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Master Thesis:
Evaluating the Biological Impact of Electric Fields in Microfluidic Cell Manipulation Platforms

In recent years, dielectrophoresis and electrorotation have emerged as powerful techniques for the manipulation and characterization of biological cells within microfluidic devices. While these methods enable precise control and analysis of single cells, their application requires careful assessment of the impact of electric fields on cellular physiology, viability and function.

This master thesis project aims to investigate the biological effects of electric-field exposure on mammalian cells and to establish robust methodologies for monitoring cellular health during electrokinetic experiments. The student will implement, optimize and apply fluorescence-based assays to assess cell viability, apoptosis, reactive oxygen species (ROS) generation and potential thermal effects induced within microfluidic devices. Particular emphasis will be placed on combining dielectric characterization techniques with time-resolved fluorescence imaging to monitor cellular responses before, during and after exposure to electric fields.

The developed methodologies will be applied to different electrokinetic platforms currently under development in the laboratory. A first objective will be to validate the biocompatibility of electrorotation experiments used to characterize cellular dielectric properties and investigate drug-induced changes in cell membrane behavior. A second objective will be to assess the compatibility of dielectrophoretic trapping strategies employed in a microfluidic droplet co-encapsulation platform, where electric fields are used to control and synchronize the encapsulation of multiple cells within the same droplet.

The outcomes of this work will provide important guidelines for the design of electrokinetic microfluidic systems, contributing to the development of more reliable platforms for single-cell analysis, cell-cell interaction studies and cell-based assays.

The project offers hands-on experience in microfluidics, single-cell analysis, fluorescence microscopy, electrokinetic cell manipulation and experimental bioengineering research.

Type of work: 10% literature review, 15% microfluidic device preparation and testing, 30% cell culture and biological characterization, 25% electrorotation and dielectrophoresis experiments, 20% data analysis and scientific reporting.

Duration: 6-8 months

Prerequisites: Ideally, someone with a background in bioengineering, life sciences engineering, biotechnology, cell biology or microtechnology. Previous experience with cell culture, microfluidics or cleanroom fabrication is highly appreciated, but not required. A strong motivation is required regardless of academic background.

Do not hesitate to contact me by email in case of interest: edoardo.bargis@epfl.ch

References:

[1] Varma and Voldman, Caring for Cells in Microsystems: Principles and Practices of Cell-Safe Device Design and Operation, Lab on a Chip, 2021.

[2] Beech et al., Active Posts in Deterministic Lateral Displacement Devices, Advanced Materials Technologies, 2019.

[3] Ryser et al., A Microfluidic Platform for Whole-Membrane Integrity Profiling in Live Neuronal Cells, bioRxiv, 2025.