LIFE SCIENCES

Droplet microfluidics for high-throughput single-cell and single-molecule studies

Vilnius University

Keywords: droplet microfluidics, ultra-high-throughput screening, single-cell assays, antibody discovery, transcriptomics, genomics, digital PCR, in vitro evolution, advanced drug delivery particles.

Research group activities

Droplet microfluidics is a powerful technology that opened new opportunities for single-cell and singlemolecule research to be performed at increased throughput, precision and sensitivity. Highly monodisperse aqueous droplets generated in an inert carrier oil can be views as the functional equivalents of the 96-wells (or 1.5 mL tubes), yet the volume of droplets is roughly a thousand to a million times smaller. Different microfluidic modules can be employed to manipulate droplets in sophisticated, yet highly controllable manner. Large numbers of droplets (>10^9) can be generated at astonishingly high rates (>30,000 droplets per second), their size tuned precisely, new reagents introduced into pre-formed droplets at defined time points, droplet split and sorted. Our group is using microfluidic droplets as a tool to analyze, profile and even selectively purify single-cells, sequence individual cells in clinical samples, screen antibody producing B-cells, perform digital DNA quantification, and many more biological and biomedical applications.

Proposal

We are experts in droplet microfluidics technology and can offer an extensive “know-how” knowledge and unpublished “secrets” of droplet technology. Our team is experienced in various single-cell assays such as antibody screening, single-cell sequencing, transcriptomics and genomics as well as digital diagnostics, in vitro evolution, synthesis of advanced drug delivery particles and more. If your work is limited by microliter plate format, or you are looking for effective collaboration to increase the throughput of biological assays and bring single-cell and molecule sensitivity, we would be more than happy to collaborate with you.

Meet our team

Multidisciplinary team, which all members have been exposed to international collaborations and projects, and have completed 1-2 year internships at top-science centres such as Harvard, Columbia, ETH Zurich, EPFL.

PI, **Linas Mazutis**, PhD – internationally educated researcher with over 10 years’ experience in microfluidics technology for biological and biomedical applications. He acquired PhD degree at Strasbourg University (Prof. Andrew Griffiths) and completed post-doctoral work at Harvard University (Prof. David Weitz). The results of his work have led to establishment of three new start-up companies: Platelet Biogenesis Inc., 1CellBio and Droplet Genomics. He has worked closely with various industrial partners (Thermo Fisher Scientific, RainDance Technologies, Novozymes, UCB, Symphogen), therefore his work experience is closely related to both academic and industrial needs.

K. Leonavicius, PhD (hydrogels, soft matter, hardware and instrumentation); **J. Nainys** (single-cell barcoding and sequencing, molecular biology assays); **R. Zilionis** (biochemist), **V. Kiseliovas** (biochemist), **G. Stonyte** (biochemist), **R. Galinis** (in vitro protein evolution), **K. Simutis** (biochemist); **D. Kuciauskas** (electronics, instrumentation; **V. Milkus** (physics, complex fluids), **J. Rutkauskaite** (antibody screening).

Research outcomes

Most important publications

- **Zilionis R., Nainys J, Veres A., Savova V., Zemmour D., Klein MA., and Mazutis L,** (2016) Single-cell barcoding and sequencing using droplet microfluidics, Nature Protocols, in press
- **Klein M*, Mazutis L*, Akartuna I*, Tallapragada N, Veres A, Li V, Peshkin L, Weitz D and Kirschner M,** (2015) Droplet barcoding for single cell transcriptomics applied to embryonic stem cells, Cell, 161(5): 1187–1201 * - joint first author
- **Mazutis L., Gilbert J., Ung L., Weitz D., Griffiths A., Heyman J.,** (2013) Single-cell analysis and sorting using droplet-based microfluidics, Nature Protocols, 8(5): 870-891
- **Thon JN, Mazutis L, Wu S, Sylman JL, Ehrlicher A, Machlus KR, Feng Q, Lu S, Lanza R, Neeves KB, Weitz DA, Italiano JE** (2014) Platelet bioreactor-on-a-chip, Blood, 124(12): 1857-1867
- **Pekin, D.** et al., Quantitative and sensitive detection of rare mutations using droplet-based microfluidics. Lab Chip 2011, 11(13), 2156-66

Patents and patent applications

- Patents and patent applications
- Microfluidic System and Methods for Highly Selective Droplet Fusion (WO/2010/128157)
- System and method for biomimetic fluid processing (WO/2014/107240)
- Microfluidic system and method for production of biopolymer-based droplets and particles (WO2015088299)
- Systems and methods for barcoding nucleic acids (WO/2015/164212)
- System and method for synthesis of DNA particles and use thereof (US 62/276,995)
- Methods and systems for capturing antibodies and RNA (US 62/244118)

Resources

Our laboratory is generally well equipped to accomplish academic and industrial projects in the existing capacity. The equipment available include two optical tables with inverted epi-fluorescence microscope (Nikon Ti-U), 8 syringe pumps (Harvard Apparatus), 2 fluorescence detection system (488, 532, 561 nm lasers), high-voltage amplifier (Trek 623B), function generator (Agilent), data acquisition and control system (LabView, National Instruments). In addition, our laboratory is equipped with instruments for microfluidic chip manufacturing and development: these include photoresist spinner (PI-KEM 6708), Oxygen plasma etcher (GaLa instrument Plasma Prep 2) and UV exposure system (OAI). We are operating the PDMS-glass microfluidic devices on daily basis and are experienced with different biological applications such as antibody screening, single-cell sequencing, in vitro evolution, digital PCR and many other applications that make use of droplet microfluidics technology. The microfluidic devices are manufactured in a clean-room facility using soft-lithography. The laboratory has access to Sanger, IonTorrent instruments, MiSeq and HiSeq 2500 Illumina platforms.

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