Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

Research Projects proposed by the Faculty in various research areas:

(Project titles are listed below; detailed descriptions are provided on the next pages)

S.No.	Project name	Floated for	Research Area
1	Development of a Lab-on-a-Chip Platform to Investigate Endothelial Physiology: Bridging In Vivo and In Vitro Experimental Models	PhD / MSR	Healthcare
2	Development of an Integrated Microfluidic Platform for Electromechanical Characterization of Human Blood Cells toward Disease Detection	PhD / MSR / MTech HVA project	Healthcare
3	Decoding Bacterial Persistence: Quantitative and Predictive Modeling of Surface-Driven Infection Risk	PhD/MSR/MTech HVA	Healthcare
4	Automated micro-droplet packaging to generate combinatorial assays for personalized cancer therapy.	PhD / MSR / MTech HVA project	Healthcare
5	Developing a platform for AI-guided selective single-cell electroporation for cholesterol-dependent intra cellular cargo-delivery	PhD / MSR / MTech HVA project	Healthcare
6	Development of an Indigenous Low-Cost Droplet Digital PCR Platform for Precision Molecular Diagnostics	PhD / MSR / MTech HVA project	Healthcare
7	Development of a multiparametric high-throughput droplet screening platform.	PhD / MSR / MTech HVA project	Healthcare
8	Rational Design and Fabrication of Engineered Nanomaterials for Tissue Regeneration	PhD	Healthcare
9	Early Detection of Cyanobacterial Blooms in Riverine Systems Using Spatio-temporal Modelling	PhD/MSR/MTech HVA	Environmental Biotech.
10	Tailoring functional electrode interfaces for enhanced extracellular electron transfer in bioelectrochemical systems	PhD	Environmental Biotech.
11	Exploring interfacial electron transfer processes in electroactive microorganisms	PhD	Environmental Biotech.
12	Next generation bioformulations	MSR / MTech HVA project	Environmental Biotech.
13	Mitigation of abiotic stresses in plants by using microbiome based approach	PhD	Environmental Biotech.
14	Storage of soil microbiome to retain its functionality	MSR / MTech HVA project	Environmental Biotech.
15	Transforming disease conducive soil to suppressive one	PhD	Environmental Biotech.
16	Microbial biosurfactant as next generation bioformulations foragricultural sustainability	PhD	Environmental Biotech.
17	Understanding the mechanism of regulation of tpx genes and development of an improved system for production of thiol peroxidases	PhD	Environmental Biotech.
18	Role of non-canonical DNA structures in bacterial adaptation	MSR/MTech HVA	Environmental Biotech.
19	Development of IoT enabled system for water quality surveillance in water bodies	PhD / MSR	Environmental Biotech.
20	Treatment of Urban Sewage for Healthy Reuse	PhD / MSR	Environmental Biotech.
21	Integrated monitoring and treatment of emerging and conventional pollutants for rejuvenation of riverine systems	PhD / MSR	Environmental Biotech.
22	Predictive Modeling of Metabolic–Mechanobiological Cross-Talk in Oral Microbiome Dysbiosis for Early Detection and Intervention	PhD/MSR/MTech HVA	Computational and Systems
23	Development of a novel One-health framework for fungal pathogen surveillance	PhD / MSR	Computational and Systems

24	Predictive modelling of transitions in cellular States across Disease and Evolution	PhD / MSR	Computational and Systems
25	Development of novel spatial omics assays for precision biology	PhD / MSR	Bio-manufacturing
26	Enhancing the ethanol productivity of glucose-limited cultures of Scheffersomyces (Pichia) stipitis.	MSR	Bio-manufacturing
27	Bacterial Microcompartments: a novel technology for recombinant protein production	PhD	Bio-manufacturing
28	Protein engineering using computational design	PhD / MSR	Bio-manufacturing
29	Cell free metabolic engineering for the production of secondary metabolites	PhD / MSR	Bio-manufacturing

(Project titles are listed above; detailed descriptions are provided on the next pages)

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

Proposed Projects

Research Area: Healthcare

Indian Institute of technology Delhi

Department of Biochemical Engineering and Biotechnology

Project details	
Project title	Development of a Lab-on-a-Chip Platform to Investigate Endothelial Physiology: Bridging In Vivo and In Vitro Experimental Models
Type of project	PhD/MSR project
Project description	The proposed work aims to develop a flow-based microvasculature-on-a-chip platform, which will mimic the dynamic conditions of human blood vessels, to understand the role of mechano-sensitive stimuli in the progression and diagnosis of cardiovascular diseases. Among the various factors that trigger the physiology of human vascular system, endothelial dysfunction appears to be the most common cause of cardiovascular disorders. The proposed microfluidic model will constitute a unique opportunity to explore in 3D and under dynamic flow conditions, and the changes in the endothelium function under altered flow conditions. The proposed lab-on-a-chip model will allow for the unprecedented and realistic identification of the major elements that compromise endothelial cell function with far-reaching consequences on cardiovascular dysfunction. The experimental approach would couple multi-physics phenomenon at various length and time scales. The execution of this project requires fundamental understanding of Fluid Mechanics.
Instruments required	Inverted microscope, BSL-2, CO2 Incubator, Centrifuge

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Priti Sinha	DBEB	sinhapriti@iitd.ac.in
Co-Supervisor			

Skills required

Qualification	ONLY BTech/MTech in Chemical/Biochemical engineering or Biotechnology or MSc Physics students will be considered for this position
Skills	Microscopy techniques, Microfabrication (not mandatory)

References

1. Laura Locatelli, Mehdi Inglebert, Roberta Scrimieri, K. P. Sinha, Gian Vincenzo Zuccotti, Paolo Milani, Lionel Bureau, Chaouqi Misbah, Jeanette A M Maier, 'Human endothelial cells in high glucose: New clues from culture in 3D microfluidic chips', FASEB **J.** (2022) 36(2), e22137.

2. M Inglebert, L Locatelli, D Tsvirkun**,** K. P. Sinha**,** J Maier, C Misbah, L Bureau, 'The effect of shear stress reduction on endothelial cells: A microfluidic study of the actin cytoskeleton', Biomicrofluidics (2020) 14, 024115

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Department of Biochemical Engineering and Biotechnology

Project details	
Project title	Development of an Integrated Microfluidic Platform for Electromechanical Characterization of Human Blood Cells toward Disease Detection
Type of project	PhD/MSR/ MTech HVA project
Project description	Human health is profoundly influenced by the physiological state of blood cells. Any alteration in the biochemical or physiological properties of these cells can disrupt vascular hemodynamics and contribute to the onset of various vascular diseases. Therefore, characterizing the mechanical properties of blood cells is essential for addressing challenges associated with blood flow dynamics and for achieving targeted biomedical objectives, such as the early detection of vascular diseases. This research aims to investigate the interplay between electric fields, hydrodynamic flow, and cellular mechanics within microchannels of a lab-on-a-chip device. The proposed approach involves developing a contactless, non-invasive, flow-based technique to assess the mechanical, electrical, and biochemical properties of both healthy and diseased cells under physiological and pathological conditions. Such microfluidic platforms are envisioned to support a broad range of applications—enhancing our understanding of cellular dysfunction, advancing research in vascular biology and biomedical engineering, and offering healthcare technologies with translational potential.
Instruments required	Inverted microscope, Centrifuge, Electrical equipment's
Any other comments	

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Priti Sinha	DBEB	sinhapriti@iitd.ac.in
Co-Supervisor			

Skills required	
Qualification	ONLY B.Tech. in Chemical/Mechanical/Electronics/Biochemical engineering or Biotechnology or M.Sc. Physics students will be considered for this position
Skills	Microscopy techniques, Microfabrication (not mandatory)

References

Grigorev, G.V.; Lebedev, A.V.; Wang, X.; Qian, X.; Maksimov, G.V.; Lin, L. Advances in Microfluidics for Single Red Blood Cell Analysis. Biosensors 2023, 13, 117

Sinha K P, Das S, Karyappa R, Thaokar RM; Electrohydrodynamics of vesicles and capsules, Langmuir 2020, 36(18), 4863-4886

Indian Institute of Technology Delhi
Department of Biochemical Engineering and Biotechnology
PhD/MSR/MTech HVA project

Project details	
Project title	**Decoding Bacterial Persistence: Quantitative and Predictive Modeling of Surface-Driven Infection Risk**
Type of project	PhD/MSR/MTech HVA
Project description	***"Linking Surface Forces, Adhesion and Single-Cell Dynamics to Infection Risk"*** Hospital-acquired infections (HAIs) remain a major healthcare challenge, as pathogenic bacteria can survive cleaning, enter dormant states and later resuscitate to cause new infections. The role of surface forces and microenvironment in this persistence is still poorly understood. This PhD project aims to establish a quantitative link between surface properties, bacterial adhesion and infection risk at the single-cell and population level. The central idea is that surface-driven adhesion influences survival under disinfectant stress and the likelihood of regrowth. The work will combine live-cell microscopy, AFM-based adhesion measurement, integrated with quantitative and data driven (AI/ML) modeling to track bacterial transitions from attachment to dormancy and revival. **The project will provide mechanistic insight into disinfectant tolerance and develop predictive tools to assess infection risk and improve surface design and hygiene strategies in healthcare settings.**
Instruments required	AFM, Inverted microscope for time-lapse imaging, microplate reader and microbiology laboratory equipment (e.g., shaker incubator, autoclave, biosafety cabinet, centrifuge)

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Garima Rani	DBEB	garimarani@iitd.ac.in

Skills required	
Qualification	Degree in Physics, Engineering, Biophysics, Microbiology or a related field.

Skills	**Strong interest in interdisciplinary research at the interface of physics and biology**; basic understanding of either microbiology or soft matter/biophysics; familiarity with data analysis and quantitative thinking; programming experience (Python/MATLAB/R) or willingness to learn.

References

1- M.C. Gonzalez-Garcia et al. Exploring bacteria–surface interactions with a fluorescent membrane tension probe, Proc. Natl. Acad. Sci. U.S.A. 122 (42) e2512977122, https://doi.org/10.1073/pnas.2512977122 (2025).

2- Garima Rani, Anupam Sengupta, Substrate stiffness governs dynamics and self-organization of nascent biofilms, *Arxiv* (2025).

3- Rene Riedel, Garima Rani and Anupam Sengupta, "Bacterial Adhesion on Soft Surfaces: The Dual Role of Substrate Stiffness and Bacterial Growth Stage", Microorganisms 13 (3), 637 (2025).

4- Garima Rani and Anupam Sengupta, "Growing bacterial colonies harness emergent genealogical demixing to regulate organizational entropy", Biophysical Reports 4, 100175, Cell press (2024).

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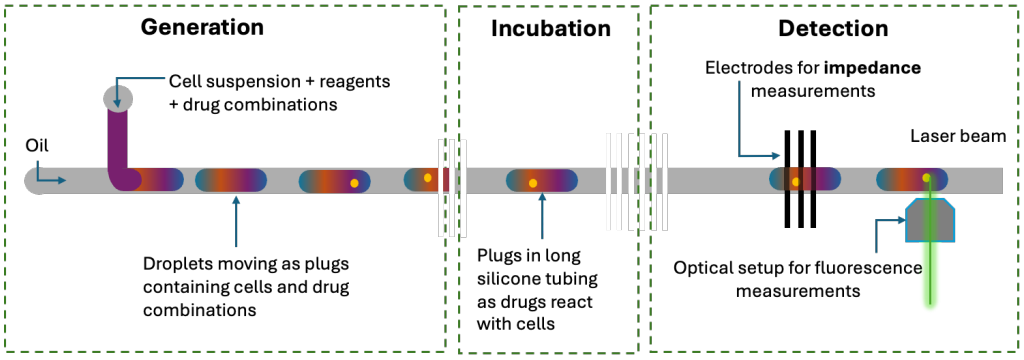
Department of Biochemical Engineering and Biotechnology

PhD project

Project details	
Project title	Automated micro-droplet packaging to generate combinatorial assays for personalized cancer therapy.
Type of project	PhD / MSR / MTech HVA project
Project description	Droplet microfluidics offers a promising avenue for studying single cells and their biochemical responses in isolation at a high throughput [1]. This approach facilitates the screening of patient tumor samples against multiple drug combinations, enabling the rapid identification of the most effective drug pairings tailored to the unique genetic makeup of an individual's tumor thereby circumventing the limitations of generalized cancer treatments [2]. However, creating these combinatorial assays is challenging, primarily due to the complexity of controlling multiphase fluid flow to accurately produce droplets with the intended drug concentrations and combinations [3]. **This project involves the design, development, and optimization of complex multi-channel fluid-flow control instrumentation for droplet packaging that is capable of generating and analysing such high-precision combinatorial assays in an automated manner** [4, 5]. Additionally, new drug-testing protocols will also be established aiming to predict the optimal personalized treatment with minimal post-biopsy sample processing especially for heterogeneous tumors, such as those found in pancreatic, breast, and colorectal cancers. The complete system development is aimed towards providing a translatable platform that is compatible with clinical requirements. Such a portable and cost-effect platform will extend the benefits of personalized cancer therapy to a wider population. 
Instruments required	Inverted microscope, Optical components (Lasers, photosensors, high-speed camera, optical bench etc.), Electronic components, Mammalian cell/tissue handling facility (biosafety hood, Co2 incubator, tissue slicer etc), Microfabricatin facility etc.
Any other comments	A major part of the project would involve **Instrumentation, Programming and Microfabrication** with limited Biotechnology Component.

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Prof. Jatin Panwar	DBEB	jatinpanwar@iitd.ac.in

Skills required	
Qualification	BTech/ MTech in Chemical, Bio-chemical, Mechanical or related field MSc /MTech any field of Life Science Engineering
Skills	Experience and interest in basic fluid-flow process control, Electronic Signal Processing, Microprocessors, Mammalian cell handling and molecular biology protocols

References

1. Moragues, Thomas, et al. "Droplet-based microfluidics." *Nature Reviews Methods Primers* 3.1 (2023): 32.
2. Eduati, F., Utharala, R., Madhavan, D. *et al.* A microfluidics platform for combinatorial drug screening on cancer biopsies. *Nat Commun* **9**, 2434 (2018).
3. Utharala, R., Grab, A., Vafaizadeh, V. *et al.* A microfluidic Braille valve platform for on-demand production, combinatorial screening and sorting of chemically distinct droplets. *Nat Protoc* **17**, 2920–2965 (2022).

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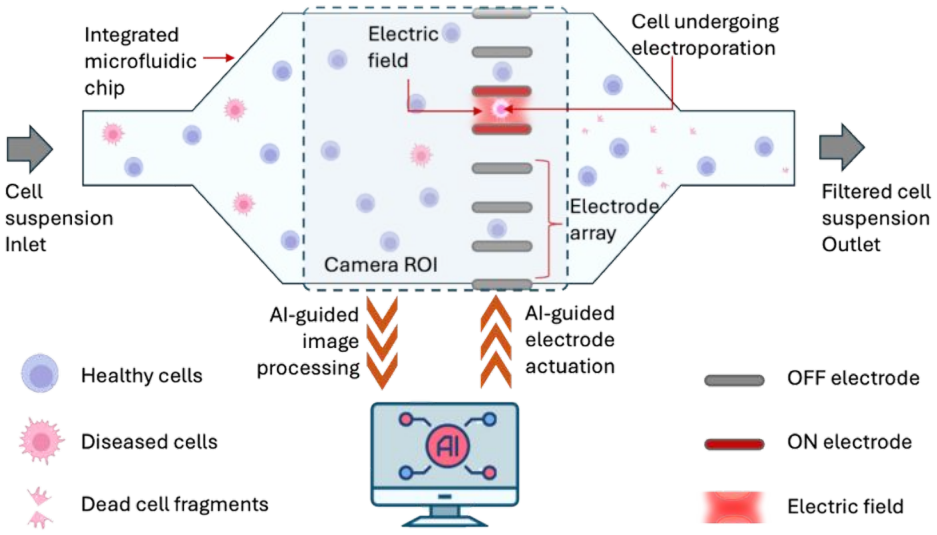
Department of Biochemical Engineering and Biotechnology

Project details	
Project title	Developing a platform for AI-guided selective single-cell electroporation for cholesterol-dependent intra cellular cargo-delivery
Type of project	PhD / MSR / MTech HVA project
Project description	Single-cell electroporation (SEP) is a technique often employed in clinical applications to create temporary or permanent channels in the plasma membrane via application of an external electric field. The goals can range from delivering specific cargo into the cell through these pores to killing the cells by rupturing the membrane. In life science research, SEP is widely used in bacterial and yeast transformation protocols, CRISPR–Cas9 genome-editing experiments, mRNA transfection assays, RNA knockdown experiments, etc. Despite its popularity, SEP has faced many adaptability challenges due to limited throughput and high cost. The electric field parameters often need to be optimized for each cell or tissue type, to achieve a target distribution of pore sizes for specific applications. Thus, optimization of the protocol becomes a bottleneck that must be addressed. The **student will develop an automated high-throughput platform** for selective SEP that will offer cell-type-based optimization of the electric field parameters informed. We will further focus on investigating the cholesterol-dependence of the SEP-based cargo delivery process, to gain insights into relevant medical conditions, like dyslipidaemia, often cited as a cause of the growing cardiovascular disease among Indian population. 
Instruments required	Inverted microscope, Lasers, sCMOS camera for Image processing, Microfabrication facility.
Any other comments	A major part of the project would involve **Instrumentation, Programming and Microfabrication.**

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Prof. Jatin Panwar	DBEB	jatinpanwar@iitd.ac.in
Co-supervisor	Prof. Amit Das	DBEB	amit.das@dbeb.iitd.ac.in

Skills required	
Qualification	B.Tech in Chemical, Bio-chemical, Mechanical, Electrical or related field
Skills	Experience and interest in device development and instrumentation.

References

1. SE, Khoo H, Hur SC. *Recent Advances in Microscale Electroporation.* Chem Rev. 2022;122(13):11247-11286.
2. Thiriet PE, Pezoldt J, Gambardella G, Keim K, Deplancke B, Guiducci C. *Selective Retrieval of Individual Cells from Microfluidic Arrays Combining Dielectrophoretic Force and Directed Hydrodynamic Flow. Micromachines*. 2020;11(3):322

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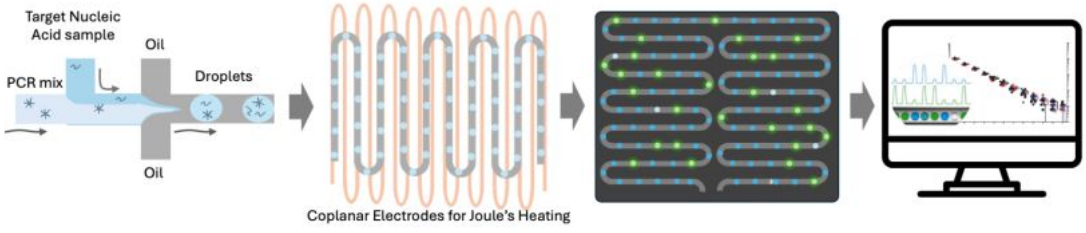
Department of Biochemical Engineering and Biotechnology

Project details	
Project title	Development of an Indigenous Low-Cost Droplet Digital PCR Platform for Precision Molecular Diagnostics
Type of project	PhD / MSR / MTech HVA project
Project description	Molecular diagnostics are central to disease detection, treatment monitoring, and surveillance. In India, high-burden diseases such as tuberculosis, HIV, hepatitis, dengue, and emerging infections require sensitive nucleic acid–based detection for early diagnosis and therapeutic monitoring. Additionally, antimicrobial resistance (AMR) demands accurate quantification of resistance-associated genetic markers. While real-time PCR (qPCR) is widely used, it has limited sensitivity at low target concentrations. Clinically relevant scenarios—such as early infection, minimal residual disease, and low viral load—often involve extremely low copy numbers, necessitating highly sensitive and absolute quantification methods. Droplet digital PCR (ddPCR) overcomes these limitations by partitioning samples into thousands of microdroplets, enabling single-molecule detection and absolute quantification without standard curves. Despite its advantages in sensitivity and reproducibility, ddPCR adoption in India remains limited due to high capital costs, proprietary consumables, and lack of systems suited for resource-constrained settings. This creates a significant gap in equitable access to advanced diagnostics, particularly in tier-2 and tier-3 laboratories. This study aims to address these challenges by developing an indigenous, cost-optimized ddPCR platform using simplified microfluidics, modular optics, and open-source electronics. The objective is to achieve performance comparable to commercial systems while significantly reducing cost. The student will: (1) develop an integrated ddPCR system, (2) engineer a robust droplet generation module, (3) design compact thermal cycling and fluorescence detection, and (4) validate performance using clinically relevant targets such as Mycobacterium tuberculosis and AMR markers, benchmarking against existing platforms. 
Instruments required	Inverted microscope, Optical components (Lasers, photosensors, optical bench), Rapid Prototyping Facility, sCMOS camera for Image processing, Microfabrication facility.

Any other comments	A major part of the project would involve Instrumentation, Programming and Microfabrication.

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Prof. Jatin Panwar	DBEB	jatinpanwar@iitd.ac.in
Co-supervisor	Prof. Ravikrishnan Elangovan	DBEB	elangovan@dbeb.iitd.ac.in

Skills required	
Qualification	B.Tech in Chemical, Bio-chemical, Mechanical, Electrical or related field
Skills	Experience and interest in device development and instrumentation.

References

1. Hindson BJ, Ness KD, Masquelier DA, et al. *High-Throughput Droplet Digital PCR System for Absolute Quantitation of DNA Copy Number*. *Anal Chem*. 2011;83(22):8604-8610. doi:10.1021/ac202028g
2. Whale AS, Huggett JF, Cowen S, et al. *Comparison of microfluidic digital PCR and conventional quantitative PCR for measuring copy number variation*. *Nucleic Acids Res*. 2012;40(11):e82. doi:10.1093/nar/gks203
3. Danfeng Xu, Weifei Zhang, Hongmei Li, Nan Li and Jin-Ming Lin. *Advances in droplet digital polymerase chain reaction on microfluidic chips, Lab Chip,* 2023, 23, 1258-1278

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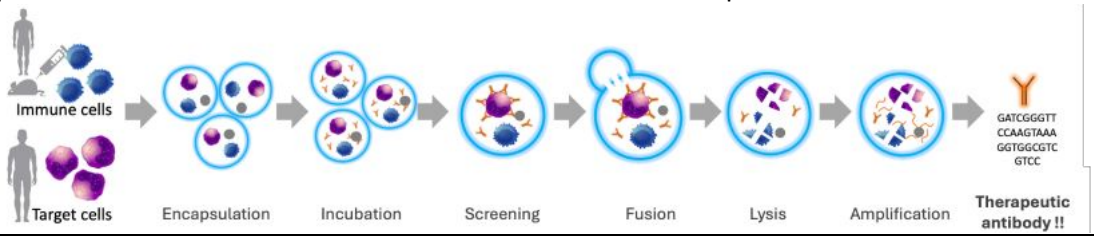
Department of Biochemical Engineering and Biotechnology

Project details	
Project title	Development of a multiparametric high-throughput droplet screening platform
Type of project	PhD/ MSR/ MTech HVA project
Project description	High-throughput droplet microfluidic platforms allow for the screening of millions of cells from both murine and human immune repertoires in a single experiment, facilitating the discovery of therapeutic antibodies[1]. Similarly, it also enables the screening of numerous droplets containing solid tumors or tumor cells alongside various drug combinations, aiding in the identification of the most effective personalized therapy[2]. For screening, droplets are analysed in real-time through a combination of optics, electronics and high-speed computational modules following which, the droplets demonstrating the desired activity are physically sorted using dielectrophoretic forces[3]. While current screening platforms predominantly rely on fluorometric analysis to detect physiological changes within the droplet, morphological changes often remain unnoticed. **The student is expected to develop instrumentation capable of deciphering the morphology of single cells by measuring their fluorescence and dielectric properties within the droplets**[4,5]. These morphological readouts will not only offer a higher resolution for examining functional antibodies but will also be valuable in screening drug combinations for treating heterogeneous tumors, presenting a significant advancement in the precision and effectiveness of high-throughput screening platforms that are cost-effect and translatable to clinical setups. 
Instruments required	Inverted microscope, Optical components (Lasers, photosensors, high-speed camera, optical bench etc.), Electronic components (Computers, FPGA systems for high-speed processing), Mammalian cell handling facility (biosafety hood, Co2 incubator etc.), Microfabrication facility (photolithography, thin film deposition, ion beam etching etc.)
Any other comments	A major part of the project would involve **computer programming, signal processing and microfabrication** with limited biotechnology component.

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Dr. Jatin Panwar	DBEB	jatinpanwar@iitd.ac.in

Skills required	
Qualification	B.Tech in Chemical, Bio-chemical, Mechanical, electrical or related field
Skills	Experience and interest in developing devices and instrumentation.

References

1. Debs, Bachir El, et al. "Functional single-cell hybridoma screening using droplet-based microfluidics." Proceedings of the National Academy of Sciences 109.29 (2012): 11570-11575.
2. Eduati, F., Utharala, R., Madhavan, D. *et al.* A microfluidics platform for combinatorial drug screening on cancer biopsies. *Nat Commun* **9**, 2434 (2018).
3. Panwar, Jatin, Alexis Autour, and Christoph A. Merten. "Design and construction of a microfluidics workstation for high-throughput multi-wavelength fluorescence and transmittance activated droplet analysis and sorting." *Nature Protocols* 18.4 (2023): 1090-1136.
4. Panwar, Jatin, and Rahul Roy. "Integrated Field's metal microelectrodes based microfluidic impedance cytometry for cell-in-droplet quantification." Microelectronic Engineering 215 (2019): 111010.
5. Sun, Tao, and Hywel Morgan. "Single-cell microfluidic impedance cytometry: a review." Microfluidics and Nanofluidics 8 (2010): 423-443.

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Department of Biochemical Engineering and Biotechnology

PhD project

Project details	
Project title	Rational Design and Fabrication of Engineered Nanomaterials for Tissue Regeneration
Type of project	PhD
Project description	Cells prefer to function efficiently in the vicinity of their native topographical features and emerging biomaterial design strategies have been directed towards mimicking the extracellular nanoenvironment of tissues. Previously, we demonstrated that nanoparticles derived from polydimethylsiloxane can be useful for recreating the nanoenvironment of skin (pl. see references). During the proposed work, an array of lipids/polymers will be synthesized for fabricating nanomaterials targeted for favourable growth of specific tissues. Various computational tools will be employed for the rational design of the nanomaterials before fabrication. The fabricated nanomaterials will also be combined with other suitable biomaterials for introducing nanotopography and the resulting nanocomposite scaffold will be utilized for tissue regeneration.
Instruments required	DLS, FE-SEM, TEM, BSL-2 Cabinet, CO_2 Incubator, Fluorescent and Confocal Microscope
Any other comments	

PhD supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Auhin Kumar Maparu	DBEB	auhin@dbeb.iitd.ac.in

Skills required	
Qualification	BTech/MTech/MSc in Chemical/Chemistry/Materials Science/Biomedical/ Biochemical Engineering or Biotechnology.
Skills	Prior experience in synthesis of nanomaterials will be preferred.

References

1. "Coating of Polydimethylsiloxane Nanoparticles Improves Bioactivity of Cellulose Paper for Culture of Fibroblasts", Auhin Kumar Maparu, Prerana Singh, Beena Rai, Ashutosh Sharma and Sri Sivakumar, *International Journal of Biological Macromolecules*, 2025, 143975
2. "PDMS Nanoparticles-Decorated PDMS Substrate Promotes Adhesion, Proliferation and Differentiation of Skin Cells", Auhin Kumar Maparu, Prerana Singh, Beena Rai, Ashutosh Sharma and Sri Sivakumar, *Journal of Colloid and Interface Science*, 659, 2024, 629-638
3. "Predicting Cytotoxicity of Nanoparticles: A Meta-Analysis using Machine Learning", Ashish Masarkar, Auhin Kumar Maparu, Yaswanth Sai Nukavarapu and Beena Rai, *ACS Applied Nano Materials*, 7, 2024, 19991-20002
4. "The Influence of Nanotopography on Cell Behaviour through Interactions with the Extracellular Matrix – A review", Jiajun Luo, Matthew Walker, Yinbo Xiao, Hannah Donnelly, Matthew J. Dalby and Manuel Salmeron-Sanchez, *Bioactive Materials*, 15, 2022, 145-159

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Department of Biochemical Engineering and Biotechnology

Proposed Projects

Research Area: Environmental Biotechnology

Indian Institute of Technology Delhi
Department of Biochemical Engineering and Biotechnology

PhD/MSR/MTech HVA project

Project details	
Project title	**Early Detection of Cyanobacterial Blooms in Riverine Systems Using Spatio-temporal Modelling**
Type of project	PhD/MSR/MTech HVA
Project description	Cyanobacterial harmful algal blooms (CynoHABs) are an emerging environmental and public health challenge in river systems worldwide. Driven by nutrient enrichment, climate variability, and altered flow conditions, these blooms can develop rapidly and release toxins that threaten water quality and ecosystem health. This project aims to develop a spatiotemporal modelling framework for early detection of bloom events using satellite observations. Satellite-derived chlorophyll-a data will be integrated with meteorological variables (such as temperature, wind speed, and rainfall) and flow-related indicators (e.g., discharge) to construct a unified dataset. The work will focus on identifying temporal patterns and lag relationships associated with bloom formation and on developing models to forecast bloom-prone conditions with short lead times. Flow effects will be incorporated through transport-informed features to account for advection and mixing, while causal inference will support interpretation of key drivers. Selected predictions will be examined through small-scale laboratory microcosm and hydrological experiments to investigate bloom responses under controlled flow and nutrient conditions. The framework will be evaluated across selected Indian rivers representing diverse hydrological and climatic conditions. **The expected outcome is a reliable and interpretable pipeline for early warning of algal blooms, with potential applications in environmental monitoring and water quality management.**
Instruments required	Workstation/HPC, microbiology laboratory facilities including incubator, spectrophotometer/plate reader, microscopy

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Garima Rani	DBEB	garimarani@iitd.ac.in

Skills required	
Qualification	Background in Bioengineering, Computational Biology, Biophysics or related fields.
Skills	**Strong interest in interdisciplinary research, with motivation to learn. Prior experience in programming and data analysis will be of advantage.**

References

1- Toward a Predictive Understanding of Cyanobacterial Harmful Algal Blooms through AI Integration of Physical, Chemical, and Biological Data,Babetta L. Marrone et al. ACS ES&T **2024** 4 (3), 844-858; DOI: 10.1021/acsestwater.3c0036

2- Nayak et al. Revisiting harmful algal blooms in India through a global lens: An integrated framework for enhanced research and monitoring, iScience 2025.

3- Park, J. et al. (2024). Recent advances in algal bloom detection and prediction technology using machine learning. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2024.173546

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Department of Biochemical Engineering and Biotechnology

PhD project

Project details	
Project title	Tailoring functional electrode interfaces for enhanced extracellular electron transfer in bioelectrochemical systems
Project description	Electroactive microorganisms can exchange electrons with external solid surfaces, such as naturally occurring metal oxides or engineered electrodes. This process, known as extracellular electron transfer, enables the generation of measurable electrical currents and underpins the field of electromicrobiology: an interdisciplinary area spanning microbiology, electrochemistry, and engineering. These organisms provide insights into unconventional metabolic pathways and have potential applications in sustainable energy and environmental technologies. This project will explore the development of novel materials for use in bioelectrochemical systems, with a focus on improving extracellular electron transfer. The research will investigate how different material properties influence interactions at the interface between biological and electrochemical components. By drawing on approaches from materials Science, electrochemistry, and microbiology, the project will examine a range of material types and fabrication strategies. The goal is to develop a broader understanding of how material characteristics can be tuned to support efficient and stable operation, contributing to future applications in sustainable technologies and environmental systems.
Instruments required	Electrochemical workstation (potentiostat). (All required equipment is readily available with the supervisors)
Any other comments	

PhD supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Prof. Lucinda Elizabeth Doyle	Department of Biochemical Engineering & Biotechnology	lucinda@iitd.ac.in
Co-supervisor	Prof. Rahul Mishra	Centre for Applied Research in Electronics	ramis@iitd.ac.in

Skills required	
Qualification	Minimum B.Tech or equivalent.

Skills	Willingness to learn new skills to carry out interdisciplinary research.

References

Grover, S. & Doyle, L.E. (2024). Advanced Electrode Materials for Microbial Extracellular Electron Transfer, *Trends in Chemistry*, 6(3), 144-158. http://doi.org/10.1016/j.trechm.2024.01.005

Aiyer, K., & Doyle, L. E. (2022). Capturing the signal of weak electricigens: a worthy endeavour. *Trends in Biotechnology*. https://doi.org/10.1016/j.tibtech.2021.10.002

Lovley, D. R., & Holmes, D. E. (2022). Electromicrobiology: the ecophysiology of phylogenetically diverse electroactive microorganisms. *Nature Reviews Microbiology*, *20*(1), 5–19. https://doi.org/10.1038/s41579-021-00597-6

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

PhD project

Project details	
Project title	Exploring interfacial electron transfer processes in electroactive microorganisms
Project description	Electroactive microorganisms can exchange electrons with external solid surfaces, such as naturally occurring metal oxides or engineered electrodes. This process, known as extracellular electron transfer, enables the generation of measurable electrical currents and underpins the field of electromicrobiology: an interdisciplinary area spanning microbiology, electrochemistry, and engineering. These organisms provide insights into unconventional metabolic pathways and have potential applications in sustainable energy and environmental technologies. This project will investigate fundamental mechanisms governing electron transfer at the interface between electroactive microorganisms and their surroundings. Particular attention will be given to emerging environmental factors that may influence these processes, alongside the development and evaluation of materials and strategies to improve the performance of bioelectrochemical systems.
Instruments required	Electrochemical workstation (potentiostat). (All required equipment is readily available with the supervisors)
Any other comments	

PhD supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Prof. Lucinda Elizabeth Doyle	Department of Biochemical Engineering & Biotechnology	lucinda@iitd.ac.in
Co-supervisor	Prof. Rahul Mishra	Centre for Applied Research in Electronics	ramis@iitd.ac.in

Skills required	
Qualification	Minimum B.Tech or equivalent.

Skills	Willingness to learn new skills to carry out interdisciplinary research.

References

Aiyer, K., & Doyle, L. E. (2022). Capturing the signal of weak electricigens: a worthy endeavour. *Trends in Biotechnology*. https://doi.org/10.1016/j.tibtech.2021.10.002

Lovley, D. R., & Holmes, D. E. (2022). Electromicrobiology: the ecophysiology of phylogenetically diverse electroactive microorganisms. *Nature Reviews Microbiology*, *20*(1), 5–19. https://doi.org/10.1038/s41579-021-00597-6

Mishra, S., Pirbadian, S., Mondal, A. K., El-Naggar, M. Y., & Naaman, R. (2019). Spin-Dependent Electron Transport through Bacterial Cell Surface Multiheme Electron Conduits. *Journal of the American Chemical Society*, *141*(49), 19198–19202. https://doi.org/10.1021/jacs.9b09262

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

MS Res and MTech HVA Project

Project details	
Project title	Next generation bioformulations
Project description	With the loss of confidence among farmers, on conventional bioformulations, its imperative to explore possibilities of development of next generation bioformulations with enhanced survival and efficiency. Supplementation of active metabolities which mediate enhanced plant growth and productivity, and serve as protectant for plant growth promoting bionoculants strains can serve as an efficient strategy mitigation the detrimental impact of climate change in agricultural context.
Instruments required	Controlled growth chamber, thermal cycler, and other routine equipments used in molecular microbiology
Any other comments	None

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Dr. Shilpi Sharma	DBEB	shilpi@dbeb.iitd.ac.in

Skills required	
Qualification	B.Tech/BE/M.Sc. in any field of Microbiology/Biotechnology/Agricultural Biotechnology/ Life Science
Skills	Desirable: Experience in microbiome analysis and/or plant microbe interactions

References

https://doi.org/10.1111/ppl.70371

https://doi.org/10.1007/s00344-023-10996-z

https://doi.org/10.1007/s42729-022-00958-x

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

PhD project

Project details	
Project title	Mitigation of abiotic stresses in plants by using microbiome based approach
Project description	Agricultural sustainability is the need of the hour. Due to the inherent limitations of application of conventional bionoculations in agriculture, more robust microbiome based approaches are being developed. The project aims to first understand the impact of stresses on rhizospheric microbial commmunity structure and function. Further, it aims to employ rhizosphere engineering to sustainably mitigate abiotic stresses in plants.
Instruments required	Real time cycler, plant growth chamber etc.
Any other comments	

PhD supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Shilpi Sharma	DBEB	shilpi@dbeb.iitd.ac.in
Co-supervisor			

Skills required	
Qualification	M.Sc / M.Tech. in Plant Molecular Biology, Plant Biotechnology, Agricultural Microbiology, Agricultural Biotechnology, Botany
Skills	Basic molecular microbiology tools

References

https://doi.org/10.1007/s10725-020-00667-4
https://doi.org/10.1007/s10725-022-00820-1
https://doi.org/10.1016/j.envexpbot.2022.104988

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

MS Res and MTech HVA Project

Project details	
Project title	**Storage of soil microbiome to retain its functionality**
Project description	With the establishment of the crucial role of the soil microbiome in promoting plant's fitness, as well as contributing to One Health, it becomes important to devise a strategy to store the soil microbiome to retain its functionality for a later application in natural conditions. The project aims to develop such an approach, and validate it through testing the stored soils efficacy in plant growth promotion
Instruments required	Controlled growth chamber, thermal cycler, and other routine equipments used in molecular microbiology
Any other comments	None

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Dr. Shilpi Sharma	DBEB	shilpi@dbeb.iitd.ac.in

Skills required	
Qualification	B.Tech/BE/M.Sc. in any field of Microbiology/Biotechnology/Agricultural Biotechnology/ Life Science
Skills	Desirable: Experience in microbiome analysis and/or plant microbe interactions

References

Bhattacharjee et al 2022 https://doi.org/10.1007/s11356-021-17164-4

Dubey and Sharma 2021, https://doi.org/10.1080/07352689.2021.1959137

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

Ph.D. project

Project details	
Project title	**Transforming disease conducive soil to suppressive one**
Project description	A thorough understanding of the mechanisms involved in soil naturally suppressive to phytopathogens can reveal the crucial metabolites and microbial members contributing to this phenomenon. These can be harnessed to transform a disease conducive soil to a suppressive one, thereby bringing in agricultural sustainability. The project aims to devise and deploy such an approach for minimizing the application of chemicals in arable land
Instruments required	Plant growth chamber, thermal cycler, and other routine equipments used in molecular microbiology
Any other comments	None

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Dr. Shilpi Sharma	DBEB	shilpi@dbeb.iitd.ac.in

Skills required	
Qualification	M.Sc./M.Tech in any field of Microbiology/Agricultural Biotechnology/ Life Science
Skills	Desirable: Experience in microbiome analysis and/or plant microbe interactions

References

Khatri et al 2024, https://doi.org/10.1007/s11274-024-03895-2

Khatri et al 2023, https://doi.org/10.1007/s11104-023-05927-6

Indian Institute of Technology Delhi
Department of Biochemical Engineering and Biotechnology
PhD/MSR project

Project details	
Project title	**Microbial biosurfactant as next generation bioformulations for agricultural sustainability**
Type of project	PhD
Project description	Biosurfactants can serve as eco-friendly alternatives to chemicals for controlling phytopathogens and plant growth promotion. This project aims to employ biosurfactant producing rhizobacterial strains as next generation bioformulations and establish their mechanism of action in enhancing soil and plant health. The specific objectives will be (1) Isolation and screening of potent biosurfactant producing bacteria from host rhizosphere, (2) Establishment of its impact on soil health, (3) Assessment of its effect on plant health, (4) Development of bioformulation
Instruments required	Basic molecular microbiology equipments, plant growth chamber

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Shilpi Sharma	DBEB	shilpi@dbeb.iitd.ac.in
Supervisor	Preeti Srivastava	DBEB	preeti@dbeb.iitd.ac.in

Skills required	
Qualification	BTech/BE in Bioengineering/Biotechnology OR MSc/MTech in Biosciences/Life Sciences and allied subjects
Skills	Desirable: Basic microbiology and molecular biology training

References

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Indian Institute of Technology Delhi
Department of Biochemical Engineering and Biotechnology
PhD project

Project details	
Project title	**Understanding the mechanism of regulation of tpx genes and development of an improved system for production of thiol peroxidases**
Type of project	PhD
Project description	Thiol peroxidases belong to the oxidoreductase class of enzyme. Recently we reported that they can be used for synthesis of porous carbon. Thiol peroxidases carry out the catalysis reaction using thiols. These enzymes do not need any cofactor or prosthetic group to show their activity and hence act as naked protein. These proteins mostly have a cysteine residue at their active sites which undergoes redox shuttling while carrying out their catalytic activity. The enzyme is usually produced by bacteria as a stress response element. However, the mechanism of regulation of the gene encoding for thiol peroxidases is not known. What are the various stress factors which can lead to induction of these enzymes is not known. The broad aim of the study is not only to understand the regulation of thiol peroxidases but also to develop a system for improved production of thiol peroxidases. The specific aims will be: a) Delineate the structure of promoter regulating the gene coding for thiol peroxidase b) Determine the various stress inducing elements which are responsible for induction c) Engineering of thiol peroxidases for enhanced activity and stability d) Development of a system for improved production of thiol peroxidases
Instruments required	Molecular biology equipments

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Preeti Srivastava	DBEB	preeti@dbeb.iitd.ac.in

Skills required	
Qualification	M.Sc/ M. Tech/B. Tech with JRF (CSIR/UGC/DBT-A)
Skills	Molecular biology skills

References

1. Patil. N. and **Srivastava, P.** (2025) Asphaltene biotransformation by a novel enzyme thiol peroxidase from Micrococcus sp. IITD107. ***Applied Environmental Microbiology*** 91:e00151-25. IF 3.7.

2. Patil.N. and **Srivastava, P.** (2025) Deletion or overexpression of *tpx* gene alters doubling time, response to stress agents and affects asphaltene biotransformation in *Micrococcus* sp. IITD107. ***Applied Microbiology and Biotechnology*** 109: 269. IF 4.3

Indian Institute of Technology Delhi
Department of Biochemical Engineering and Biotechnology
MSR project

Project details	
Project title	**Role of non-canonical DNA structures in bacterial adaptation**
Type of project	MSR
Project description	There are several non-canonical DNA structures which include G quadruplexes, hairpins, cruciform, i-motifs etc. The role of these structures in microbial adaptation is not known. The broad aim of the study will be to map the presence of these structures in the genome of a biodesulfurizing bacterium Gordonia sp. IITR100. The presence of these structures will be studied in other Gordonia spp. as well. The presence of these structures will be visualized by microscopy. The formation of these structures will be studied in the presence of different salts and other stress factors. The role of these structures in genetic adaptation which will include upregulation or downregulation of genes, regulation of translation, DNA replication and genetic rearrangements, will be studied.
Instruments required	Molecular biology equipments

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Preeti Srivastava	DBEB	preeti@dbeb.iitd.ac.in

Skills required	
Qualification	B. Tech
Skills	Molecular biology skills

References

1. **Makova, K.D. and Weissensteiner, M.H. (2023) Non-canonical DNA structures are drivers of genome evolution. Trends Genet. 39: 109-124.**

Department of Biochemical Engineering and Biotechnology

Format for preparation of MS(R)/PhD project proposals

Title: Development of IoT enabled system for water quality surveillance in water bodies

Objective: Development of IoT enabled sensor assembly for efficient and rapid monitoring of conventional and emerging pollutants present in water bodies.

Background: Increase in water pollution and reduction of fresh water reserve is leading towards a situation of dire water scarcity. Global warming is also catalyzing the possibility. Rapid and efficient monitoring system can ensure rapid identification of pollution caused by different effluent and this can help in taking appropriate measures to protect receiving water bodies. IoT enabled monitoring system would help in remote monitoring and reduce the chance of mishandling of the monitoring system. An array of sensors will be developed and used in a compact housing to make easily deployable small sensor assembly for monitoring water quality. Predictive models will be developed based on the data obtained from the monitoring systems.

Methodology : Estimation of abundance of conventional and emerging pollutants, estimation of kinetics of pollutants proliferation, neural network model to predict the water quality.

Equipment required : Potentiostat, qPCR, MALDI-TOF, LC-MS, GC-MS, HPLC, spectrophotometer, GC

Special chemicals/reagents required: NA

Department of Biochemical Engineering and Biotechnology

Format for preparation of MS(R)/PhD project proposals

Title: Treatment of Urban Sewage for Healthy Reuse

Objective: Assessment of different treatment schemes to treat urban sewage and development of appropriate strategy for healthy reuse of the treated water.

Background: Management of urban sewage in efficient and economical manners is very challenging. An assessment of different treatment options will be made to identify appropriate treatment (secondary and tertiary) options in treating urban sewage (conventional and emerging contaminants). Risk assessment will be done for making use of the treated water in most effective and sustainable manner for various purposes. Overall strategy will be developed in managing the urban sewage for its healthy reuse.

Methodology : Estimation of different conventional and emerging contaminants, Development of different secondary and tertiary treatment systems and assessment of their performance in treating different contaminants

Equipment required : qPCR, MALDI-TOF, LC-MS, GC-MS, HPLC, spectrophotometer, GC,

Special chemicals/reagents required: qPCR master mix, SPE column

Department of Biochemical Engineering and Biotechnology

Format for preparation of MS(R)/PhD project proposals

Title: Integrated monitoring and treatment of emerging and conventional pollutants for rejuvenation of riverine systems

Objective: Assessment of different pollutant sources contributing to river water pollution and development of appropriate strategy for rejuvenating the river.

Background: Rivers such as the Ganga are critical water resources that support the domestic, agricultural, and economic activities of large populations living within their basins. However, river water quality is increasingly threatened by a wide range of chemical and biological contaminants, including both conventional pollutants and emerging contaminants. Low-cost and sustainable interventions such as riverbank filtration, phytoremediation, and treatment using phototrophic microorganisms offer significant potential for improving water quality. These approaches can serve as effective and frugal solutions, particularly when integrated with solar-energy-based systems, while also enabling resource recovery for farming communities.

Methodology : Estimation of different conventional and emerging contaminants, Development of different secondary and tertiary treatment systems and assessment of their performance in treating different contaminants, study a 100 km stretch of Ganga river to understand the problem and testing the efficacy of the interventions

Equipment required : qPCR, MALDI-TOF, LC-MS, GC-MS, HPLC, spectrophotometer, GC,

Special chemicals/reagents required: qPCR master mix, SPE column

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

Proposed Projects

Research Area: Computational and Systems Biology

Indian Institute of Technology Delhi
Department of Biochemical Engineering and Biotechnology
PhD/MSR/MTech HVA project

Project details	
Project title	**Predictive Modeling of Metabolic–Mechanobiological Cross-Talk in Oral Microbiome Dysbiosis for Early Detection and Intervention**
Type of project	PhD/MSR/MTech HVA
Project description	The oral microbiome forms a highly structured and dynamic ecosystem that maintains tissue homeostasis through metabolic cooperation and spatial organization. In diseases such as periodontitis and oral cancer, this homeostasis is disrupted, leading to dysbiosis, altered metabolic interactions, and changes in the mechanical microenvironment (e.g., biofilm structure, shear stress, tissue stiffness). Despite advances in microbiome profiling, a mechanistic understanding of how microbial interactions, metabolism and physical forces co-evolve during disease progression remains limited, and current approaches are largely descriptive with limited predictive capability. **This PhD research aims to develop an AI-driven computational framework to understand and predict the transition of the oral microbiome from healthy to dysbiosis by integrating microbial interactions with metabolic and mechanobiological processes. By combining modeling with machine learning, the project seeks to develop a toolbox to identify early biomarkers of disease and uncover key mechanisms driving oral conditions like periodontitis and oral cancer.**
Instruments required	High-performance workstation/ HPC cluster

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Garima Rani	DBEB	garimarani@iitd.ac.in

Skills required	
Qualification	Degree in Bioinformatics, Computational Biology, Engineering, Biophysics or related quantitative fields

Skills	**Strong interest in interdisciplinary research at the interface of physics, biology, and computation; proficiency in programming.** **Experience in mathematical modeling and statistical analysis or machine learning will be of advantage.**

References

1- Soghli N et al. Recent advancements in artificial intelligence-powered cancer prediction from oral microbiome. Periodontology 2000. 2025;98:181-213. doi:**10.1111/prd.70000**

2- Li, C., Fan, Y. & Chen, X. Oral microbiota–driven immune modulation along the oral–gut axis: from local signals to systemic inflammation. *npj Biofilms Microbiomes* **12**, 46 (2026). https://doi.org/10.1038/s41522-026-00912-0

Project no 23

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

PhD project

Project details	
Project title	Development of a novel One-health framework for fungal pathogen surveillance
Type of project	MSR/PhD project
Project description	The project establishes an integrated One-Health surveillance system tracking fungal pathogen emergence from environmental reservoirs like bird droppings and poultry litter to clinical infections. It combines Nanopore metagenomics from urban transport hubs and hospitals with CRISPR-based diagnostics. AI models will be developed to predict pathogen load and spillover risk by integrating genomic, clinical, and geotagged environmental data. Clinical isolates from hospital networks enable resistance profiling, creating a national repository linking environmental circulation to human outbreaks. This scalable framework addresses fungal antimicrobial resistance gaps, informing stewardship and outbreak response.
Instruments required	High-throughput sequencing using Illumina, MGI sequencer, Oxford Nanopore sequencing and Genomics software, High performance computing. Mammalian Cell Culture Facility (Biosafety Hood, Co2 incubator etc), PCR, Molecular biology related equipments (Gel Running Apparatus, PCR, rt-qPCR etc.)
Any other comments	None

PI: Prof. Ishaan Gupta

Skills required

Qualification	BTech/BE in any field of Engineering or Life Science OR BSC or BS with MSc/MTech in any field of Engineering or Life Science
Skills	Experience in executing Computational Biology projects. Experience in Basic Molecular Biology Experiments.

Project no. 24

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

PhD project

Project details	
Project title	Predictive modelling of transitions in cellular States across Disease and Evolution
Type of project	MSR/PhD project
Project description	Cells constantly face competing demands—growth versus survival, function versus stress response—that shape their behavior in disease and evolution. Using single-cell and spatial gene expression data from human tumors and animal models, this project reveals how these trade-offs drive cancer progression and species divergence, creating predictive models with broad applications in medicine and evolutionary biology. Research Questions How do cellular trade-offs manifest as distinct patterns in cancer gene expression atlases? What principles govern normal-to-malignant cell state transitions? How do similar cell types evolve differently across species over millions of years? Student will be working with cutting-edge computational tools to build an open-source software pipeline that uncovers these hidden patterns, creating predictive models for disease progression and evolutionary adaptation.
Instruments required	HPC
Any other comments	None
Supervisors	Prof. Anjan, Prof. Ishaan

Skills required	
Qualification	BTech/BE in any field of Engineering or Life Science OR BSC or BS with MSc/MTech in any field of Engineering or Life Sciences
Skills	Experience in executing Physics, Mathematics, Computational Chemistry or Computational Biology projects. Prior experience with mathemtical/computational modeling will be preferred.

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

Proposed Projects

Research Area: Bio-manufacturing

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

PhD project

Project no. 25

Project details	
Project title	Development of novel spatial omics assays for precision biology
Type of project	MSR/PhD project
Project description	Spatial omics technologies revolutionize precision biology by mapping molecular profiles to tissue architecture, revealing cellular neighborhoods and intercellular communication undiscoverable by dissociated single-cell methods. We develop next-generation assays combining high-plex imaging (CosMx/MERFISH) with in situ sequencing (ExSeq/seqFISH), achieving sub-cellular resolution across 1000+ genes. These platforms enable precision oncology applications including immunotherapy response prediction, tumor-immune spatial dynamics, and drug resistance mapping directly from clinical FFPE biopsies.
Instruments required	High-throughput sequencing using Illumina, MGI sequencer, Oxford Nanopore sequencing and Genomics software, High performance computing. Mammalian Cell Culture Facility (Biosafety Hood, Co2 incubator etc), PCR, Molecular biology related equipments (Gel Running Apparatus, PCR, rt-qPCR etc.)
Any other comments	None

PI: Prof. Ishaan Gupta

Skills required	
Qualification	BTech/BE in any field of Engineering or Life Science OR BSC or BS with MSc/MTech in any field of Engineering or Life Science

Skills	Experience in executing Computational Biology projects. Experience in Basic Molecular Biology Experiments.

Indian Institute of technology Delhi

Department of Biochemical Engineering and Biotechnology

MSR project

Project details	
Project title	Enhancing the ethanol productivity of glucose-limited cultures of *Scheffersomyces (Pichia) stipitis*.
Project description	**Background:** The yeast *S. cerevisiae*, which is typically used for ethanol production, ferments (ie., produces ethanol) only in the presence of a few sugars such as glucose. In contrast, the yeast *S. stipitis* ferments almost all sugars — a considerable advantage for fermentation of the sugar mixtures that occur in lignocellulosic hydrolysates. However, *S. stipitis* is completely outperformed by *S. cerevisiae* in the presence of glucose, the most common sugar in lignocellulosic hydrolysates. First, *S. cerevisiae* ferments glucose 3 times faster than *S. stipitis*. Second, *S. cerevisiae* ferments glucose under oxygen-excess, oxygen-limited, and oxygen-free conditions, whereas *S. stipitis* does so only under oxgyen-limited conditions. If these two limitations of *S. stipitis* could be overcome, it would be superior to *S. cerevisiae* in every way. **Objectives and Methodology:** The literature suggests that the abovementioned deficiencies of *S. stipitis* in the presence of glucose are due to a limitation at the level of transport. The goal of this work is test this hypothesis by studying ethanol production in cells over-expressing the glucose transporter(s). To this end, we have constructed a plasmid specifically for engineering *S. stipitis*, and identified potential glucose transporters for overexpression. The efficacy of strains overexpressing glucose transporter(s) will be tested in shake flasks, and their genetic stability will be determined in bioreactors.
Instruments required	
Any other comments	

PhD supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
PI	Prof. Atul Narang	DBEB	anarang@dbeb.iitd.ac.in

Skills required	
Qualification	B. Tech. (Biotechnology or Biochemical Engineering, MSc (Biochemistry or Molecular Biology or related Life Science disciplines)

Skills	The project involves cloning and strain construction techniques of molecular biology.

References

1. Maitra, Shraddha, and Atul Narang. "Quantifying the parametric sensitivity of ethanol production by Scheffersomyces (Pichia) stipitis: development and verification of a method based on the principles of growth on mixtures of complementary substrates." *Microbiology (Reading, England)* 164, no. 11 (2018): 1348-1360. Available at https://doi.org/10.1099/mic.0.000719
2. Maitra, Shraddha, and Atul Narang. "Existence of a scaling relation in continuous cultures of Scheffersomyces stipitis: the steady states are completely determined by the ratio of carbon and oxygen uptake rates." *Biotechnology for biofuels* 12, no. 1 (2019): 19. Available at https://link.springer.com/article/10.1186/s13068-019-1357-3

Indian Institute of Technology Delhi
Department of Biochemical Engineering and Biotechnology
PhD project

Project details	
Project title	**Bacterial Microcompartments: a novel technology for recombinant protein production**
Type of project	PhD
Project description	Bacteria have often been the preferred choice of host owing to their ease of growth and availability of tools for genetic manipulation. A number of tools have been developed for the production of recombinant proteins in different bacterial hosts. Production of toxic proteins or proteins containing disulfide bridges however, remains a challenge. Several methods including the use of tightly regulated promoter or use of fusion partners for toxic proteins and secretion vectors for expression of proteins with disulfide bridges have been suggested. Here, we propose the use of bacterial microcompartments (BMCs) for the production of such proteins. The objectives will be i) Development of E. coli and Rhodococcus strains expressing BMC shell proteins; ii) Optimization of the EP sequences; iii) Construction of an indigenous universal plasmid vector for expression of recombinant proteins in BMCs; iv) Construction of multiple helper plasmids and expression of toxic proteins. The work would result in the development of an indigenous host vector system for the easy production of toxic proteins.
Instruments required	Transmission electron microscope, fluorescence microscope, other molecular biology equipments

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Preeti Srivastava	DBEB	preeti@dbeb.iitd.ac.in

Skills required	
Qualification	M.Sc/ M. Tech/B. Tech with JRF (CSIR/UGC/DBT-A)
Skills	Molecular biology skills

References

1. Chandrakanta, C., Karmakar, S., Jain, P., Kumar, V., Shefrin, S., Sundar, D. and **Srivastava, P.** (2025) Construction and characterization of cloning vector and Temperature sensitive vectors for Gordonia sp. IITR100. ***Gene***. 951, 149376. IF 2.6
2. Bagchi, A., Karmakar, S., Bisaria, V.S. and **Srivastava, P.** (2023) Recombineering. ***Methods in Microbiology*** (accepted). IF 3.0
3. Jaishankar, J., Keshav, A., Jayaram, B., Chavan, S. and **Srivastava, P.** (2022) Characterization and regulation of divergent promoters PmaiA and Phyd from *Gordonia*: coexpression and regulation by CRP. ***BBA Gene regulatory mechanisms*** (2022). 1865 (6):194843. IF 6.3

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

PhD/MSR project

Project details	
Project title	**Protein engineering using computational design**
Whether PhD or MSR project	PhD / MSR project
Project description	Protein engineering is an important field of study that has widespread applications in the design of better biological therapeutics, bulk enzymes and multiple industrial processes like food and biochemical production. Protein design seeks to predict specific changes in amino acids to improve protein properties using naturally occurring proteins as templates. Multiple approaches have been proposed for protein design; however many lack experimental validation. This project aims to use different methods to predict enhancement of specific protein properties followed by its experimental validation. Initially, *in silico* tools that use phylogenetic sequence analysis will be used for predicting protein sequence changes for improving protein properties. These will be used to make mutations in specific target proteins *in vitro* using techniques like site directed mutagenesis. Paramaters will then be measured to identify predicted improvement in the proteins.
Instruments required	Shaker incubator
Any other comments	

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor 1	Ashish Misra	DBEB	ashishmisra@dbeb.iitd.ac.in

Skills required	
Qualification	M. Tech/B. Tech Biochemical Engg/ MSc in Life Sciences/Biotechnology

Skills	Molecular biology/ Biochemistry/ Bioprocess Engg

References

1. Goldenzweig, A., & Fleishman, S. J. (2018). Principles of protein stability and their application in computational design. *Annual review of biochemistry*, *87*(1), 105-129.
2. Diaz, D. J., Gong, C., Ouyang-Zhang, J., Loy, J. M., Wells, J., Yang, D., ... & Klivans, A. R. (2024). Stability Oracle: a structure-based graph-transformer framework for identifying stabilizing mutations. *Nature Communications*, *15*(1), 6170.

Indian Institute of Technology Delhi

Department of Biochemical Engineering and Biotechnology

PhD/MSR project

Project details	
Project title	**Cell free metabolic engineering for the production of secondary metabolites**
Whether PhD or MSR project	PhD / MSR project
Project description	Cell-free metabolic engineering is emerging as a new approach that overcomes the limitations of existing cell-based systems. Cell-free systems allows easy access to reaction conditions, can circumvent competing by-product pathways, offer fewer toxicity constraints, and avoid the need to divert energy and carbon resources to supporting cell growth circumventing challenges associated with classical metabolic engineering. Secondary metabolites form a class of extremely valuable compounds that are hard to produce via traditional metabolic engineering because of complex metabolic regulation and control which limits flux to the pathway In this project, high value secondary compound(s) will be produced in-vitro starting with cheaper substrate in a one pot process. The project will involve cloning and expression of the enzymes of the pathway in a suitable recombinant host, estimating the parameters such as Km,Kcat, inhibition constants and developing kinetic models to optimize bioconversion. Further, processes for producing the enzymes in reactors and purification/immobilization will be developed, followed by purification of the product.
Instruments required	Bioreactor, HPLC
Any other comments	

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor 1	Ashish Misra	DBEB	ashishmisra@dbeb.iitd.ac.in
Supervisor 2	Preeti Srivastava	DBEB	preeti@dbeb.iitd.ac.in

Skills required

Qualification	M. Tech/B. Tech Biochemical Engg/ MSc in Life Sciences/Biotechnology
Skills	Molecular biology/ Biochemistry/ Bioprocess Engg

References

1. Kaprakadden, A., **Srivastava, P.,** and Bisaria, V.S. (2017) In vitro biosynthesis of 9,10 dihydroxyhexadecanoic acid using recombinant *Escherichia coli*. ***Microbial Cell Factories*** 16(1):85
2. Jaishankar, J., Keshav, A., Jayaram, B., Chavan, S. and **Srivastava, P.** (2022) Characterization and regulation of divergent promoters PmaiA and Phyd from *Gordonia*: coexpression and regulation by CRP. ***BBA Gene regulatory mechanisms*** (2022). 1865 (6):194843.
3. Dudley, Q. M., Karim, A. S., & Jewett, M. C. (2015). Cell-free metabolic engineering: biomanufacturing beyond the cell. ***Biotechnology journal***, *10*(1), 69-82.