DRA Project Portfolio (2022)

Biomedical Engineering Design Devices
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Completed Projects (*Active continued development):

Low-cost Neonatal Feeding Pump (2021-22)*

Blast Microchamber for Overpressure Injury (2022)*

Automated Electrical Stimulator (2021)*

ECG Amplifier - BME teaching labs (2013+)

Integrated Microscope Stimulation (2014+)

Multistimulus Microfluidic Delivery (2018)

Light Sheet Microscope Stimulation (2018)

Timelapse behavior recording system (2013)

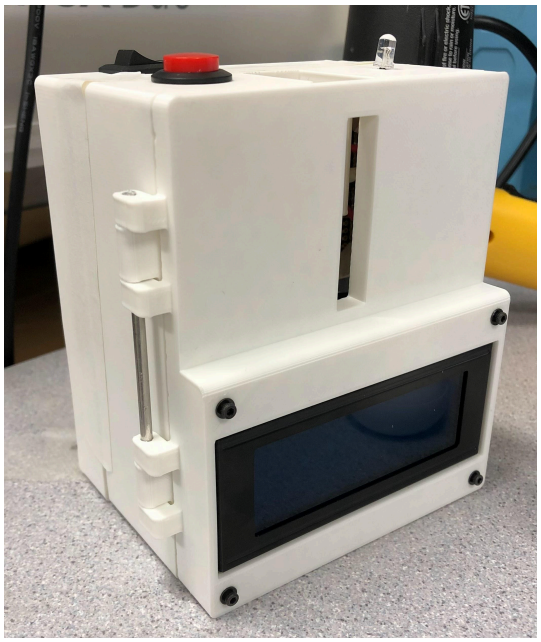
Microfluidic Behavior Arena with Precise Spatiotemporal Stimulation (2011)

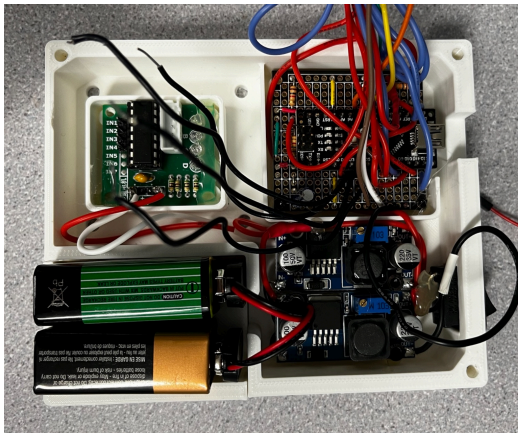
Dielectrophoretic Cell Patterning system (2005)

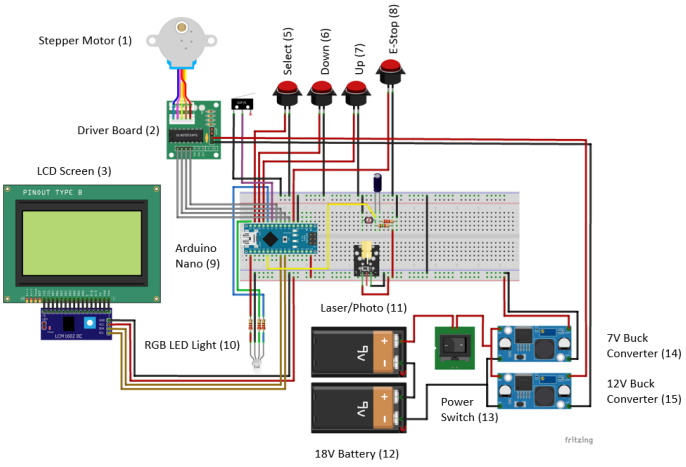
Upcoming Projects:
Accurate Auto-Auscultation Blood Pressure Sensor (2023)
Medical Device Development Kit (2022-23)

Low-cost Neonatal Feeding Pump (2021-22)*

Premature infants born with low birth weight often have underdeveloped feeding physiology requiring external feeding pumps, which can cost >1000 USD and require specific pump tubing. For low- to middle-income countries (LMIC), less expensive and more versatile devices are needed to accommodate different conditions experienced in urban and rural clinics. Devices must provide user adjustable feeding volume and flowrate. To minimize power consumption, this design uses gravity flow, monitoring flow via a drip chamber and automatically pinching tubing to regulate flowrate and stop flow upon completion of the feeding session.



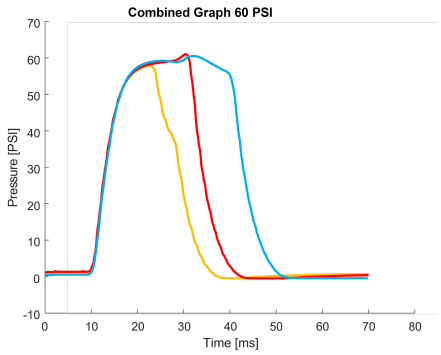


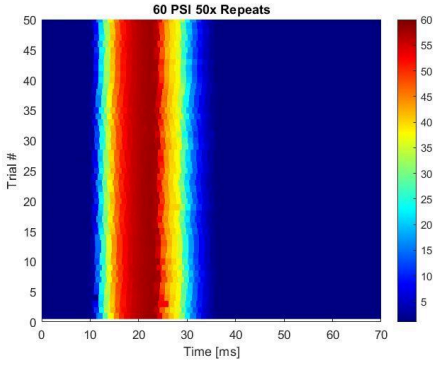


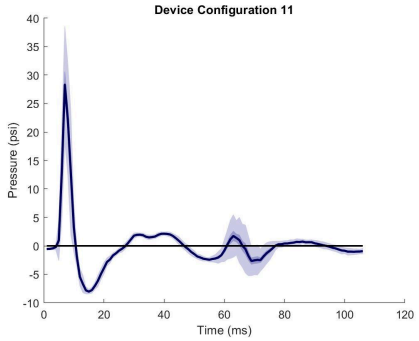
Blast Microchamber for Overpressure Injury (2022)*

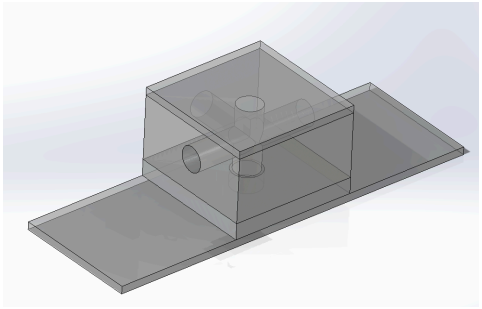
Related Patent Pending: 63/392,257
NEUROLOGICAL MODEL FOR TRAUMATIC INJURY

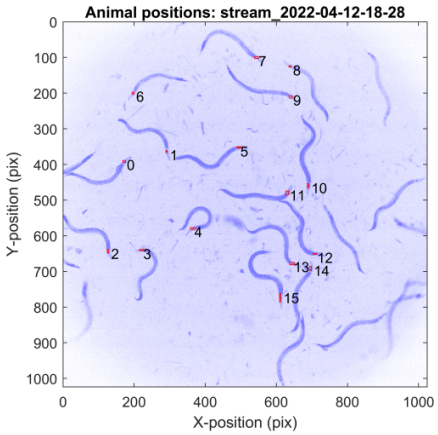
To study blast overpressure effects on neuronal function, a miniature blast microchamber was developed to deliver up to 100 psi pressure pulses at 4 - 30 ms. A microcontroller (ATSAMD ARM Cortex-M0) logs pressure data from two 150 psi pressure sensors at up to 3 kHz (streaming) or 17 kHz (burst) while controlling digital outputs with user-specified timing. MATLAB scripts read in data automatically organize pressure data. Neuronal recordings are controlled with the “Integrated Microscope Stimulation” system, which allows for optical recording of neural activity, even ***during*** the overpressure blasts!

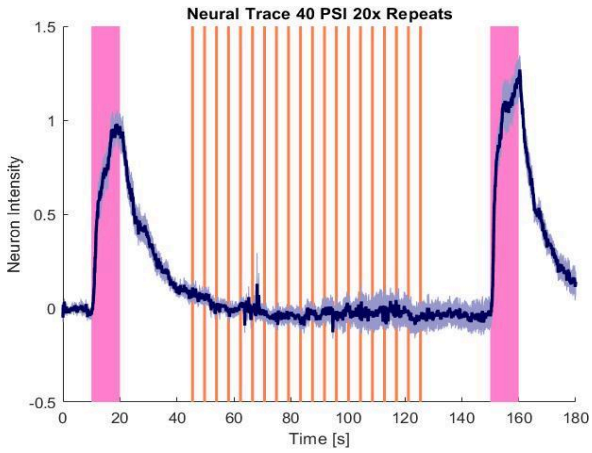






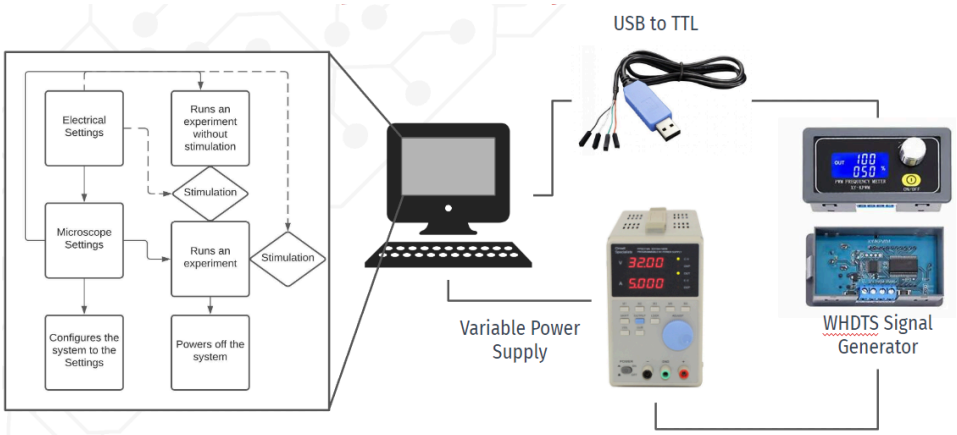


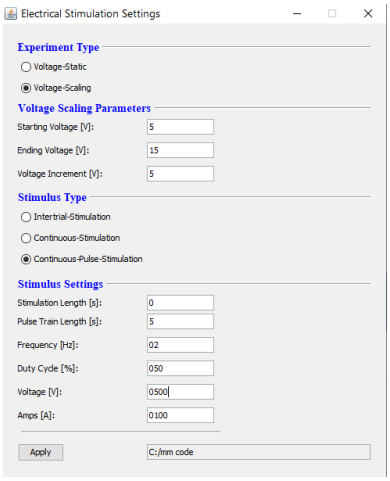


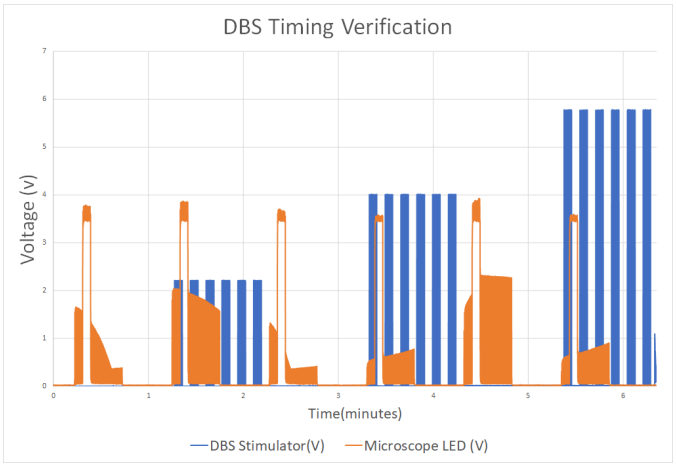


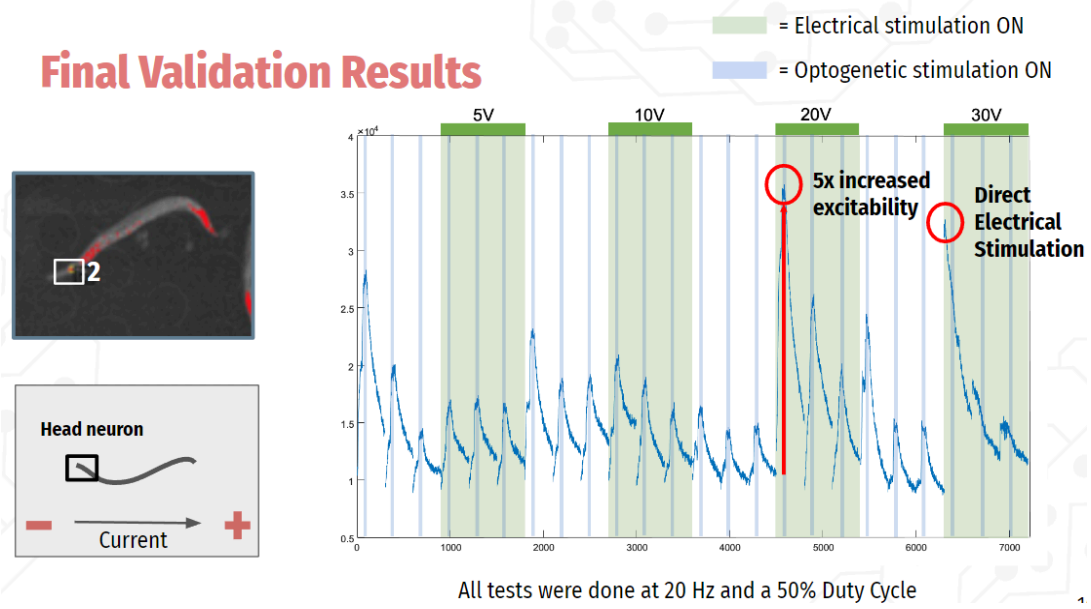
Automated Electrical Stimulator (2021)*

Coordination of electrical stimulation, optical stimulation, and timelapse imaging to study the effects of different Deep Brain Stimulation (DBS) parameters. Microscope control software written for Micro-manager coordinates voltage level, simulation timing, and microscope via serial commands.









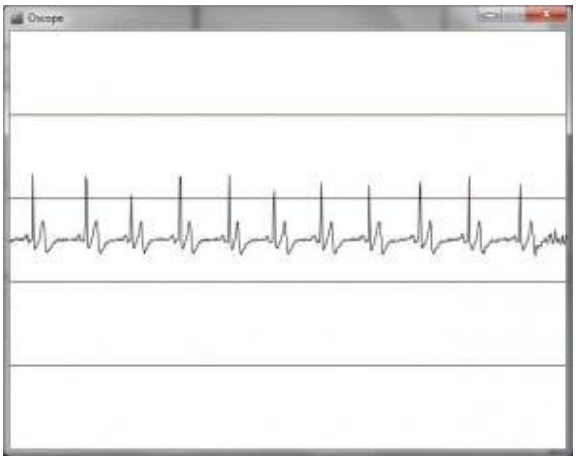
ECG Amplifier - BME teaching labs (2013+)

Using a $30 Arduino Uno sensor kit and $8 component pack with amplifiers, capacitors, and resistors, students work through four self-directed labs culminating in an ECG circuit lab. Students master basic circuit wiring, resistive circuits and sensors (position, light, moisture), capacitors and frequency filters, and amplifiers. This innovation-award-winning course has been developed over 9 years and >1000 students, and implemented in remote, in person, and hybrid learning formats.

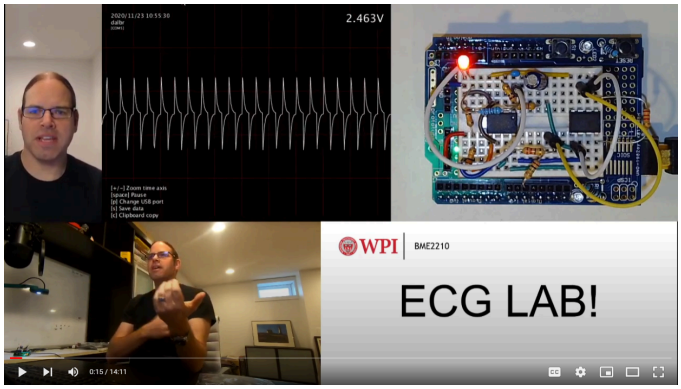
https://wp.wpi.edu/qntl/education/courses/ecg-lab/

https://www.wpi.edu/news/announcements/dirk-albrecht-named-romeo-l-moruzzi-young-faculty-year

https://www.wpi.edu/news/announcements/wpi-faculty-and-staff-win-asee-best-paper-awards-hands-learning-experiences

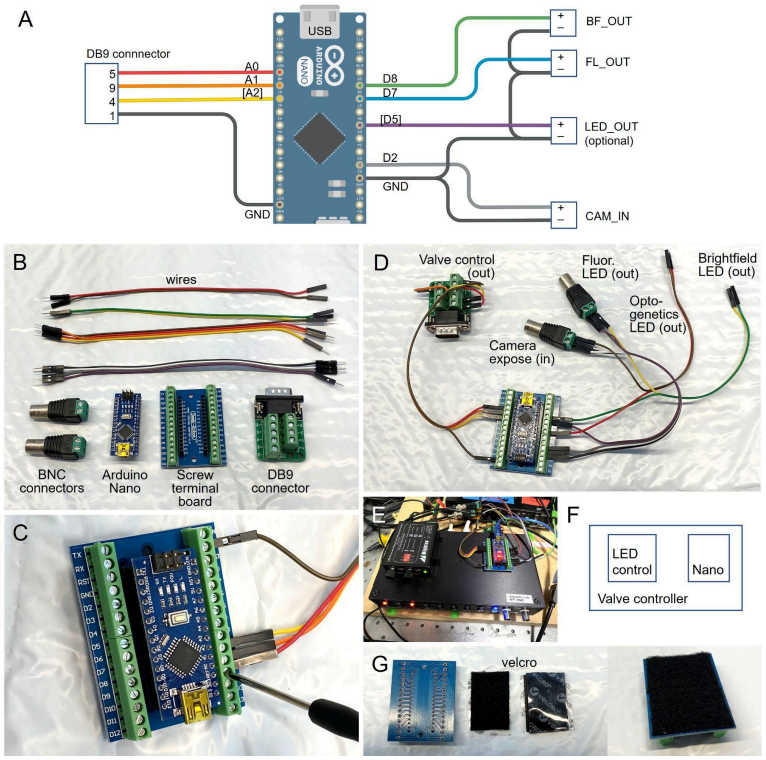


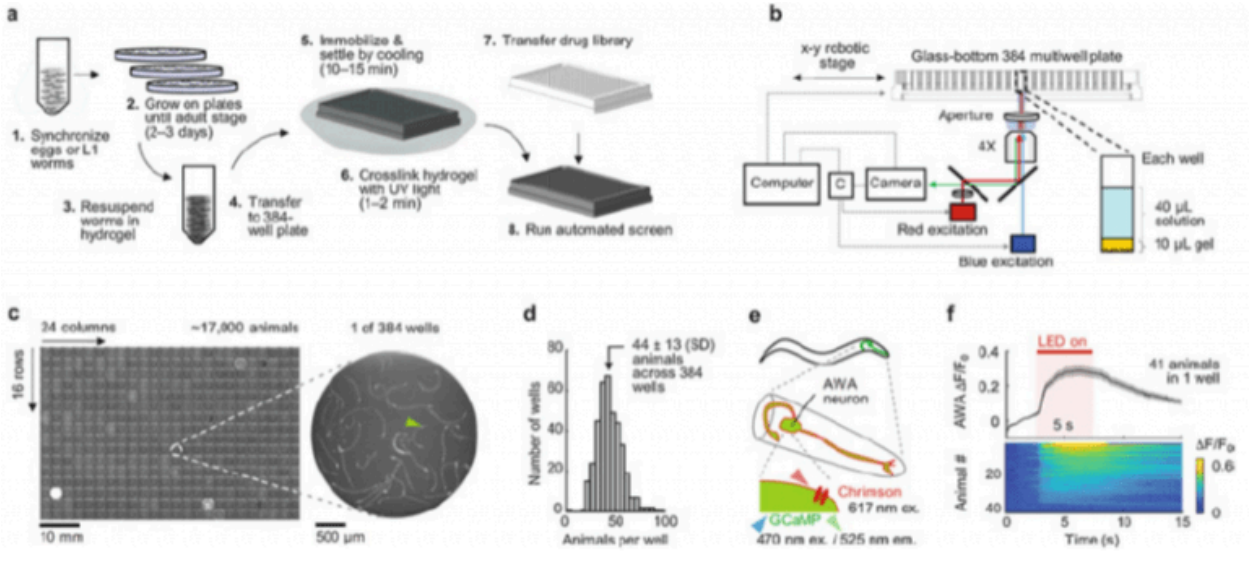
https://www.youtube.com/watch?v=3FEw2XDnxnw



Integrated Microscope Stimulation (2014+)

We developed an open-source Arduino-based microscope integration system that controls experiment stimulation such as chemical or pressure stimulation via solenoid valves, LED illumination for fluorescence, brightfield, or optogenetic stimulation, and electrical stimulation. Timing and dose can be preprogrammed in many versatile configurations, such as repeats, different chemicals and concentrations, including algorithmic patterns such as pseudorandom m-sequences. The system can be run in a closed-loop format, triggering stimulation based on animal behavior (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7939084/), and works with multiple inputs such as the “Multistimulus Microfluidic Delivery” system or multiwell XY-stage systems (https://link.springer.com/protocol/10.1007/978-1-0716-0830-2_14). We built an inexpensive “NanoController” (image below) and a larger version with touchscreen.



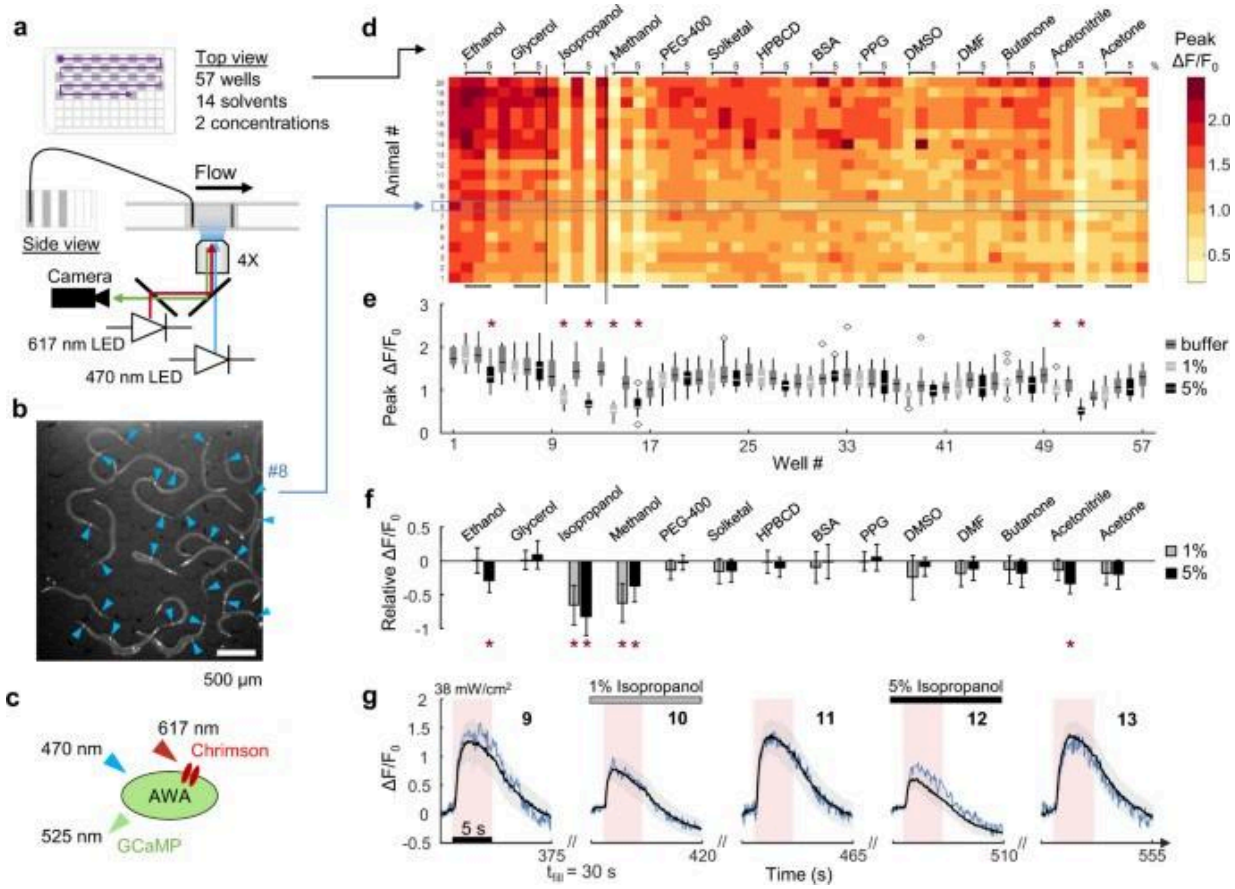


Multistimulus Microfluidic Delivery (2018)

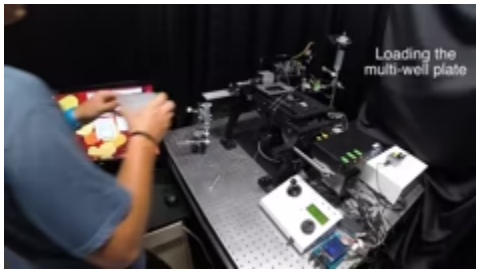
Patent Issued: 11,249,100
MODULAR ROBOTIC SYSTEMS FOR DELIVERING FLUID TO MICROFLUIDIC DEVICES

Microfluidic systems typically contain inlets with fixed tubing delivering a specific fluid. Rotation valves can deliver multiple fluids through a single inlet (8, 10, or 12 maximum). To deliver from a larger number of fluids, we developed a robotic system that draws liquid from multiwell plate such as a 96-well plate. A draw tube raises and lowers into wells positioned by an XY-stage, and specific flow balancing prevents bubble entry or cross-contamination. We demonstrated functionality by automating a 10-step cell staining procedure and a solvent screen investigating effects on neurological response.

Lagoy RC and **Albrecht DR(§)**. "Automated fluid delivery from multiwell plates to microfluidic devices for high-throughput experiments and microscopy" *Scientific Reports* **8**(1), 6217 (2018). https://www.nature.com/articles/s41598-018-24504-x



https://vimeo.com/721496833

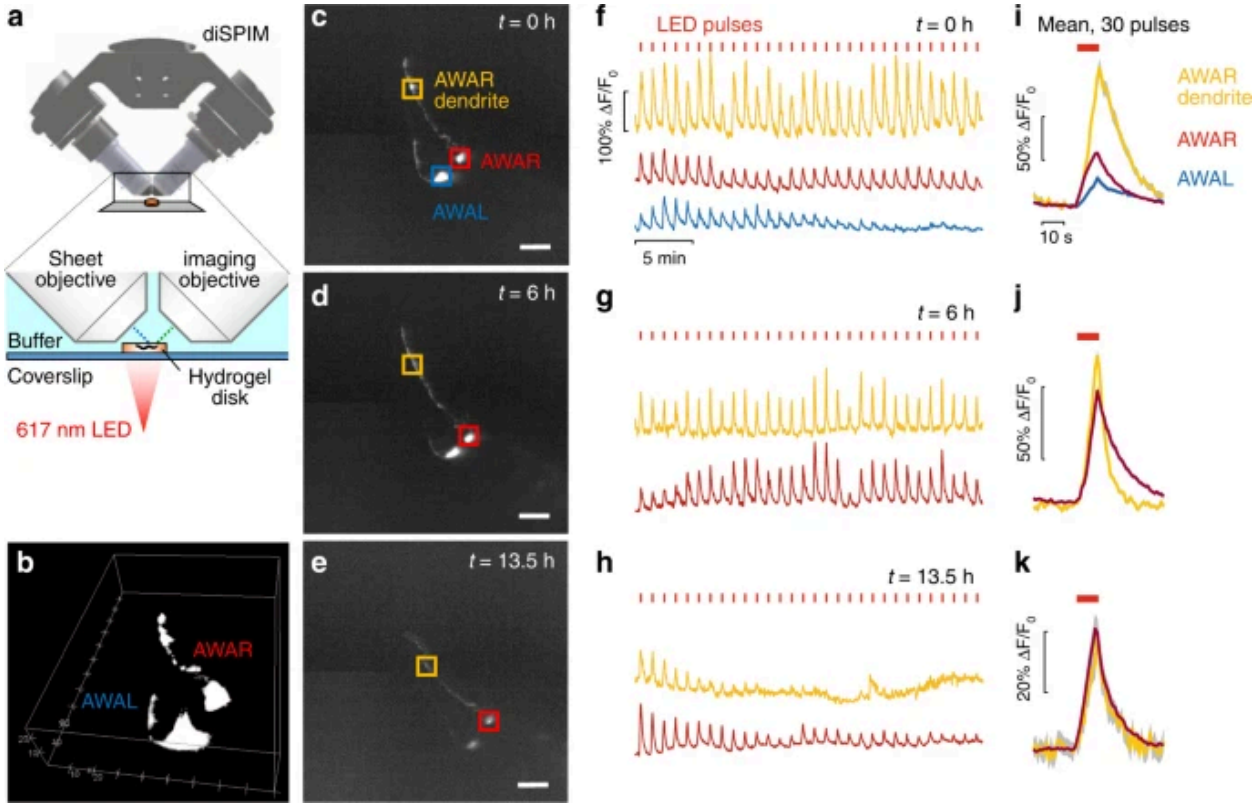


Light Sheet Microscope Stimulation (2018)

Related Patent Issued: 11,248,995
HYDROGEL ENCAPSULATION OF LIVING ORGANISMS FOR LONG-TERM MICROSCOPY

We customized an ASI diSPIM light sheet 3-D microscope to trigger optogenetic or chemical stimulation at specific recording volumes. This makes use of our encapsulation system for immobilizing living organisms.

Burnett K, Edsinger E, and **Albrecht DR(§)**. "Rapid and gentle hydrogel encapsulation of living organisms enables long-term microscopy over multiple hours" *Communications Biology* (2018). https://www.nature.com/articles/s42003-018-0079-6

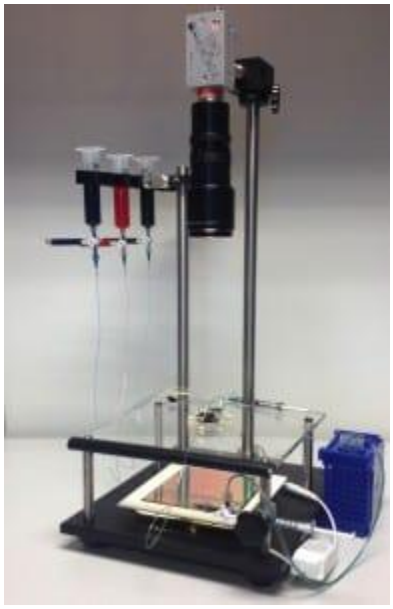


Timelapse behavior recording system (2013)

For recording organism behavior over long times, we built an inexpensive imaging system using machine vision camera, LED backlight, and MATLAB-based acquisition software. Recordings are typically captured at 2 fps for 30-min to 2 hours, but long timelapses of up to 11 days have been demonstrated (see videos below).

Lagoy RC and **Albrecht DR**. Microfluidic Devices for Behavioral Analysis, Microscopy, and Neuronal Imaging in *Caenorhabditis elegans*. *Methods Mol Biol.* **1327**:159-79. doi: 10.1007/978-1-4939-2842-2_12. (2015).

http://users.wpi.edu/~dalbrecht/MicrofluidicAssay.html



https://wp.wpi.edu/qntl/resources/hardware/

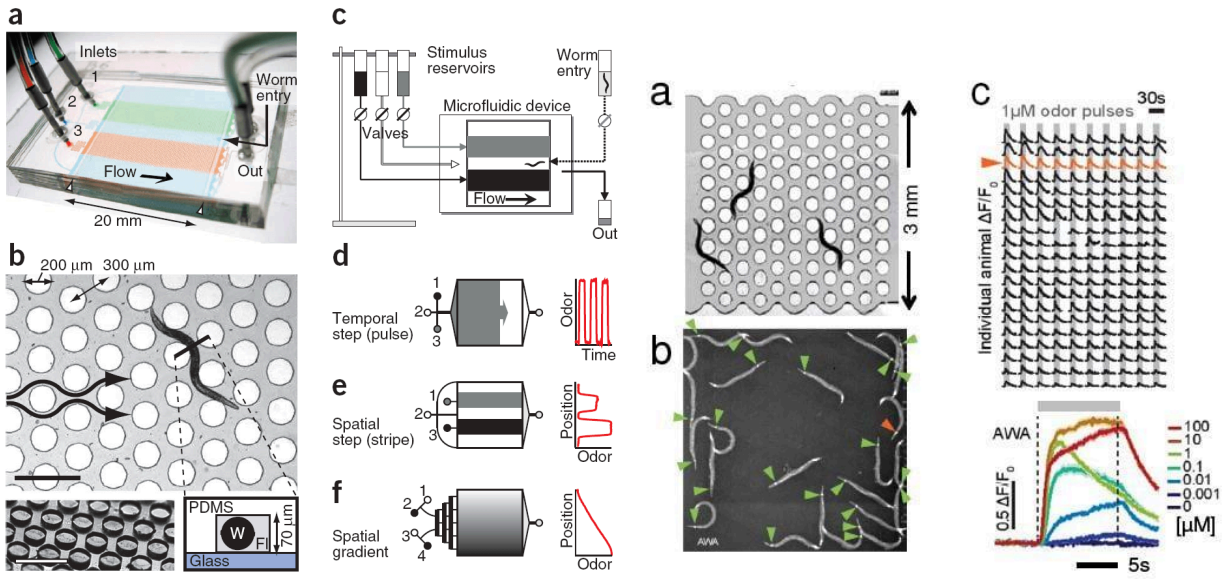
https://vimeo.com/127600437?embedded=true&source=vimeo_logo&owner=37290838

Microfluidic Behavior Arena with Precise Spatiotemporal Stimulation (2011)

We developed microfluidic arenas to house C. elegans animals and allow sinusoidal crawling locomotion in fluid environments. Spatiotemporal chemical stimulus patterns, such as pulses, stripes, and gradients, are dynamically stable, repeatable, and durable. Behavioral and neuronal responses can be assessed to these different stimuli to interrogate neural circuit function.

Albrecht DR and Bargmann CI. High-content behavioral analysis of Caenorhabditis elegans in precise spatiotemporal chemical environments. *Nature Methods* **8**(7):599-605 (2011). http://www.nature.com/nmeth/journal/v8/n7/full/nmeth.1630.html

Larsch J, Ventimiglia D, Bargmann CI, and **Albrecht DR**. High-throughput imaging of neuronal activity in C. elegans. *Proc Natl Acad Sci* **110**(45):E4266-E4273 (2013). http://www.pnas.org/content/110/45/E4266.abstract



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Dielectrophoretic Cell Patterning system (2005)

Related Patent Issued: 8,906,684
THREE DIMENSIONAL CELL PATTERNED BIOPOLYMER SCAFFOLDS AND METHODS OF MAKING THE SAME

To study cell microorganization, we developed a parallel electrokinetic cell positioning system using dielectrophoretic forces to pattern living cells according to a microfabricated electrode template within minutes. Patterns are held following crosslinking of a biopolymer hydrogel.