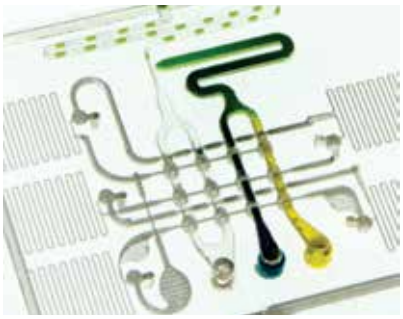
Microfluidics-Based Bioanalytical Solutions Change the Game

Microfluidic devices operate at physical length scales similar to biological constituents (*e.g.,* cells and molecules) and can manipulate solutions of these constituents within microscale channels and chambers. A microfluidic device, also called a lab-on-a-chip (LOC), takes advantage of physics at these small dimensions to detect low sample concentrations — in the nanomolar to picomolar range — with high sensitivity. LOC devices can carry out assays at extremely small volumes, with just a microliter or picoliter of fluid.

LOC devices have the potential to rapidly detect toxins in blood, quickly screen hundreds of potential drugs, isolate cells for cancer diagnostics and treatment, and provide information on plant health to improve crop outputs.

At the Center for Advanced Design and Manufacturing of Integrated Microfluidics (CADMIM), supported by the National Science Foundation, researchers are developing microfluidic platforms for rapid assessment of the environment, food and water supplies, and human health. Current methods to obtain such data are inefficient, costly, and labor intensive. By developing microscale tools and technologies in partnership with industry, CADMIM aims to bring simpler, faster, and cheaper bioanalytical capabilities to a wide variety of business sectors.



▲ This lab-on-a-chip is capable of autonomous mixing of fluids and compartmentalizing the resulting stream into individual droplets, which serve as miniature biochemical reaction vessels. Image courtesy of UCI (E. Werner, E. Hui).

CADMIM-funded technology has formed the basis for several startup companies. The center facilitates cross-site collaboration and technology translation. CADMIM is composed of two university sites — Univ. of California, Irvine (UCI) and the Univ. of Illinois at Chicago (UIC). The center's industrial advisory board has 11 corporate members.

CADMIM scientists are pursuing innovative, pre-competitive research in key application areas such as sample preparation (*e.g.,* tissue dissociation, nucleic acid purification, and cell and particle separation and sorting). They are targeting a wide range of specimens for testing, including untreated biofluids, plant and animal cell lysate, and tumor biopsies. CADMIM also develops microfluidics systems for diagnostics, automated bioassays, and *in vitro* and wearable point-of-care systems. The center is particularly focused on innovations that are easy to manufacture, which helps streamline the idea-to-product process.

CADMIM Director Abraham Lee, Jered Haun, and Wendy Liu from UCI are developing an addressable microwell array to select, identify, and recover single cells for applications in healthcare. Improved methods to isolate single cells, such as from human solid tumor tissue specimens, would dramatically advance our understanding of cancer biology and usher in an era of cell-based molecular diagnostics in clinical settings.

Ian Papautsky (UIC), CADMIM Codirector, is addressing the needs of the agricultural biotechnology industry with the development of an electrochemical sensor to assess plant nutrition. The sensors would be placed directly on the plant to measure levels of critical nutrients such as nitrates, electrolytes, and sodium, giving researchers a better assessment of plant health. This would in turn help farmers optimize agricultural practices and improve crop yields. And, sensor technologies developed as part of this project could be extended beyond plant sciences and used to monitor cells in culture.

CADMIM faculty members from both sites often collaborate on industrially relevant research. Salman Khetani (UIC) and Elliot Hui (UCI) are developing an organ-on-a-chip — a microfluidic screening platform that will mimic multicellular systems such as the liver. Using this concept to create a liver-on-a-chip will help researchers develop novel therapeutics against diseases such as hepatitis B viral infection. The platform will enable the screening of thousands of compounds in early drug discovery research, and will help mitigate the risk of drug toxicity to patients in the clinic.

CADMIM LOC devices are applicable in emerging areas such as:

- personalized medicine and precision agriculture, where analysis is correlated to the person or plant's specific makeup (*e.g.,* genome, habits, environment, etc.)
- forensic science and homeland security, where point-of-need screening for drugs or residues is required
- digital healthcare, rehabilitation, and wellness monitoring.

CADMIM's innovative research ecosystem has positioned the center to make lasting impacts in bioanalytics and beyond. CEP

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