Indian Institute of technology Delhi

Department of Biochemical Engineering and Biotechnology

MSR project (jointly with Prof Jatin Panwar)

Project details	
Project title	Automatic data acquisition in a bioreactor of an accelerostat.
Project description	**Background:** Since bioreactors are operated for several days orweeks, automatic data acquisition is of critical importance. It reduces manpower requirement, but more importantly, it allows the user to determine in real time if good quality data is being obtained. Over the last two years, we have automated the flow rates and composition of the gas stream flowing into and out of the bioreactor, as well as the dilution rate of the liquid stream feeding nutrients to the bioreactor. We have also checked the proof-of-concept for automatic sensing of biomass concentration and automatic collection of samples from the bioreactor. However, it remains to test their performance in a working bioreactor. **Objectives and Methodology:** The goal is to test the performance of the existing biomass sensor and sample collection device in a working bioreactor, and to optimise the design if necessary. This optimisation process will potentially entail 3D-printing for modification of the biomass sensor and sample collection device (if necessary).
Instruments required	Bioreactor (available in Bioprocess lab) and 3D printing (available in Institute workshop).
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. or M. Tech. (Biotechnology or Biochemical Engineering or Chemical Engineering)
Skills	The project involves operation of bioreactors and programming (since LabView is being used for on-line data acquisition and manipulation).

References
1. Adamberg K, Valgepea K, Vilu R. Advanced continuous cultivation methods for systems microbiology. Microbiology. 2015 Sep 1;161(9):1707-19. Available at https://doi.org/10.1099/mic.0.000146

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Department of Biochemical Engineering and Biotechnology

PhD/MSR project

Project details	
Project title	Automated micro-droplet packaging to generate combinatorial assays for personalized cancer therapy.
Type of project	Either PhD or MSR 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 (Computers with high-speed prcessing capacity), Mammalian cell/tissue handling facility (biosafety hood, Co2 incubator, tissue slicer etc), Molecular biology related equipments (Gel Running Apparatus, PCR, centrifuge etc.)
Any other comments	None

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Dr. 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).
4. 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.
5. Panwar, Jatin, et al. "iSort enables automated complex microfluidic droplet sorting in an effort to democratize technology." *Cell Reports Methods* 3.5 (2023).

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Department of Biochemical Engineering and Biotechnology

PhD/MSR project

Project details	
Project title	Developing a multiparametric high-throughput droplet screening platform.
Type of project	Either PhD or MSR project
Project description	Microfluidic droplets serve as miniaturized bio-reactors, enabling the study of individual cells in isolation [1]. This is particularly advantageous for areas like single-cell secretomics, antibody discovery, combinatorial drug screening, directed evolution, and cell-cell interaction studies. For instance, this technology allows for the screening of millions of cells from both murine and human immune repertoires in a single experiment, facilitating the discovery of therapeutic antibodies [2]. 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 [3]. For screening purposes, 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 [4]. While current screening platforms predominantly rely on fluorometric analysis to detect physiological changes within the droplet, morphological changes often remain unnoticed. In this project, we aim to develop instrumentation capable of deciphering the morphology of single cells by measuring their dielectric properties within the droplets [5, 6]. 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 low-resource clinical setups.
Instruments required	Inverted microscope, Optical components (Lasers, photosensors, high-speed camera, optical bench etc.), Electronic components (Impedance spectroscope, high-voltage amplifier, computers with high-speed prcessing capacity), Mammalian cell/tissue handling facility (biosafety hood, Co2 incubator etc.), Molecular biology related equipments (Gel Running Apparatus, PCR, centrifuge etc.)
Any other comments	None

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

Skills required	
Qualification	BTech/ MTech in Chemical, Bio-chemical, Mechanical, Electrical or related field MSc /MTech in 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. 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.
3. Eduati, F., Utharala, R., Madhavan, D. et al. A microfluidics platform for combinatorial drug screening on cancer biopsies. Nat Commun 9, 2434 (2018).
4. 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.
5. Panwar, Jatin, and Rahul Roy. "Integrated Field's metal microelectrodes based microfluidic impedance cytometry for cell-in-droplet quantification." Microelectronic Engineering 215 (2019): 111010.
6. Sun, Tao, and Hywel Morgan. "Single-cell microfluidic impedance cytometry: a review." Microfluidics and Nanofluidics 8 (2010): 423-443.

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PhD/MSR project

Project details	
Project title	Manipulation of red blood cell in microfluidic platform
Type of project	MSR project
Project description	Human health is greatly influenced by physiological functions of red blood cells (RBCs). Any alteration in the physiological function of RBCs leads to complications in the human circulatory system resulting in a plethora of vascular diseases. Therefore, characterization of electromechanical and biochemical properties of RBCs is required to achieve specific objectives that are relevant in problems related to blood flow. This research problem, wherein an understanding of the interplay of flow fields and electric fields in microchannel of microfluidic device is targeted, is aimed to understand the underlying physics of altered RBC interaction which is commonly observed in blood vessels under both physiological and pathological conditions. This study would involve conducting experiments on healthy and diseased RBCs under dynamic flow conditions, and will lead to insights into fluid-electric field interaction, fluid-cell interaction, cell-cell interaction, cell-electric field interaction, and other electromechanical responses. For the execution of this project a basic knowledge and understanding of technical components such as fluid mechanics, low Reynolds number hydrodynamics, electro-hydrodynamics, physics would be required.
Instruments required	Inverted microscope, Centrifuge
Any other comments	

PhD/MSR supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Dr. Kumari Priti Sinha	DBEB	priti.iitb09@gmail.com

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

References

1. Miki Kanemaki, Analysis of Red Blood Cell Movement in Whole Blood Exposed to DC and ELF Electric Fields, Bioelectromagnetics. 2022 Apr; 43(3): 149–159

2. G V Grigorev et al., Advances in Microfluidics for Single Red Blood Cell Analysis, *Biosensors* 2023, *13*(1), 117

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Project no.

Department of Biochemical Engineering and Biotechnology

MSR project

Project details	
Project title	Construction and characterization of empty bacterial microcompartments in heterologous hosts
Type of project	MSR project
Project description	Bacterial microcompartments are attractive prokaryotic organelles loaded with catabolic or anabolic enzymes in prokaryotes. They are made up of proteinaceous shell, instead of phospholipid membrane. Several microorganisms have been reported to contain bacterial microcompartments. However, bacterial microcompartments from only few microrganisms have been experimentally characterized. Further, there are only limited reports on the construction of empty bacterial microcompartments. Empty bacterial microcompartments can be used to encapsulate various types of enzymes. Thus, they can serve as tools for loading desired proteins or enzymes. The specific objectives will be a) Construction of empty bacterial microcompartments b) Characterization of empty bacterial microcompartments c) Encapsulation of GFP in empty bacterial microcompartments
Instruments required	Fluorescence microscope, Transmission electron microscope
Any other comments	

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

Skills required	
Qualification	B. Tech in Biotechnology
Skills	Microbiology and Molecular biology skills

References

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Department of Biochemical Engineering and Biotechnology

MS Res 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

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Department of Biochemical Engineering and Biotechnology

PhD/MS(R) project

Project details	
Project title	Mathematical modeling to understand coordination of bacterial growth and division in microbes
Project description	Cell division is a crucial process for the survival and proliferation of microbes. It needs to be coordinated with the growth of biomass and the replication of DNA, so that a fixed average size is maintained (size homoeostasis), and also to ensure that the daughter cells inherit the minimum copies of crucial, low copy number macromolecules. Multiple competing molecular mechanisms have been suggested to describe this coordination. However, the causality and implications are not clear. In this project we will do mathematical modeling of cellular division, and division control to understand the underlying principles of this coordination. We will also aim to make predictions that can validate/falsify competing models.
Instruments required	Laptop/Desktop
Any other comments	

PhD supervisors			
Role	**Faculty**	**Academic unit at IITD**	**E-mail**
Supervisor	Anjan Roy	DBEB	anjanroy@iitd.ac.in
Co-supervisor			

Skills required	
Qualification	Previous degree in quantitative sciences.

Skills	Critical thinking. Coding in C/Python/Julia/Matlab. Mathematical aptitude.

References

[1] **Roy, A.**, Goberman, D., Pugatch, R. (2021). A unifying autocatalytic network-based framework for bacterial growth laws. PNAS, 118(33)