins and nucleic acids, and their dynamics in the picosecond to millisecond time scales.

Achievements in 2023–24

- 35 researchers were trained through half yearly hands-on training programme and Protein NMR Spectroscopy course.
- 4 internal users used the facility.
- Number of industrial users and external academic users has increased.
- Total facility usage time increases significantly compared to the previous years.

Crew Arnab Dey

Faculty Advisory Committee Ranabir Das, Minhaj Sirajuddin, and Praveen V

19 Radioactivity Facility

Radioactivity Facility has been classified as a Type-2 radioactive laboratory. The facility is equipped to handle ^{32}P, ^{55}Fe, $^{12}5I$, ^{3}H, and ^{14}C isotopes, and operates strictly within the guidelines set by the Atomic Energy Regulatory Board (AERB). The facility also has a cobalt-based Gamma Irradiation Chamber (GIC) to irradiate animal cells.

Achievements in 2023–24

- 22 users used the facility.
- 5 new users trained in using the facility under the supervision of the campus Radiological Safety Officer (RSO).
- 4 publications acknowledged the contribution of the facility.

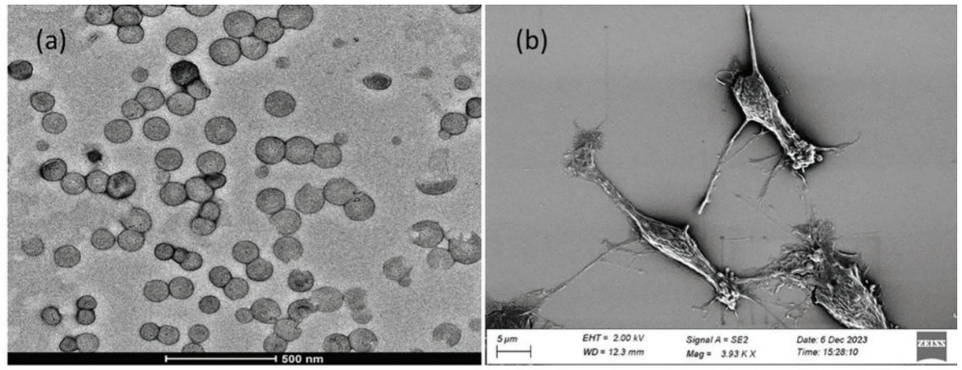
Crew Akshay Tharali (RSO, NCBS)

Faculty Advisory Committee Shivaprasad PV and Sunil Laxman

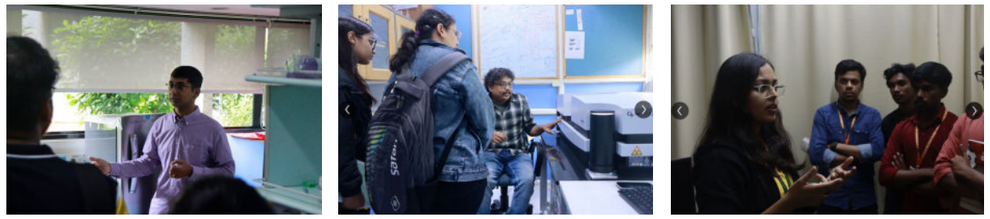
20 Stem Cell Facility

Stem Cell Facility (SCF) provides a high-end BSL-2 shared space needed to culture, edit and image stem cells.

Bangalore Microscopy Course 2023



(a) TEM images of hollow cage microstructure of QS21 saponin, a gold standard vaccine adjuvant, unpublished (b) SEM image of Neural Stem Cells from Ron Philip (Raghu Lab), unpublished and (c) Micro-CT transverse views of the adult fly indirect flight muscles, published https://doi.org/10.1371/journal.pgen.1011251.



Interactions with the students inside EM Facility.

5th Hands on workshop "Integrated OMICS" (4th December to 8th December 2023).

Core Research Facilities Day - Technology Platforms for Advancing Biological Research (May 03, 2024).

NCBS Library

Avinash Chinchure

The NCBS Scientific Information Resource Centre (SIRC) is a well-equipped and modern academic research facility that serves the research needs of the members of the entire campus, as well as visiting scholars and researchers. It plays a very important role in supporting the academic programs of the institute.

The primary aim of the SIRC is to develop, organize, preserve and deliver information and scholarly resources. To achieve this, the SIRC continually expands its collection, explores new resources, and develops an excellent partnership with users to provide effective information services. All SIRC holdings can be systematically searched through the online catalogue.

SIRC has a large collection of books, journals, and other resources in the biological sciences, including interdisciplinary areas. It also has a collection of electronic journals and e-books that can be accessed online. In addition to its collections, the SIRC provides a range of services to support research, including inter-library loan services, reference services, document delivery services, etc.

SIRC actively participates in consortiums to expand access to various resources. Under the DAE Consortia, NCBS has access to journals from Elsevier, Nature, Springer and Wiley. We also explore new subscription models, such as transformative agreements, to enhance access and offer APC waivers. Currently, we have Read and Publish arrangements with the Company of Biologists journals independently and through consortia with publishers like Wiley and Springer Nature journals.

The NCBS SIRC is open to all the campus members and is available 24/7 round the year, so users can walk-in whenever they need the services. The facility provides a comfortable, welcoming environment and modern infrastructure, including private study carrels, wired and wireless internet and more to its users for their academic use.

SIRC is an important resource for the entire campus research community and beyond. Its extensive collection, knowledgeable staff, and range of services make it an essential resource for every member and a core facility for the academic and research activities of the institute.

Retirement Note

Axel Brockmann

Written by Sanjay Sane

After a distinguished career as an insect neuroethologist, Axel Brockmann retired as an Associate Professor from the National Centre for Biological Sciences (NCBS) in June 2023. Following postdoctoral stints with Prof. Gene Robinson at the University of Illinois Urbana-Champaign and Prof. Jürgen Tautz at the University of Würzburg, Axel joined NCBS in 2012 as an international Young Investigator and served as an Assistant Professor until 2019. He was promoted to Associate Professor in 2020.

Axel's research spans multiple facets of honeybee behavior, from large-scale social organization to the neural mechanisms underlying their iconic waggle dance. Inspired by Karl von Frisch's pioneering work, which first decoded the waggle dance of the European honeybee *Apis mellifera,* Axel's lab at NCBS focused on understanding variations in this communication system across different honeybee species, including Indian honeybees. His team also investigated the roles of neuromodulators and genetic factors in regulating this behavior.

Under Axel's leadership, the lab tackled diverse questions, ranging from the behavioral ecology of honeybees to the genetic and neural foundations of their communication. They examined the evolution of the waggle dance and demonstrated fundamental behaviors such as a fly's innate tendency to wander and return to a food source after encountering sugar, even in complete darkness. True to the neuroethological tradition, Axel's group developed innovative assays to study and quantify natural behaviors in controlled environments.

Axel's contributions extend beyond research to studying the urban ecology of rock bees and raising public awareness about the importance of honeybees, particularly in urban contexts. He engaged with the public through lectures and documentary films, emphasizing the ecological significance of these pollinators.

Collaborating with colleagues at NCBS and internationally, Axel made significant strides in honeybee research. Following his retirement, he returns to Germany, where he will work on developing resources to support Indian scientists in advancing honeybee studies.

Partnerships and Flagship Programmes

Archives at NCBS

Venkat Srinivasan

The **Archives at NCBS** ***(https://archives.ncbs.res.in/)*** is a public collecting centre for the history of science in contemporary India. **Over 350,000 processed objects** across over **50 collections** are housed at the **2000-square-feet state-of-the-art physical centre**. Our objectives are four-fold: to strengthen research collections and public access in our domain, push the frontiers of research in archival sciences in India, build capacity through education, and reimagine the archives as part of the commons through vibrant public engagement. Most of our work is generously supported by TNQ Foundation and Arcadia.

Obaid Siddiqi Chair in the History and Culture of Science 2024-25

The Obaid Siddiqi Chair in the History and Culture of Science at the Archives at NCBS was founded to bridge gaps in the practice, history, and philosophy of science and the humanities *(https://archives.ncbs.res.in/OS).* Dr Savithri Preetha Nair was chosen as the recipient of the fourth Obaid Siddiqi Chair, 2024-2025. Nair is a historian and philosopher of science, whose work has been transdisciplinary and primarily examines the material culture of doing science. Prof Gita Chadha, the noted sociologist, concluded her tenure as the Chair in July 2024. She brought an intersectional feminist perspective to discussions of the study of science in India, with particular emphasis on fieldwork through ethnographic studies within NCBS. She concluded her tenure with three lectures around feminist practices in the sciences and in the archives.

Collections

The Archives at NCBS completed two years of its grant from Arcadia toward "Documenting the Contemporary History of Science in India". We have processed more than 200,000 digital objects and 100 interview sessions from across over 40 collections, including papers of under-represented communities in science, led by the accessioning work of Deepika S. They cover 140 years of science history from various corners of India, and bring together stories from individual lives, environmental movements, socio-cultural and global geopolitical events *(https://archives.ncbs.res.in/collections).* We also launched India's first regrant program for under-represented histories of science *(https://archives.ncbs.res.in/past).*

Research and collaborations

The Archives at NCBS collaborated for the fifth annual Milli Sessions on Jun 7 2024 *(https://milli.link/sessions2024/),* with a focus on archives, ethics and law. It joined the Milli Archives Foundation, a network of individuals and communities interested in the nurturing of archives *(https://www.milli.link),* as one of 18 networked archives collaborating to develop open-access archival tools and projects for the country.

Ravi KB put into operation the first archival media transfer lab in any educational institution in Bangalore. Ojas Kadu and Anoopa John developed the wireframe of the first archival annotation prototype in India. Sindhu N formalized the first archival assessment template for manuscript collections in India. Dhatri S and Sravya D developed Silverfish, the first publication of the Archives. Parvathy V showcased her work as a researcher and archivist on ecological histories at an oral history conference in Shillong. Anjali JR, Deepika S and S Prashant Kumar were invited to present on archives and women in science, and on archivist-historian collaborations for space science histories, at a conference of the International Council on Archives in San Francisco. The Archives also kick-started a research fellowship and scholar-in-residence program through support from TNQ Foundation *(https://archives.ncbs.res.in/scholars).*

Education

The Archives at NCBS continued to build capacity in archival training through internships offered to more than a dozen students. Savithri Preetha Nair and S Prashant Kumar taught courses anchored at the Archives at NCBS, and around the history, philosophy and cultures of science. Carol D'Souza and Anjali JR started an archives-in-education programme toward curriculum modules that use archival material for critical thinking.

Public Engagement

The Archives celebrated its five-year anniversary with the launch of 100,000 new digital objects on Feb 17, 2024 *(https://www.ncbs.res.in/events/apls-archives-five),* along with the fifth exhibition season, "Breakfast Table" by Pragya Bhargava, Nausheen Khan and Aparajitha Vasudev. The multi-sensorial exhibition explores the food we eat and the societal, political, scientific and economic processes from field to table. We hosted Iz Paehr, an artist-in-residence from the bangaloREsidency program of the Goethe-Institut. Iz worked on diverse ways of thinking about and visualizing networks in society and the archives. The Archives Public Lecture Series, a monthly public fixture to initiate dialogue and debate on an array of diverse topics and histories of ideas, completed 65 editions in September 2024, with a lecture on scripts and voices in the archive. We did not put out a public call for exhibitions and reduced public engagement due to budgetary constraints.

2024 team

(https://archives.ncbs.res.in/team): Anjali JR, Carol D'Souza, Carol Daniel, Deepika S, Dhatri S, Hari Sridhar, Hetal V, Kinjal Shah, Muhammad Sinan, Nayanika Shome, Ojas Kadu, Parvathy V, S Prashant Kumar, Preeti Shree Venkatram, Ravi K Boyapati, Raza Kazmi, Salama U, Samyamee Sreevathsa, Sindhu Nagaraj, Sravya Darbhamulla, Twisha Sangwan, Venkat Srinivasan.

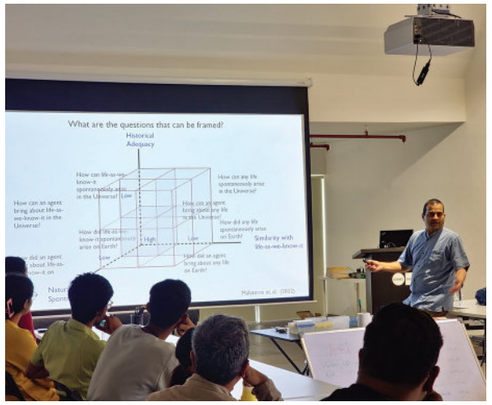
"Breakfast Table" by Pragya Bhargava, Nausheen Khan and Aparajitha Vasudev. This multi-sensorial exhibition (February 2024 - January 2025) is the fifth season of commissioned exhibitions at the Archives at NCBS. Using a combination of documentary footage, archival material, and tailored artwork, it explores the food we eat and the societal, political, scientific and economic processes from field to table.

Science Gallery Bengaluru

Jahnavi Phalkey

In 2024, the collaboration between the National Centre for Biological Sciences (NCBS) and Science Gallery Bengaluru (SGB) resulted in **impactful exhibitions** and **public programmes.** This partnership featured prominently in two major exhibition seasons—**CARBON** and **Sci560**.

Public Lecture with Chinmayee L Mukunda



Workshop with Nayan Chakraborty and Shashi Thutupalli

Workshop with Amey Redkar

Workshop with Rupsy Khurana

At **CARBON** (19 January–14 July 2024), NCBS researchers Shashi Thutupalli and Nayan Chakraborty recreated the historic *Jīvāṇu* experiment, originally conducted by Krishna Bahadur and S Ranganayaki, which explored the spontaneous emergence of life-like properties from chemical mixtures. With over 2,66,000 visitors, CARBON successfully bridged scientific research with public engagement.

Following this, NCBS contributed significantly to **Sci560** (from 24 August 2024), an exhibition exploring Bengaluru's scientific history. Highlights included *The Jīvāṇu Experiment: Redux* workshop, where participants recreated the pioneering experiment, and *Tiny Wings, Big Lessons,* a genetics and development workshop featuring *Drosophila* research.

During **NCBS's Open Day** (14 February 2024), SGB hosted a stall showcasing collaborative exhibitions and the Student Learning Experiences (SLE) programme, engaging **116 visitors**.

Exhibitions

CARBON (19 January – 14 July 2024)

- ***Jīvāṇu Experiment:*** A recreation of Krishna Bahadur and S Ranganayaki work exploring life's origins through chemical mixtures.

Sci560 (24 August 2024 – Ongoing)

- ***Jīvāṇu Experiment Redux:*** Interactive exploration of life's origins.
- ***Bheja Fry:*** Visualising neural activity with an in-house-built 2-photon microscope.
- ***Wind Tunnel:*** Reflecting on Obaid Siddiqi's pioneering research on olfaction.
- ***Physarum Pathways:*** Studying Bengaluru's transit systems through slime mold experiments.

Programmes

As part of **Sci560**, NCBS facilitated workshops and lectures, attracting **92 participants**:

- ***Patterns in Nature:*** A hands-on exploration of fractals and symmetry.
- ***The Jīvāṇu Experiment: Redux:*** A workshop recreating experiments on life's origins.
- ***The Nose Knows:*** A lecture on insect olfaction.
- ***Tiny Wings, Big Lessons:*** Exploring genetics through *Drosophila.*

Programme/ Exhibition Metrics

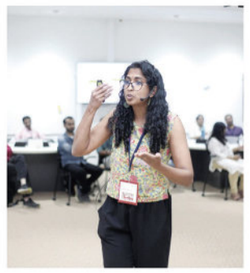
- 14 February 2024: **Open Day –** 116 visitors
- 19 January – 14 July 2024: **CARBON –** 2,66,000+ visitors
- 24 August 2024 – Ongoing: **Sci560 –** 9,750 visitors

IndiaBioscience

Engaging Communities, Enabling Change

Karishma S Kaushik

Since its inception in 2009, **IndiaBioscience** has been **a science facilitation programme based out of the National Centre for Biological Sciences (NCBS), with a pan-India vision, mission and impact.** Initiated by a group of young scientists over a dinner table conversation, IndiaBioscience has grown from its initial stages of support from NCBS to a Department of Biotechnology (DBT) funded programme based out of NCBS. The partnership with NCBS has been immensely valuable to IndiaBioscience and the life science community at large.



Across the years, being nestled in NCBS has given IndiaBioscience the opportunity to interact, engage and interface with the life science community. This includes not only scientists, researchers, students, and communicators in the Bangalore Life Science Cluster (BLiSC) but also science professionals visiting the campus for meetings, events, workshops, and collaborations. These ongoing in-person interactions, meetings and workshops conducted by IndiaBioscience across the country, and a large digital presence have meant that the programme has regularly felt the 'pulse' of the life science community in India. IndiaBioscience's partnership with NCBS has also opened the way for other local, national and international partnerships. Some notable examples include engagement with i wonder..., a science magazine for school teachers by Azim Premji University, Office of Principal Scientific Advisor to the Government of India, international funding programmes, and regional meetings such as the recently held Regional Young Investigators' Meeting in Bengaluru. The campus has served as a venue for several workshops and courses led by IndiaBioscience, most recently being the Lab Leadership Courses in partnership with EMBO. And of course, the invaluable support from the accounts, administration, instrumentation, hospitality, and facilities at NCBS has been the invisible engine that propels the work at IndiaBioscience, one day and one paper at a time!

More recently, IndiaBioscience has steadily grown in its activities and impact, with a range of concurrent initiatives and programs across the country. The programme has truly achieved national reach and impact, via its several in-person events and an expanding digital footprint. This is reflected in its engagement with science professionals from research institutes, state and central universities, private universities, industries, incubation parks, and government bodies. It has also grown into the one-stop place for international organisations looking to engage with the life science community in India. As it continues to fill the niche of being a catalyst for conversations and change in the life science ecosystem across India, the partnership with NCBS – solid, supportive, and steadfast – stands as an exemplar of the ability of research institutes to spawn initiatives with larger and lasting impact.

Team IndiaBioscience on campus.
Photo credit: Sulu Mohan

Bengaluru Sustainability Forum

The **Bengaluru Sustainability Forum (BSF)** is a dynamic, multi-institutional initiative **dedicated to addressing urban and peri-urban sustainability challenges in Bengaluru**. We bring together diverse stakeholders—academics, researchers, social advocates, citizens, and practitioners—to foster cross-disciplinary conversations and collaborations that drive innovative solutions for the city's future.

At BSF, we believe in empowering local initiatives and supporting a decentralized approach to changemaking. By linking smaller efforts to larger sustainability goals, we amplify the impact of each initiative. Our work spans key interconnected areas such as biodiversity, climate, water, waste, and urban planning.

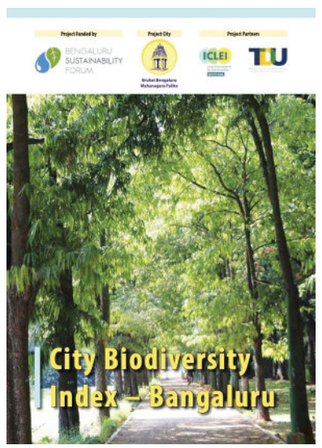
What We Do

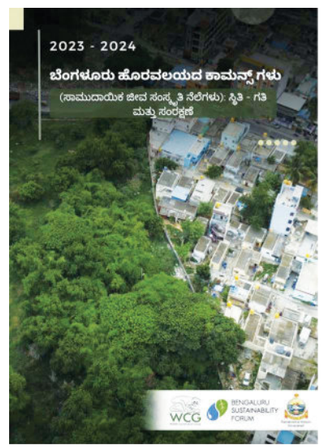
- **Support Local Initiatives:** We champion local projects that contribute to the broader vision of a sustainable Bengaluru.
- **Foster Collaboration:** We facilitate partnerships that allow one organization's work to complement and strengthen others.
- **Leverage Interconnectedness:** Our approach aims to integrate diverse issues into a cohesive understanding towards sustainable solutions for the city.

Our year-round activities include **retreats, workshops, panel discussions, webinars, film festivals, exhibitions,** and **a small grants programme**. Through these engagements, BSF has catalyzed ongoing conversations on the city's sustainable future.

Highlights for 2024

- The **Climate Charche Series**, a curated set of engagements on the interlinkages between different aspects of climate change and city systems.
- A collaboration with the IIHS Library and Mihir Kulkarni, IIHS School of Environment and Sustainability, on a **library exhibition on Urban Ecology**.
- The **Green Scene Calendar**, a curated list of sustainability events in Bengaluru, on our website and social media. Users can share events or sign up for updates.
- Showcasing BSF-supported projects at events like the **Civic Summit, IamOneHealth Festival, NCBS Open Day, IWEC** and **SCCS.**
- Social Media campaigns on the themes of **water, heat** and **public health.**





Small Grants Programme Project Updates

- **City Biodiversity Index** was developed for Bengaluru and will serve as a baseline for its biodiversity conservation efforts and to plan for a healthier and more liveable city.
- **Reclaiming the Commons at the fringes**, a report on community action in mapping and protection of the commons in the peri-urban areas of Bangalore. A film produced under the project can be seen here: *https://www.youtube.com/watch?v=L-5Gs7odWwA*
- **Heat in Bangalore: System's research and engagement for Climate Action in Marapanapalya Ward.** A short film on the project is available here: *https://www.instagram.com/reel/C6nwJsiopNu/?utm_source=ig_web_copy_link&igsh=MzRlODBiNWFlZA%3D%3D*

New Projects

We are also supporting **four exciting new projects** this year:

- Vanasuma - A **book on common wildflowers** in Bannerghatta National Park.
- A **mobile nursery** promoting native ecosystems.
- A **popular culture - driven engagement** for young Bengalureans on environmental and sustainability issues.
- **Revitalizing Purnaiah Nala** in Mysuru to create a sustainable urban waterway.

Partner Institutions

Azim Premji University · biome Environmental · wipro · iihs INDIAN INSTITUTE FOR HUMAN SETTLEMENTS · SCIENCE GALLERY · ncbs National Centre for Biological Sciences Tata Institute of Fundamental Research

BSF continues to drive forward collaboration, learning, and action for a more sustainable and resilient Bengaluru. Visit our website, sign up for our mailing list or follow us on social media to stay connected.

Website: www.bengalurusustainabilityforum.org | **Email:** bsf@ncbs.res.in
Twitter: @sustainBLR | **Instagram:**@sustainBLR | **Facebook:** @sustainBLR

Bangalore Life Science Cluster (BLiSC)

Joint Efforts

iBRIC-inStem and NCBS

C-CAMP and NCBS

TIGS and NCBS

Joint Efforts

LS Shashidhara

Bengaluru Life Science Custer (BLiSC) comprises of **National Centre for Biological Sciences** (NCBS-TIFR; established in 1991), a constituent of Tata Institute of Fundamental Research, an autonomous body under the Department of Atomic Energy, Government of India; **Institute of Stem Cell Science and Regenerative Medicine** (InStem; established in 2009), an autonomous body under the Department of Biotechnology, Government of India; The **Centre for Cellular and Molecular Platforms** (C-CAMP; established in 2009), a for non-profit initiative of the Department of Biotechnology, Government of India and **Tata Institute of Genetics and Society** (TIGS; established in 2017) a for non-profit initiative of Tata Trusts.

BLiSC represents best of fundamental and translational research with an excellent ecosystem for innovation and entrepreneurship. Constituent members of BLiSC employ diverse approaches to S&T governance with a vision to achieve greater impact, both individually and collectively. BLiSC pursues biological research covering all scales of size and complexity, from single molecule to forest ecosystem, and develops/adopts the most advanced techniques.

All research facilities, irrespective of their source and mode of procurement, are available for all researchers across the campus akin to BLiSC working as one single organization. This is exemplary and a role model for the rest of the country. This has enabled BLiSC members to establish a seamless pipeline for the propagation of an idea from fundamental to applied to translational research to innovative product development for the benefit of end users with a focus on scale, affordability, and excellence. The BLiSC ecosystem, therefore, is a major attraction for start-ups seeking support and mentorship.

Collectively, BLiSC ecosystem has supported more than 300 start-ups, more than a dozen life-science products have entered the market, initiated many campus-wide interdisciplinary research such as Accelerator program for Discovery in Brain Disorders using Stem Cells, which has now grown as Centre for Brain and Mind (funded initially by DBT and now by Rohini Nilekani Philanthropies; in collaboration with NIMHANS), A national facility for Cryo-EM and Big Data (funded by DBT), Centre for Chemical Biology & Therapeutics (a DBT funded initiative) etc. All of these were possible because of a collaborative approach and diverse organisations working together as one campus.

BLiSC's Contribution to Addressing Covid-19 Pandemic

In addition to high-quality research in the area of biomedical research, which is highly acclaimed worldwide, during the pandemic BLiSC has contributed significantly by:

- Helping scale-up India's capacity to make indigenous reagents and RT-PCR kits for SARS Cov-2 detection from 1 million kits per month (as of August 2020) to 30 million kits per month by June 2021; *https://www.ccamp.res.in/indx-indigenous-diagnostics).*
- Running a large RT-PCR testing centre for Bengaluru city.
- Sequencing more than 20,000 virus genomes to trace the evolution of new variants and making recommendations to the city authorities on public health strategy for effective control of the spread of new variants.
- Developing methodologies and conducting wastewater water surveillance as early warning system (continuing).
- Addressing the vaccine efficacy by conducting a 15-month longitudinal study on the immune response to infection and vaccination and directly estimating protection against new variants.

iBRIC-inStem and NCBS

Maneesha Inamdar

iBRIC-inStem's mandate is to undertake **world-class research in the area of stem cells and regenerative medicine for the benefit of humankind**. Our focus is on developing out-of-the-box solutions for stem cell research and its applications. Capitalizing on the diverse and cross-disciplinary expertise we have and our interactions with the BLiSC campus, new approaches to regenerative biology have been initiated.

Pushing the boundaries in stem cell biology and regenerative medicine, inStem and Centre for Stem Cell Science (our Vellore Unit) demonstrated success in gene therapy clinical trials for Hemophilia A in 2024. Meanwhile, stem cell-derived models such as lung, cardiac, brain, retinal, and bladder organoids have been efficaciously developed in-house.

With the intention of facilitating local interactions with the wider Bangalore research community, we initialled the "Interdisciplinary Local Interactions" Series of talks in 2024, open to attend for the all BLiSC members. We hope it ignited ideas, new directions and stoked research ambitions. Another highlights included the conference of the 'Indian Society of Developmental Biologists', 'New Directions in Blood Cell Biology Meeting', and 'International Cardiovascular Medicine Summit' where we hosted over 300 speakers and participants.

We also put in motion our plans to "be local, go global" by striving to be a resource for quality Indian stem cell lines, research and training. This aim has found unwavering support from the Department of Biotechnology (DBT) and the Biotechnology Research and Innovation Council (BRIC). We also partner with the International Stem Cell Banking Initiative (ISCBI) for training in good lab practices for stem cells culture, ethics, regulation, and policy.

Impowering the scientists across the country, iBRIC-inStem also organised several capacity building events such as Workshops on 'Good Cell Culture Practices in Stem Cells', 'Academic Integrity and Regulatory Compliance', 'Mass Spectrometry Imaging-based Spatial "Omics"', 'Cryobiology and Assisted Reproductive Technologies (ARTs) in the Laboratory Mouse', and EMBO Practical Course on 'Metabolite and Species Dynamics in Microbial Communities'. We are certain that these efforts will contribute to creation of critical expertise in the country to undertake leading research in life sciences.

The progress we have made has been appreciated at the national and international stage with inStem being conferred the Confederation of Indian Industry (CII) Award for Excellence in Women in STEM and representation at the Human Frontier Science Program (HFSP) Presidential Seminar. The year ended with the launch of the anti-pesticide suit for farmers - *'Kisan Kavach'* by Honourable Minister of Science and Technology Dr Jitendra Singh. This protective armour suit fulfils a long-standing societal need - to protect our *Annadaata,* our farmer community from the lethally toxic effects of pesticide sprays.

The past year has also seen us nurturing the next generation of scientists through our robust Summer Internships, PhD, and postdoctoral programs. These young minds are the future of life sciences, and it is our privilege to guide them as they embark on their own journeys of discovery. Their enthusiasm and fresh perspectives are a constant source of inspiration for all of us.

As we look to the future, I am excited about the possibilities that lie ahead. We are building on a strong foundation, with ambitious plans to deepen our research and expand our impact. With the continued support of BLiSC, BRIC, DBT and all our funders and collaborative partners, I am confident that we will continue to make strides in our mission to improve human health and well-being.

C-CAMP and NCBS

Taslimarif Saiyed

C-CAMP, as a founding member of the Bangalore Life Sciences Cluster (BLiSC), is privileged to be sharing the campus with NCBS, along with inStem and TIGS. BLiSC is one of the world's top biology research and innovation campuses mandated to take science from lab to life. **C-CAMP brings technology platforms, research translation and innovation capabilities to the Cluster.**

With phenomenal support over the years from NCBS, as the established organisation on campus, C-CAMP has grown and flourished in the last 15 years and we are deeply grateful for this.

Supported by the Department of Biotechnology, Govt. of India in 2009 as a catalyst of research and innovation in life sciences, C-CAMP has established itself as India's premier bio innovation hub fostering biotech solutions across healthcare, agriculture, animal health and environment. These solutions are not only local and contextual but also global gamechangers with particular relevance for low-and-middle income countries in the Global South where the real burden of systemic gaps exist.

There have been multiple scientific activities and programmes that C-CAMP has built along with the sister institutes of the Cluster which highlight the diversity of scientific advancement, from facilitating high-end research to supporting cutting-edge technology solutions for societal needs. Considering the diverse mandates of the 4 institutes, the BLiSC has become a confluence of driving forces to take science to society. C-CAMP is delighted to co-habit with NCBS, inStem and TIGS in this scientific powerhouse of a campus and going forward C-CAMP aims to build many more intra-cluster collaborative activities to develop solutions in the important areas of healthcare, agriculture and environment, or in other words bio for life.

TIGS and NCBS

Rakesh Mishra

The Tata Institute for Genetics and Society (TIGS) is part of the Bangalore Life Science Cluster (BLiSC) alongside TIFR-NCBS, DBT-inStem, and C-CAMP. This collaboration **amplifies the impact on life sciences research**, fostering a synergistic environment that significantly advances scientific innovation and progress within the BLiSC community. TIGS conducted several outreach events and activities in partnership with TIFR-NCBS, DBT-inStem, and C-CAMP.

- The year kicked off with the **25th Anniversary Celebrations** of the BLiSC Campus on February 14th, where over 300 students from Bengaluru, including a significant number from government schools, delved into the fascinating world of genetics. The event featured DIY DNA bracelets, genetics-themed crossword puzzles, and fabulous stickers, making genetics accessible and fun. This initiative not only entertained but also educated, leaving a lasting impression on young minds.
- On February 29th, the spotlight turned to **International Rare Genetic Disease Day 2024**. Hosted at the prestigious Infosys Science Foundation, Bengaluru, this event brought the community together to explore the complexities of rare diseases. Through talks and interactive activities, it highlighted the importance of awareness, inclusivity, and collaboration, fostering a supportive community for those affected by rare diseases.
- June 30th marked the beginning of a series of **events focusing on Antimicrobial Resistance (AMR)**, starting with a workshop that brought together clinicians, researchers, and policymakers. This interdisciplinary approach emphasized the critical role of collective action in tackling global health challenges like AMR.
- The summer months were bustling with activities aimed at **Dengue awareness and education**, culminating in a felicitation ceremony for social media campaign participants. These workshops, organized by Dr. Sufia Sadaf and partners, targeted a diverse audience, enhancing understanding and engagement in the fight against Dengue.
- The **Antimicrobial Resistance Conference (ARC 2024)** on August 22-23 served as a dynamic platform for discussing one of the most pressing public health challenges. The conference fostered meaningful dialogue and collaboration, empowering the global community to take actionable steps against AMR.
- September was a month of outreach and capacity building. The **NCBS Open Day 2024** saw the TIGS team engaging over 300 visitors with interactive genetics-themed activities, enhancing genetic literacy. This was followed by an inaugural **Hands-On Training Workshop** focused on environmental surveillance and molecular diagnostic approaches, marking a significant step in strengthening technical expertise.
- The **importance of AMR and policy stewardship** was highlighted in workshops on September 30th and October 14th, educating medical students and research institutes on the emergence of AMR and advocating for policy changes.
- **Collaborations** have been a cornerstone of TIGS's success. The partnership with ICMR-CAR and BLiSC Partners aims to advance research in neuromuscular genetic disorders, while the joint PhD program with AcSIR, NCBS, and inStem ensures a comprehensive academic experience. Additionally, TIGS's collaborations with inStem and other partners have led to significant advancements in research and development, from creating mouse models for rare genetic disorders to developing personal protection suits for farmers.
- The year concluded with **AMR workshops** on November 6th and 11th, reinforcing TIGS's commitment to addressing global health challenges through education and collaboration. These events, along with the institute's various collaborative initiatives, underscore the importance of integrating diverse expertise and resources to improve patient outcomes and foster innovation in healthcare.

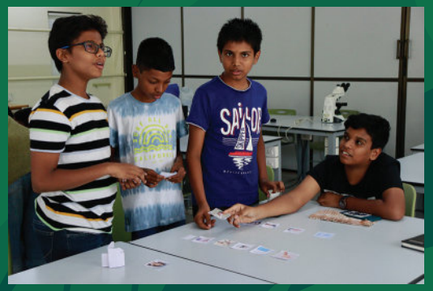
Office of Science Communication and Outreach

Rupsy Khurana

Our Office of Science Communication and Outreach has wrapped up an incredible year! This year was about **spreading joy**, **wonder** and **curiosity** far and wide, but also experimenting with all sorts of **exciting ways to connect** with everyone. Well, almost everyone!

This year, we welcomed two fantastic additions to our team: Christeen and Mrunal! They jumped right into the action, and we have been a powerhouse of creativity ever since. We churned out over a dozen popular science stories showcasing the research at NCBS.

We also launched a super cool comic series spotlighting the brilliant research of our women faculty with the widely cherished– **Tinkle comics at Amar Chitra Katha- Superwomen of Science!**



Our goal? To push science into the mainstream with vibrant visuals and engaging stories making science fun and accessible to the younger ones. Our hope? They believe that they can be one of those scientists in the comics someday.

Then there was our foray into the world of theatre! We teamed up with a brilliant theatre troupe to create a **science play**, getting our hands dirty with the script and brainstorming ideas. We wanted to tell a compelling story about Zoonoses, that weaves accurate science in a way that's both engaging and relatable. It was a real adventure diving into acting, screenplay, dialogue and so much more which was new to us. Oh, did we love every moment of it!

Our **Open Day** and **Campus@25** celebrations were a total blast! We threw open our doors to school kids, giving them a chance to get up close and personal with science. Seeing their eyes light up with curiosity as they explored and experimented was pure magic. It was all about showing them how science is woven into the fabric of our everyday lives.

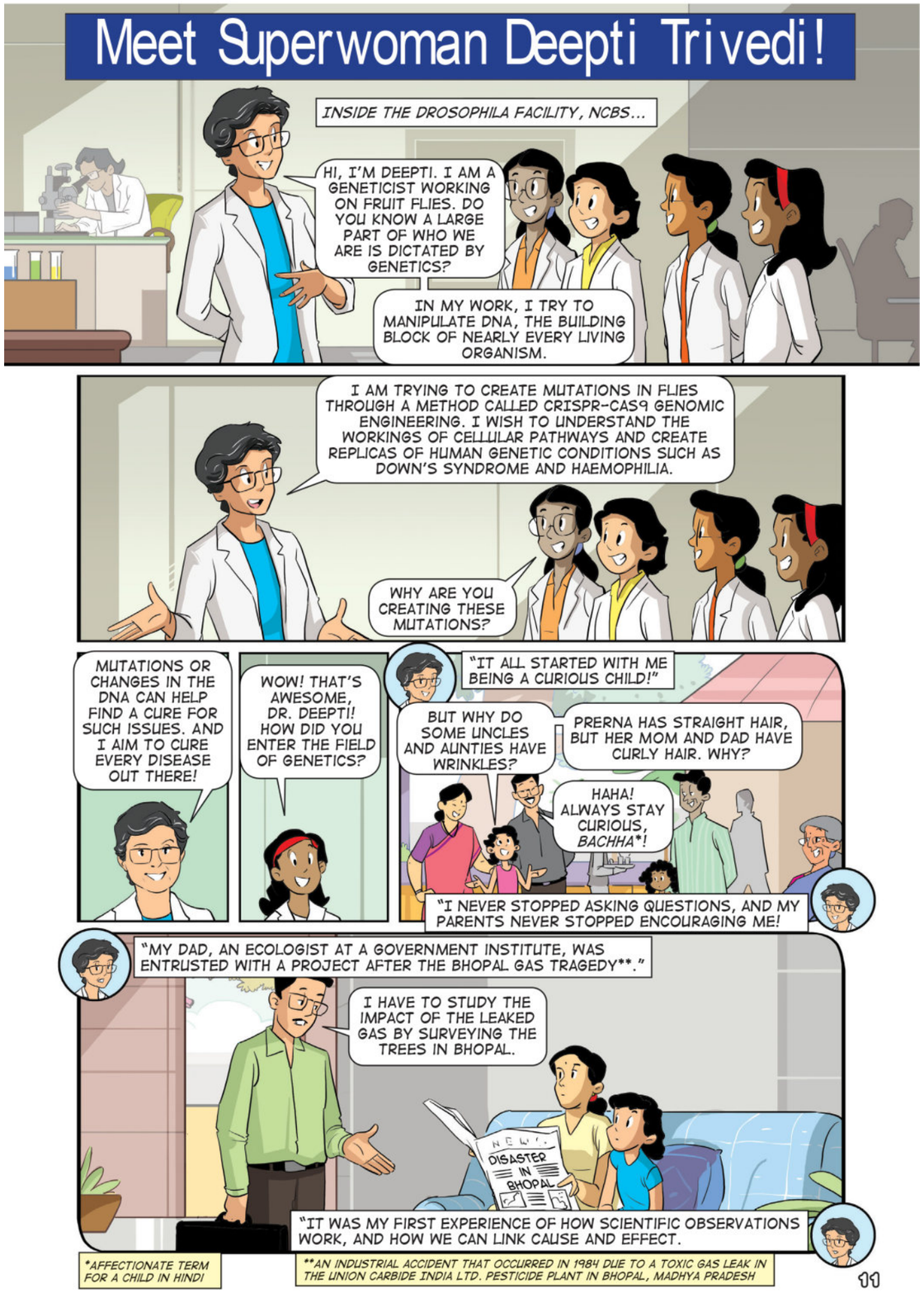
And because we love a good conversation, we teamed up with **Archives@NCBS** for a **video podcast** Gender in/of Science. These are curated within an interdisciplinary framework of feminist science studies that explore a range of issues beginning with the underrepresentation of women and their gendered experiences in science.

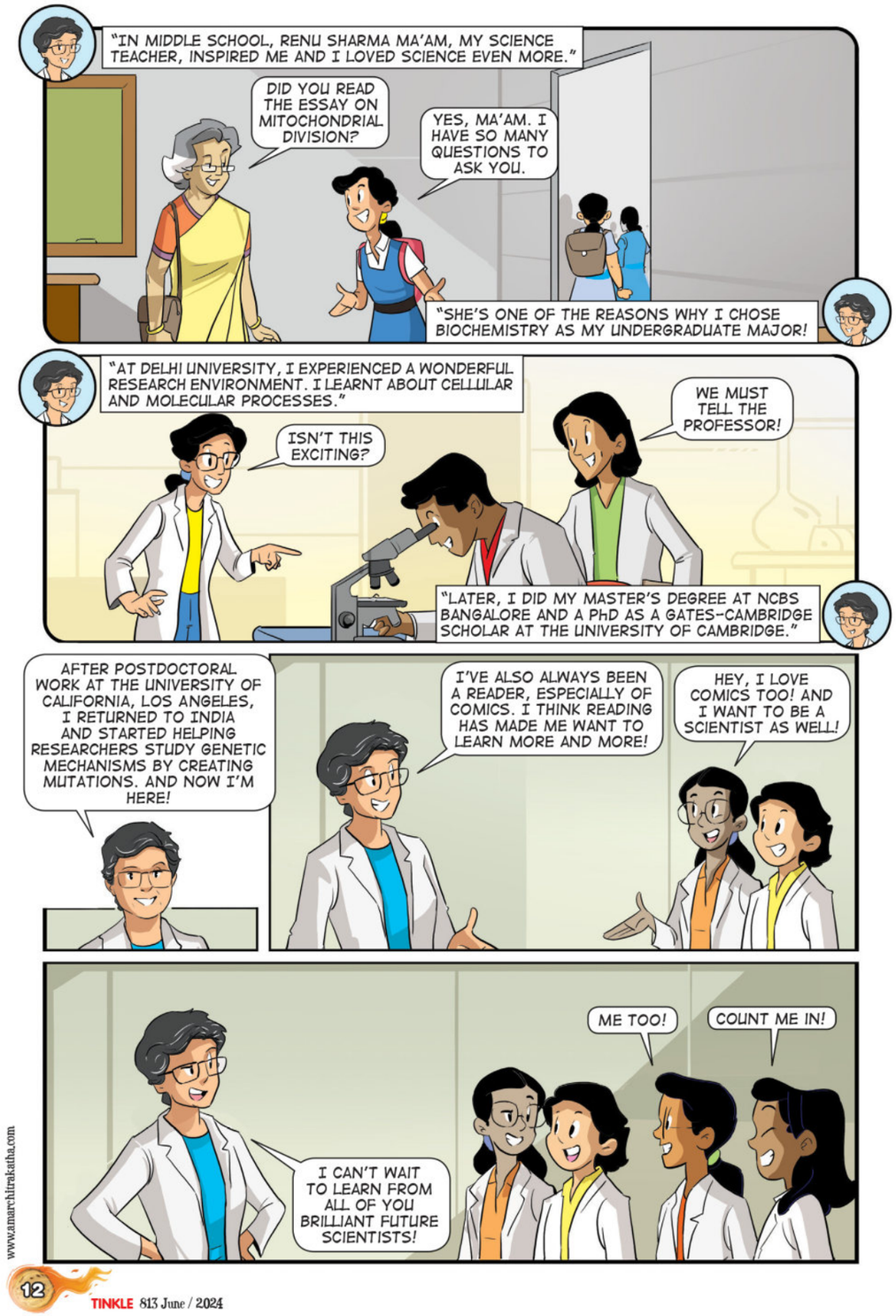
We also partnered with Springer Nature India on Podcasts to tell interesting and newsworthy stories in the history of science in India.

But that's not all! We've also been taking NCBS research on tour around Bangalore! We've popped up at places like the **Science Gallery Bengaluru (SGB), Param Innovation Centre, Visvesvaraya Industrial & Technological Museum (VITM), the Bangalore Creative Circus,** and even the **Echoes of Earth music festival.** It's been such a pleasure to connect with these incredibly diverse audiences. They've given us so much food for thought on how to tweak our communications and get even closer to our goals. It's been amazing and gratifying to see how excited people are about science, even in unexpected places!

This year has been a rollercoaster – a mix of wins, experiments, a few stumbles, and a whole lot of learning. We've had incredible support and creative freedom, thanks to Prof. LS Shashidhara and Prof. Uma Ramakrishnan – huge thanks to them for believing in us! And a massive shout-out to the amazing NCBS students. We couldn't have done any of this without their energy and enthusiasm.

We're so excited to keep moving forward, bringing more science to you through digital and print media and in all ways fun and exciting! Stay tuned for more!





Highlights of the Year

Pan-TIFR Biologist Meet

July 3-4th, 2024, Bangalore

Hiyaa Ghosh and **Shruthi Viswanath**

This meeting **aimed to understand the current state of research in biology** at TIFR and **discuss future prospects** at a collective level for TIFR-Biologists. 48 faculty members from different centres of TIFR; NCBS, DBS, TIFR-H and ICTS, congregated for this meeting, which was held in Bangalore on July 3-4th, 2024. The sessions consisted of 5-minute scientific pit-talk presentations from each faculty and an open-house discussion on research facilities and operations-related topics.

As presented in the pit-talks, research in TIFR biology extends over a broad spectrum of topics, ranging from biomolecular, cellular, and organismal to ecological dynamics and adaptations, genetics and evolution, physics of biological systems, to questions of brain development, connectivity and resilience, to disease biology encompassing cancer, immunological, metabolic and neurological diseases.

Alongside the fundamental understanding of first-principles rules for biological phenomena, the biology research ongoing at TIFR also presents prospects in areas relevant to national and global issues, such as food security, synthetic, chemical, and biophysical approaches for applicational purposes, and efforts for mitigating human disease burden, such as cancer, neurological and metabolic diseases. For example, ongoing research focusing on genetic and epigenetic mechanisms of crop yield, plant disease resilience and plant-microbe interaction, will provide insights that will be useful for food security in the long run. Similarly, several groups are working to gain a deeper understanding of the dynamics of biomolecules such as proteins and lipids that could provide critical insights for synthetic design of molecules and drug targeting in the future. Research on microbes and host-pathogen interactions will allow exploiting these systems for human advantage, be it for creating better solutions for defense against microbes of humans and crops or using the microbial machinery for industrial-scale production of useful molecules. Research into a mechanistic understanding of DNA mutations causing cancer, metabolic aspects of human diseases, neurodevelopmental, psychiatric, neurodegenerative diseases and brain ageing, will further build our knowledge base for handling disease burden. Finally, while research at NCBS in the area

of ecology and evolution has already yielded by providing critical insights for policy decisions for urban and forest management, going forward this may extend and expand to address questions pertinent to our understanding of climate change and the role of ecological diversity and conservation.

The existing facilities and infrastructure at TIFR centres present a wide range of equipment and sophisticated facilities. This includes a wide range of specialized microscopes that enable resolution at the electronic, atomic, and single molecule level, up to whole cell, organ, and live-animal imaging. Facilities and equipment for biophysical and molecular assays ranging across NMR, X-ray crystallography, a variety of spectroscopy, multi-omics, and flow-cytometry are also available. Facilities for a range of model organisms including fly, fish, worms and rodents are available for sophisticated genetic engineering, behavioral, neurobiological, and immunological studies. However, consistently upgrading the existing technologies in a timely manner will be critical for keeping up with the cutting-edge requirements of research.

Grounded on the mandate for discovery of fundamental principles of nature, the ongoing research in biology across TIFR promises both progress on fundamental knowledge alongside applicational prospects, pushing at the forefront of cutting-edge science of global standards.

Meetings & Workshops 2024

Jan

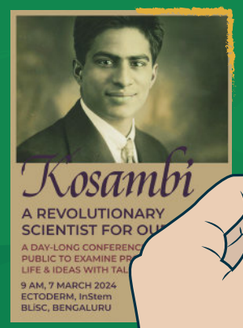
- **10-12**
  NCBS Annual Talks 2024: "Inter connected life"
- **23-24**
  Exploring Emerging Questions in Ocean Biology
- **January 29 - February 2**
  Hands on Workshop on Basic Bio-Methodology of Laboratory Mice & Rats

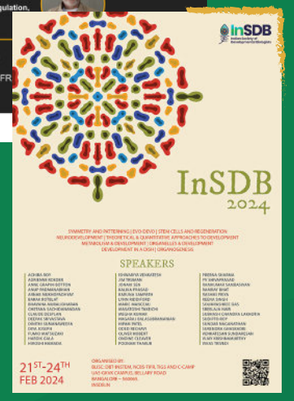
Feb

- **9**
  EMBO Global Lecture Series
- **14**
  Campus @25
- **21-24**
  Indian Society for Developmental Biologists

Mar

- **7**
  D.D. Kosambi: Revolutionary Scientist for our Times
- **17-30**
  11th Annual Science Journalism Workshop





Apr

- **4**
  Bangalore Neuroscience Meeting
- **23**
  7th Scientific Expert Committee - Deep Ocean Mission (SEC-DOM) Meeting

May

- **2-3**
  Climate Change in your Classroom: A Workshop for Teachers of all Disciplines
- **4**
  Technology Platforms for Advancing Biological Research
- **6-10**
  6th Hands-on Workshop on Integrated OMICS (Genomics, Proteomics and Bioinformatics)
- **16-17**
  NSTMIS-Project Advisory Committee (PAC) Meeting
- **May 29 - June 4**
  Hands-on Workshop for College Teachers on using Drosophila Melanogaster for Biology Laboratory Classes

Jun

- **7**
  DBT- Khorana Feedback Meeting
- **14-16**
  Wildlife Ecology Conference
- **17-18**
  Discussion meeting on Bat Conservation
- **24-25**
  Workshop on Open-Source Mass Spectrometry Data Analysis and Visualization Tool

Jul

- **1-10**
  Physics of Life 2024 - 9th Annual Monsoon School
- **3-4**
  Pan- TIFR Biology
- **8-13**
  NCBS-RIKEN BDR Joint Meeting
- **8-21**
  SAGE Training Program

Aug

- **5-9**
  Hands-on Workshop on Basic Bio-methodologies of Laboratory Mice and Rats
- **22-23**
  ARC-2024 (AMR Research Conference)
- **26-29**
  Hands-on workshop: Cryobiology and Assisted Reproductive Technologies (ARTs) in the Laboratory Mouse
- **29-31**
  Workshop and Symposia on Mass Spectrometry Imaging-based Spatial "Omics"

Sep

- **1-7**
  Statistical Genomics Workshop
- **12-14**
  Living Lightly - Futures for Pastoralism and Grasslands in India
- **22-29**
  14th Bangalore Microscopy Course

Oct

- **15-19**
  7th Hands-on Workshop on Integrated OMICS (Genomics, Proteomics and Bioinformatics)
- **21-24**
  EMBO Lab Leadership Course
- **25**
  RNP Manotsava

Nov

- **5-7**
  Insectary Workshop
- **11-14**
  Birds in Focus: An Introduction to Specimen-Based Research
- **28-29**
  REDRESS 2024

Dec

- **2-3**
  Insect Map: Blueprints for Sustainable Long-Term Monitoring of Insects
- **3-10**
  Marine Cell Biology Workshop
- **16-17**
  State of India's Birds

Campus@25

Sufia Sadaf

On February 14, 2024, the **Campus@25 celebration** marked a significant milestone: 25 years since NCBS moved out of the Indian Institute of Science (IISc) campus and established itself within the lush, sprawling GKVK campus. The campus@25 event showcased the science at NCBS through a variety of **outreach activities** and **exhibits**. The event opened the doors of NCBS to young school children, the general public, and friends and families of the NCBS community fraternity!

Reaching this 25-year milestone is no small feat. NCBS campus has grown upon the shoulders of its various leaders, staff, faculty, students and alumni.

From its humble beginnings in a single building, the campus has expanded to become the Bangalore Life Sciences Cluster (BLiSC), which now includes NCBS, inStem, TIGS, and C-CAMP. This remarkable journey was initiated under the visionary leadership of Prof. Obaid Siddiqi, the founder and first Director of NCBS. Prof. Siddiqi's relentless efforts saw NCBS evolve from a concept within its parent institute, TIFR, into a thriving center for cutting-edge biological research.

It was steered further by Prof. K VijayRaghavan, who served as the Director of NCBS for 17 years and expanded on the existing state-of-the-art, cutting-edge technologies, imaging and microscopy, biophysics, biochemistry and collaborative avenues. Prof. Satyajit Mayor, further expanded NCBS during his 10 years as the Director, by fostering collaborative and open-research culture and establishing the BLiSC campus by adding inStem, TIGS, and C-CAMP to its fold.

The NCBS campus continues to flourish and thrive under the leadership of Prof. LS Shashidhara, embracing the culture of pan-India collaborative consortia and taking the science from benches towards translational applicability! Throughout its various leadership, NCBS has been a unique space brimming with creative and curious ideas, collaborative environments and empathy.

The campus research has been aligned towards excellency, deciphering the fundamentals of biological sciences through various fields of study, including biochemistry, cell biology, development and genetics, ecology and evolutionary sciences, neurobiology, biophysics and cross-modalities, traversing collaborations in-house, across multiple institutes within India and globally.

With the fervor to honor the past 25 years, Bharat Ratna Prof CNR Rao, accompanied by Dr. Indumathi Rao, inaugurated the event. As the day's celebration began, a swelling crowd of enthusiastic BLiSC members cheered on to welcome Prof. Rao and Dr. Indumati Rao, the chief guests for the occasion.

They were welcomed by Prof. Shashidhara and Prof. Maneesha Inamdar, Director of inStem, who reflected on Prof CNR Rao's profound contributions to Indian science. Former NCBS Directors, Prof. VijayRaghavan and Prof. Satyajit Mayor, recounted the institute's formative years, while heartfelt anecdotes and gratitude were shared by speakers including Mr. Ranjith, Prof. Dasaradhi Palakodeti, Prof. Anjana Badrinarayanan, Ms. Nivedita Mukherjee, and Prof. Anu Rangarajan.

The day's celebrations truly came alive as schools explored the exhibits. From intricate models of insects and animals to hands-on science experiments, alumni films, and creative artworks like the lantana elephants, each stall sparked their curiosity and excitement. The Campus@25 celebration also marked a significant step towards the expanding Outreach programs at BLiSC, minimizing the barriers between Science and Society.

Through its exceptional research, engaging outreach, and collaborative spirit, NCBS—now the heart of BLiSC—continues to grow, setting its sights on an even brighter future, with immense support from across various campus facilities and staff. We extend our heartfelt gratitude to the entire campus, including administration, accounts, hospitality, security, grounds teams, daycare facility, research grants and outreach, archives, scientific teams and research facilities for enabling the growth and journey.

NCBS Collaborations

International Collaborations

National Collaborations

- DBT-inStem
- TIGS, Bangalore
- C-CAMP, Bangalore
- NIMHANS, Bangalore
- Indian Institue of Science (IISc), Bangalore
- IIT, Delhi
- IIT, Madras
- IIT-Bombay
- India Malabar Cancer Centre
- Tata Memorial Centre
- Cytecare Hospitals Pvt.Ltd.
- Rajiv Gandhi University of Health Sciences (RGUHS), Bangalore
- Long Term Ecological Observatories for Climate Change (LTEO)
- Centre for Cellular & Molecular Biology (CCMB), Hyderabad
- Gujarat Biotechnology Research Centre(GBRC), Gandhinagar
- Pune Knowledge cluster foundation (PKCF)
- Indian Institute of Technology (IIT), Gandhinagar
- St.John's Research Institute
- The Thackeray Wildlife Foundation (TWF)
- Ashoka University
- VPS Lakeshore Hospital
- CBCI Society for Medical Research
- Christian Medical College, Vellore
- Tamil Nadu Agricultural University
- The Advanced Centre for Treatment, Research and Education in Cancer (ACTREC)
- Nference, Bangalore
- Feather Library, Gujarat
- Sankara Academy of Vision (SAV)
- Rohini Nilekani Philanthropies Foundation
- SKUAST Kashmir
- Becton Dickinson India Private Limited
- Central Zoo Authority (CZA)
- Indian Council of Forestry Research and Education (ICFRE)
- Indian Council of Forestry Research and Education - Institute of Forest Genetics and Tree Breeding (ICFRE-IFGTB), Coimbatore
- Indira Gandhi National Forest Academy, Central Academy for State Forest Service
- Gennova Biopharmaceuticals Ltd
- WIPRO
- International AIDS Vaccine Initiative
- Kodo Lifescience Pvt Ltd
- Bat Conservation India Trust
- Kerala Agricultural University
- Sahjeevan
- Nanaji Deshmukh Veterinary Science University(NDVSU)
- Indian Institute for Human Settlements
- Indian Council of Forestry Research and Education-Institute of Wood Science and Technology (ICFRE-IWST)
- Zydus Life Sciences Ltd
- Ashoka Trust for Research in Ecology and Environment (ATREE)
- MassTech Life and Analytical Sciences
- Aster Hospitals
- I-Hub for Robotics and Autonomous Systems Innovation Foundation (ARTPARK)
- Amar Chitra Katha Pvt Ltd (ACK)
- CSIR-Centre for Cellular & Molecular Biology (CCMB), Hyderabad
- National Institute of Ocean Technology (NIOT), Chennai
- Wipro Foundation
- Avestagen
- Sri Shankara Cancer Hospital and Research Centre
- TNQ Foundation
- Springer Nature India Private Limited (SNIPL)
- Tadoba Andhari Tiger Reserve Conservation Foundation (TATRCF)
- ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, Bengaluru
- India Foundation for the Arts (IFA)
- ICAR-National Institute on Foot and Mouth Disease, Bhubaneswar
- Shiv Nadar Institution of Eminence (SNIOE)
- Field Director Simplipal Tiger Reserve
- Kuvempu University
- ICAR-National Institute of High Security Animal Diseases (NIHSAD)
- Housing and Urban Development Corporation Limited (HUDCO)
- University of Agricultural Sciences (Gandhi Krishi Vigyana Kendra), Bengaluru
- National Institute of Animal Biotechnology (NIAB)
- Salin Ali Centre for Ornithology and Natural History (SACON), Anaikatty-Coimbatore
- Hindustan Unilever Limited
- Translational Health Science and Technology Institute (THSTI), Faridabad

Scientific and Management Board

Management Board

The Management Board is in charge of the overall management of NCBS, and also functions as a research council.

- **Prof. Jayaram Chengalur,** Director, TIFR Mumbai
- **Prof. Thomas Daniel,** University of Washington, USA
- **Prof. Gagandeep Kang,** Christian Medical College, Vellore
- **Dr. Anurag Behar,** Azim Premji Foundation, Bangalore
- **Prof. Gillian M. Griffiths,** Cambridge Institute for Medical Research, UK
- **Prof. Harmit Malik,** HHMI & Fred Hutchinson Cancer Center, USA
- **Prof. Matthew Freeman,** Sir William Dunn School of Pathology, University of Oxford, UK
- **Prof. Rama Govindarajan,** ICTS, Bangalore
- **Prof. L.S. Shashidhara,** Centre Director, NCBS, Bangalore, (ex-officio)
- **Dean-Research,** NCBS, Bangalore, (ex-officio)
- **Ms. Sushma Taishete,** Joint Secretary (R&D), DAE, (ex-officio)
- **Prof. Maneesha S Inamdar,** Director, inStem, Bangalore, (ex-officio)
- **Dean-Faculty,** NCBS, Bangalore, (ex-officio)
- **Dean-Academics,** NCBS, Bangalore, (ex-officio)
- **Prof. Uma Ramakrishnan,** NCBS Bangalore
- **Registrar,** TIFR, Mumbai, (ex-officio)
- **Head, Administration and Finance,** NCBS, (ex-officio) - Non Member Secretary

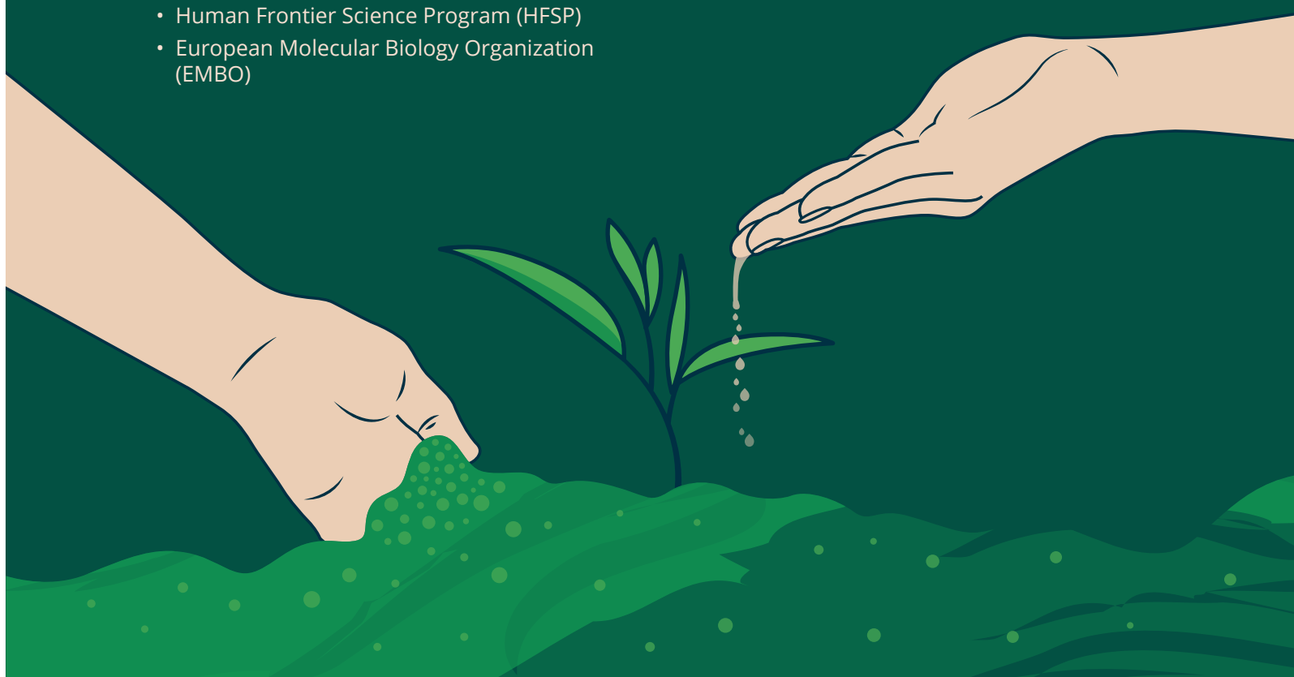
Scientific Advisors

- **Prof. Joan E. Strassmann,** Washington University in St Louis, USA
- **Prof. Jan Marino (Nino) Ramirez, University of Washington,** Seattle, USA
- **Prof. Mary Beckerle,** University of Utah, USA

Funders

NCBS-TIFR

- Department of Biotechnology, Govt. of India
- Department of Science and Technology, Govt. of India
- Science and Engineering Board, Govt. of India
- Biotechnology Industry Research Assistance Council (BIRAC), Govt. of India
- Ministry of Environment, Forest and Climate Change (MOEFCC), Govt. of India
- DBT/Wellcome Trust India Alliance
- Indian Council for Medical Research (ICMR), Govt. of India
- Department of Health Research (DHR), Govt. of India
- CEFIPRA
- One Health (PSA, Govt. of India)
- Tata Trust
- Rohini Nilekani Philanthropies Foundation
- Hindustan Unilever Limited and Unilever Industries P Ltd.
- Rockefeller Foundation (via CCMB, Hyderabad)
- Infosys Foundation
- Kiran Mazumdar Shaw
- TTK, Prestige Ltd
- Narayana Murthy
- Srikanta and Radhika Gopalakrishnan (Philanthropic Donors)
- Simons Foundation
- DeFries-Bajpai Foundation
- Human Frontier Science Program (HFSP)
- European Molecular Biology Organization (EMBO)
- Air Force Office of Scientific Research (AOARD), USA
- National Geographic
- Max Planck Group
- Wildlife Conservation Trust
- Panthera Corporation, New York, USA
- ICA (International Council on Archives) Fund for the International Development of Archives (FIDA)
- Arcadia Philanthropic Trust, UK
- Duleep Mathai Trust
- On the Edge Conservation (OTEC), UK
- Global Partnerships Fund. International Relations and Partnerships Team, Newcastle University, UK.
- Conservation, Food and Health Foundation, USA
- TNQ Technologies
- Bill and Melinda Gates Foundation (BMGF),USA
- Housing and urban Development Corporation Ltd (HUDCO), India
- Global Partnerships Fund, Newcastle University, UK
- Sahjeevan -Centre for Pastorilsm
- Kavli Foundation, USA
- Leo Foundation, Netherlands



Reaching out

Uma Ramakrishnan

Science: it is about curiosity, about exploring the unknown, a unique creative enterprise. Such an enterprise demands new and unique perspectives, a diversity of thought process. So everyone should have something to bring to science and the scientific process. But what if a whole section of society carried extra burdens, making it difficult for them to become scientists? In India, as is the case in many (mostly) patriarchal societies, women carry many burdens: the burden of expectation, the burden of a conservative milieu. Add in lack of freedom to explore their passion, curiosity and creativity. This often leaves women out of science.

This year, the NCBS communications office celebrated women scientists in our community using non-traditional approaches to disseminating their stories and narratives: podcasts and comic series. Dr. Gita Chadda, Obaid Siddiqui chair (2023-2024) conducted a series of interviews about women in and of science, hosted now on the NCBS Youtube channel *(link)*. We collaborated with Tinkle magazine to showcase ten women in science through two page comics *(link)*. We hope that these stories will inspire aspiring scientists: women and girls so they know it is possible, and others so they know science is a place not only for a favoured few. We hope to continue to showcase inclusive stories in science and of scientists.

These activities are synergistic with the theme of this year's annual report: reaching out. Academia is a bubble, sometimes an ivory tower. Yet the science we do, the relationships we make and the answers we find are impacting the world around us. Join us through a journey of 2023-2024 through this lens!

Designer's Note

Sumita Nanda
www.superpixel.in

This year's theme - **'Reaching out'** is a tribute to NCBS's efforts to collaborate with multiple sectors – other organizations, education and training institutes, clinicians, hospitals, policy makers, stakeholders, and the general public. This idea of getting *'science to society'* is portayed by a take on Michaelangelo's painting *'The creation of Adam'* on the cover of the report. The hand on the right represents NCBS and the gesture here symbolizes a flow of knowledge.

Our hands are one of our body's most useful and adaptable tools *('tool of tools' as Aristotle put it),* a fascinating piece of natural engineering seamlessly integrated into our cognitive system. We use them to function, reach out, feel, express, grasp, communicate, and so much more, hardly noticing how indispensable they are in our everyday lives. In addition to using hands to illustrate the theme of ***reaching out*** on the cover of the report, we have utilized them in other sections of the report as well – conveying different ideas and helping us express.

A special thanks to the NCBS Communications Office for all their efforts, help and suggestions in putting this report together, it's always a pleasure working with them.

Report design: **www.superpixel.in**

NATIONAL CENTRE FOR BIOLOGICAL SCIENCES
Tata Institute of Fundamental Research, Bellary Road, Bengaluru, Karnataka 560065
Tel: +91 80 23666001 / 02 / 18 / 19 **Fax:** +91 80 23636662 **Email:** info@ncbs.res.in **Web:** www.ncbs.res.in
NCBS_Bangalore NCBS.Bangalore ncbs-tifr ncbs_bangalore BLiSCIndia