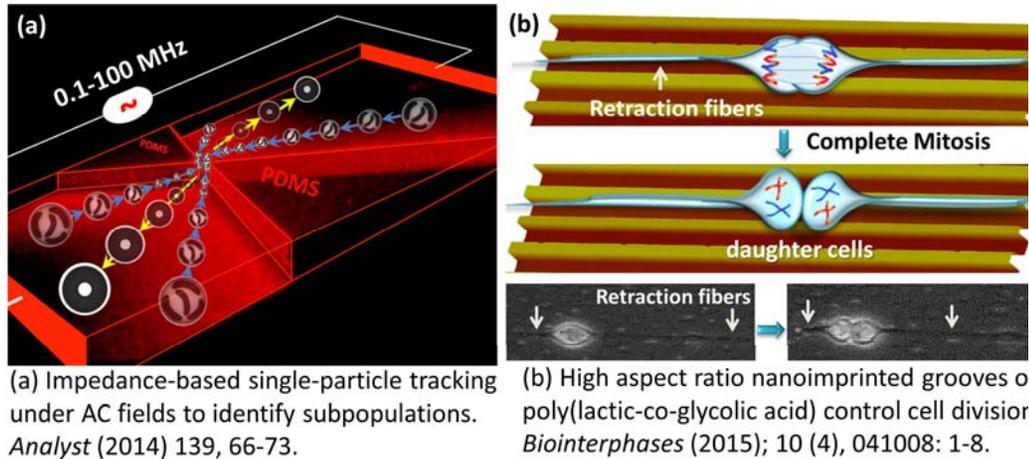


Nano/Biosystems Integration Group



Biosystems continually exhibit subpopulations with phenotypic heterogeneity, as part of their adaptation strategy to genetic and environmental influences. Stratifying this heterogeneity can lead to precision medicine-based approaches for disease diagnostics and for screening subjects towards advanced therapeutics, transplant therapies and tissue regeneration platforms. My research group is focused on label-free nano/microfluidic approaches to analyze and sort single particles for measuring the emerging heterogeneity within organisms, cells, and molecular biomarkers. We also focus on multi-level hydrogel assisted patterning of cellular microenvironments for tissue regeneration and for screening of system-level multi-cellular interactions using organ-on-chip and tissue chips. Capabilities include: soft & imprint lithography; microfluidic cytometry and separation platforms using impedance and deformability for single-cell manipulation & analysis; and biomedical circuit, signal & image analysis systems to interpret the emerging patterns in biomedical data sciences.

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"Devices for enabling quantitative systems biology"



Subcellular phenotypic analysis for optimizing microbiota interactions

To supplement conventional infection control methods based on antibiotics with a strategy based on commensal microbials to inhibit the pathogenic organisms, we seek to influence their ability to colonize the intestine, reduce their ability to secrete toxins, and decrease their intestinal permeability. To speed the discovery process for optimizing such microbiota for antagonistic interactions to inhibit *C.difficile* infections, this project develops *in vitro* and *in vivo* probes for microfluidic monitoring of subcellular alterations to pathogenic bacteria.

Conformation-specific enrichment and detection of molecular biomarkers

The early diagnosis of diseases and detection of their pathogenesis requires quantification of a spectrum of closely related biomarkers, which are present in extremely small quantities (~ng-pg/mL). We seek to selectively enrich particular biomarkers of interest over interfering molecules in the bio-fluid media, using the electrostatics arising from their characteristic size, shape, surface charge and conformation. We focus on cancer and neurological biomarkers.

Microfluidic isolation & single-particle cytometry of vesicles, cells & aggregates

To characterize phenotypic heterogeneity, we focus on isolation and analysis of subpopulations for personalized and transplant therapies. Specifically, we use the impedance and deformability responses in microfluidic systems for sorting and analysis.. Analogously, we use data science approaches to couple single cell microfluidics that identifies mitochondrial heterogeneity by quantifying emerging subpopulations to image analysis that analyzes perturbations to populations of tumor lines to inhibit tumor development by mitochondria-shaping proteins.

Nano/micropatterned cellular microenvironments, organ-on-chip & tissue chips

For control of tissue regeneration, alongside vascular integration, we seek to create biomimetic micro-architectures with patterned neural and muscle activity. For screening of personalized therapies, we seek to develop tissue chips and organ-on-chip systems.

RECENT RESEARCH DEVELOPMENTS

- Improved Biomolecular Sensors:
 - Enhancing detection sensitivity through micro/nanofluidic devices:
Lab Chip (2015), 15, 4563 – 4570
Biosens. Bioelectron. (2016), 78, pp. 244-252
- Integrative tissue regeneration:
 - Spatial control of cell division through nanoimprinted structures
Biointerphases (2015); 10 (4), 041008: 1-8
Acta Biomaterialia (2012), 8, 3982

RECENT GRANTS

- AFOSR FA2386-15-1-4105 – Aptamer-based nano-slit platforms for profiling human performance biomarkers
- NSF EFRI – Patterned & electrically mediated complex tissue regeneration
- Naval Air Warfare Center – FaSTR DNA Profiling Systems for Forensic Analysis
- Paul Manning Foundation – Microfluidic Selection & 3D-Bioprinting of Islets for Transplantation in Diabetes
- NIH 1R21AI130902-01 on optimizing microbiota to control *C.difficile* infections

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