SCALABLE MICRO-ELECTRO FLUIDIC PLATFORMS FOR HEALTH, MATERIALS, AND BIOPHYSIC APPLICATIONS IN RESOURCE-CONSTRAINED CONDITIONS

Leonardo Lesser-Rojas[1], Estefany García-Martínez[2], Katherine Acuña-Umaña[3], David Monge-Castillo[3], Guido Ramírez-González[3], Caterina Guzmán-Verri[4], Karina Torres-Castro[5], Carolina Centeno-Cerdas[6]

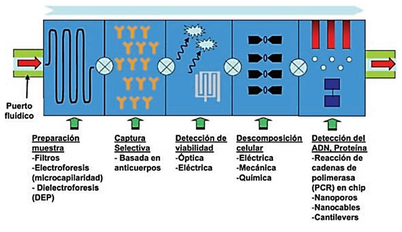
[(1)] Centro de Investigación en Ciencias Atómicas, Nucleares y Moleculares and Escuela de Física. Universidad de Costa Rica, San José (San Jose) -Costa Rica, [(2)]Escuela de Física. Universidad de Costa Rica, San José (San Jose) - Costa Rica, [(3)] Medical Devices Engineering Master's Program. Tecnológico de Costa Rica, Cartago - Costa Rica, [(4)] Programa De Investigación en Enfermedades Tropicales, Escuela De Medicina Veterinaria. Universidad Nacional, Heredia - Costa Rica, [(5)]Department of Mechanical Engineering. State University of New York (SUNY) at Stony Brook, New York - United States , [(6)]School of Biology, Biotechnology Research Center. Tecnológico de Costa Rica, Cartago - Costa Rica

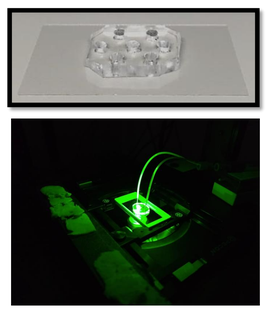
Research Direction
Micro-Electro-Fluidic Devices/Micro-Analysis-Total Systems (μTAS)/Lab-on-a-chip (LOCs)

- Miniaturization.
- Easy to manufacture.
- Active and passive elements.
- Electrical, optical, magnetic, thermal or mechanical properties/detection.

Of interest

- Biomanipulations and separations
- Biosensors and low-cost analysis
- Organ-on-chip
- Bioreactors-on-chip

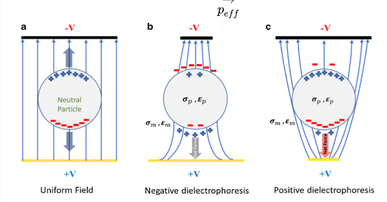




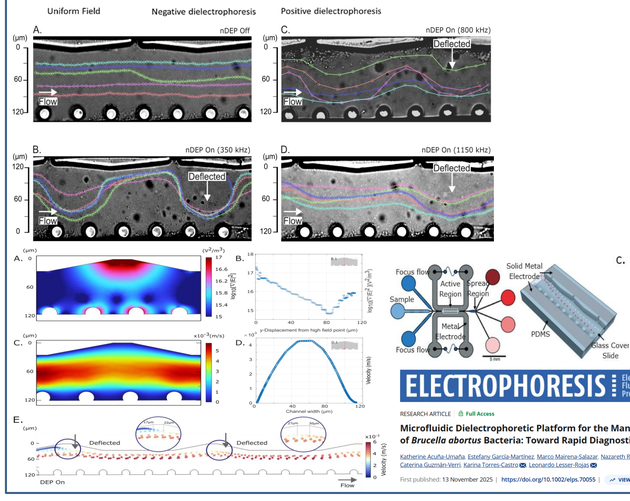
(Courtesy: Oropeza Ramos y Hauterfeuille, 2000)

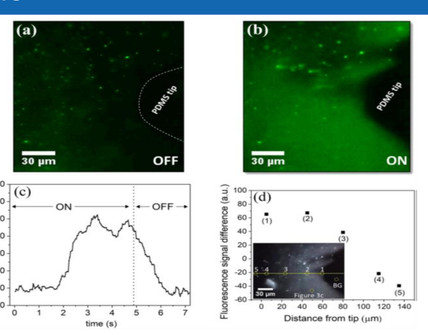
Preconcentration of *B. abortus* by Combined Electrokinetic Manipulations

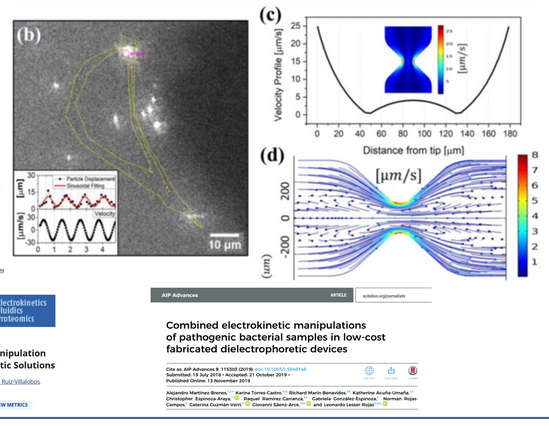
$$\left\langle \vec{F}_{DEP} \right\rangle = \underbrace{2\pi r^3 \mathrm{Re}[K(\omega)]}_{p_{eff}} \nabla(E_{rms}^2) \qquad K(\omega) = \frac{\varepsilon_p^* - \varepsilon_m^*}{\varepsilon_p^* + 2\varepsilon_m^*}$$



- Dielectrophoresis (DEP)
- Electroosmosis (EO)
- Hidrodynamic Flow (HF)







Dielectrophoretic Manipulation of Preosteoblastic Cells in Presence of a Silica-based Alloplastic Scaffold in a Microfluidic Flow Cell Device

- Generation of biomimetic grafts or scaffolds for bone regeneration based on a composite material made of polylactic acid (PLA) and different percentages of silica (SiO2) obtained from frustules of ocean diatoms and 3D printed based on a computerized axial tomography of trabecular bone [Oral presentation and poster **SEMIT 2026 BONE & CARTILAGE REGENERATION Satellite Meeting**]
- To verify the biocompatibility of these materials and study these physiological processes, it is necessary to understand the behavior of a cell line against these composites and scaffolds under in vitro conditions,. This could be achieved using a microfluidic flow cell and preconcentration platform



Source: https://www.mayoclinic.org

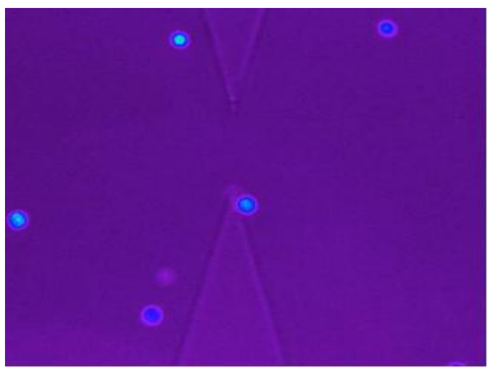
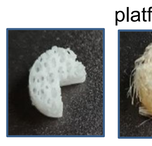
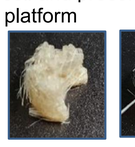


Image of MC3T3-E1 cells (blue) near dielectric microconstrictions during pDEP trapping on the upper dielectrophoretic level.

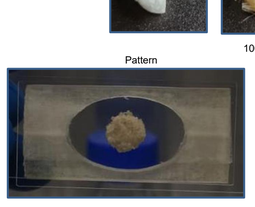


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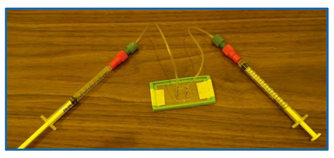


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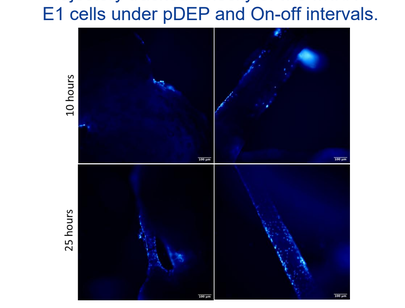
Pattern



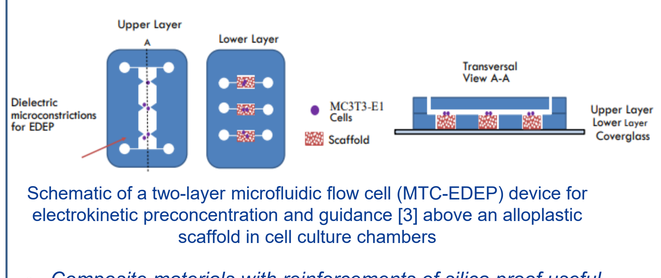
Fluidic cell for studies of cell adhesion in composite materials



System of syringes and metal cylinders connected to microfluidic flow cell for DEP experiments.



Trajectory tracked velocity of two MC3T3-E1 cells under pDEP and On-off intervals.



Schematic of a two-layer microfluidic flow cell (MTC-EDEP) device for electrokinetic preconcentration and guidance [3] above an alloplastic scaffold in cell culture chambers

Cell adhesion in composite SPBIII 88C scaffold inside a fluidic cell. Cells stained with Hoechst 33342≈400-600nm

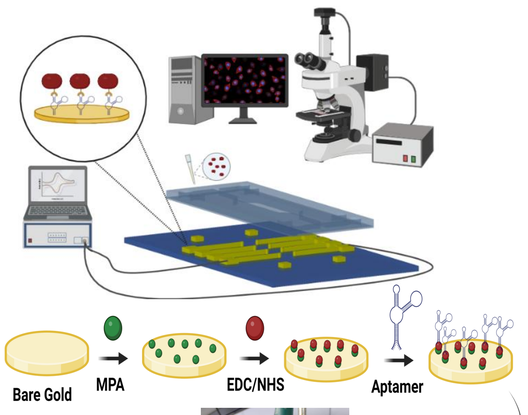
- *Composite materials with reinforcements of silica proof useful to construct bone regeneration scaffolds.*
- *Cell proliferation on the scaffold*
- *Cell activitity observed on flow cells.*
- *Positive DEP was achieved using fined tuned buffer conditions for DEP and cell viability.*
- *Scale dependent cell activity (pore size matters!)*
- *Osteoinduction.*

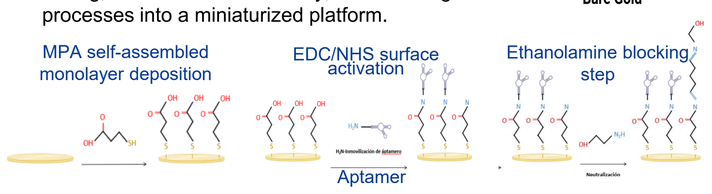
L.V. Trejos-Soto, L. Lesser-Rojas, et.al. "Dielectrophoretic Manipulation of Preosteoblastic Cells in Presence of a Silica-Based Alloplastic Scaffold in a Microfluidic Flow Cell Device" 27th International Conference on Miniaturized Systems for Chemistry and Life Sciences (μTAS 2023), Katowice, Poland, 15 – 19 October 2023. Poster.

Development of Microfluidic-assisted Bacterial Biosensors

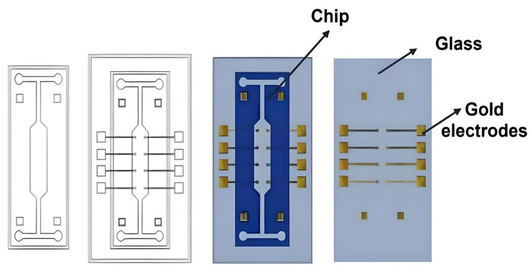
Aptamer-based Impedimetric Biosensors with integrated microfluidics

- Analytes are detected through electrical signals generated by biological interactions.
- Aptamers: are short, stable, single-stranded RNA or DNA molecules that exhibit high affinity and specificity and are easy to modify.
- Electrochemical impedance spectroscopy is a technique used to characterize surfaces and molecular recognition events.
- Microfluidics: reduces sample volumes, accelerates mixing, enhances sensitivity, and integrates all processes into a miniaturized platform.



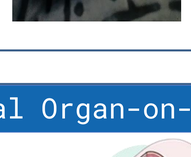






AutoCAD-based 2D prototype of the microfluidic biosensor





D. Monge-Castillo, A. Gutiérrez-Hernández, D. S. Dumani, C. C. Villarreal, L. Lesser-Rojas

Biosensors & Bioelectronics: X

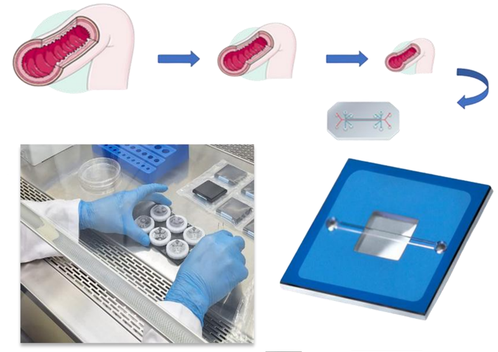
(2026) Under review

- *Electrochemical impedance spectroscopy (EIS) enabled the sensitive characterization of surface modification and biological recognition processes, validating each stage of biosensor assembly and revealing significant impedance changes after aptamer immobilization.*
- *The functionalization of the gold surface yielded reliable results, supporting its implementation in the fabricated prototype.*
- *This interdisciplinary approach promotes innovation in diagnostics, environmental monitoring, and food quality control.*

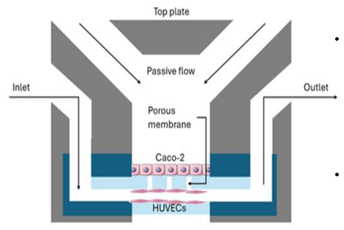
Evaluation of Commercial Organ-on-a-Chip Platform

Organ-on-Chip (OoC) Technology

- Cell cultures that simulate organs.
- Enable physiological, cancer, pharmacokinetic, inflammation, and related studies.
- Simple models use cellular barriers; more complex models incorporate microbiota, organoids, tumors, and/or immune cells.

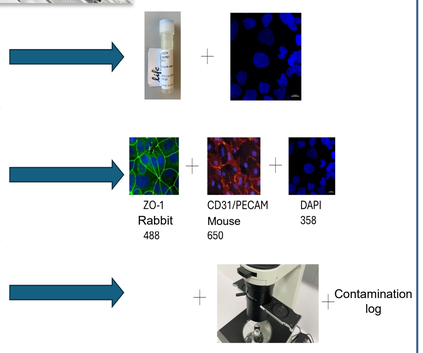


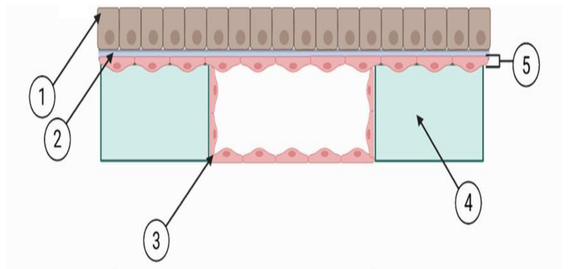
- inCHIPit by BIOND Biotechnologies
- Simple architecture
- PDMS
- Fibronectin and type I collagen
- 4 μm porous membrane (fabricated by spin coating)
- Integrated dynamic culture system
- Compatible with Cytation and other plate readers



Device schematics and experiment conceptual design

- Short term culture: Caco-2 for a week (proliferation) Caco-2 for 3 days (coculture).
- Long-term (Dynamic culture): Caco-2 for 3 weeks





Cross-sectional representation of the chip indicating possible three-dimensional migration within the channel (HUVECs).

- *Cell viability and proliferation were qualitatively observed in Caco-2 and HUVEC cells under different culture conditions, particularly at early stages.*
- *A reproducible protocol was successfully established for cell culture, maintenance, and analysis (including immunofluorescence and microfluidic conditions).*
- *The **in vitro** model proved suitable for short-term applications but showed limitations in long-term cultures, which are necessary for fully differentiated intestinal models.*
- *Overall, the platform is partially feasible as a gut-on-a-chip, requiring further optimization to achieve greater physiological relevance in long-term studies.*

PLOS One

Operational Lifespan Analysis of a Commercial Organ-on-Chip Platform for Gut Modeling

Ramírez-González, G [1, 2, 6]; Quirós-Solano, W.F[4]; Calvo-Castro, L[2]; Vargas-Méndez, E[3]; Lesser-Rojas, L[5,6]; and Centeno-Cerdas, C [2,3] (2026) Under review

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*Corresponding author's email: leonardo.lesser@ucr.ac.cr