

MATTHEW T. FLAVIN

Contact: matthew.flavin@northwestern.edu

Homepage: <https://flavinresearch.io>

EDUCATION

Massachusetts Institute of Technology Cambridge, MA
Ph.D. in Electrical Engineering 2021
Committee: Jongyoon Han, Ph.D. (advisor) GPA: 5.00/5.00
Charles Lissandrello, Ph.D.
Polina Anikeeva, Ph.D.
Dennis Freeman, Ph.D.

Massachusetts Institute of Technology Cambridge, MA
Master of Science in Electrical Engineering 2017
GPA: 5.00/5.00

University of Illinois Urbana–Champaign, IL
Bachelor of Science in Electrical Engineering 2015
Minor in Bioengineering GPA: 3.60/4.00
James Scholar (academic honors)

RESEARCH VISION

My aim as an independent researcher is to develop powerful peripheral neural interfaces and mechatronic wearables that leverage advanced sensors and intelligent systems to address important and unresolved challenges in mechanobiology and patient care.

RESEARCH POSITIONS

John Rogers Research Group (Northwestern University) Evanston, IL
Post-doctoral Researcher December 2021 – Present
Projects led: Wireless indentation haptic actuators
Sensory substation for diabetic neuropathy
Monitoring of trans-epidermal water loss (TEWL)

Micro/Nanofluidics and BioMEMS Research Group (MIT) Cambridge, MA
Post-doctoral Researcher June 2021 – December 2021
Projects led: Mass transport modelling of plunging jets of brine

Micro/Nanofluidics and BioMEMS Research Group (MIT) Cambridge, MA
Graduate Research Assistant August 2015 – May 2021
Projects led: Electrochemical modulation of rat sciatic nerve *in vivo* with ion-selective electrodes
Advanced architectures for electrochemical modulation, closed-loop and continuous operation
Rapid manufacturing of cuff electrodes
Fundamental study of active electrical polarization of ion-selective membranes

Biophotonics Imaging Research Group (UIUC) Champaign, IL
Undergraduate Researcher January 2014 – July 2015
Projects led: Magneto-mechanical stimulation of metabolic activity in cultured cells
Gauss–Newton curve-fitting on FPGA hardware for real-time FLIM imaging

John Rogers Research Group (UIUC) Champaign, IL
Undergraduate Researcher September 2012 – September 2014
Projects: Three-dimensional architectures of micro/nanomaterials
Skin-conformable microfluidic devices
Fabrication of network composite materials

Argonne National Laboratory

Undergraduate Researcher

Projects: Ratiometric FRET-based protein microarray using nanocrystal donor molecules

Lemont, IL

May 2013 – August 2013

GRANT ACTIVITY

Brine Dispenser and Dilution Utilizing Novel Plunging Liquid Jet Reactor Incorporating Annular Riser 2024

Status: under review

Research Sector, Kuwait University

Role: Co-investigator

Full Freedom-of-Motion Haptic Actuators and Their Use in a Wireless System for VR Environments 2023

Status: awarded

Army (W911QY-20-R-0022)

Role: Co-investigator

Haptic neuro-prosthesis for spinocerebellar ataxia 2023

Status: awaiting site visit as a finalist

Raynor Cerebellum Project

Role: Co-investigator

High-frequency Electrical and Thermal Stimulation for Pain Management 2019

Draper Internal Research and Development Grant

Principle Investigator: Charles Lissandrello, Ph.D.

Role: Co-investigator

Focal Neuromodulation via Localized Ca²⁺ and Mg²⁺ depletion and enrichment 2016

BRAIN Initiative RFA-EY-16-001

Principle Investigator: Jongyoon Han, Ph.D.

Localized Modulation of Synaptic Activity Using Calcium Ion-selective Membrane Coated Electrodes 2015

Amar G. Bose research grant (MIT internal)

Principle Investigator: Jongyoon Han, Ph.D.

Role: Co-investigator

FELLOWSHIPS AND AWARDS

NIH Fellowship in Circadian and Sleep Research October 2023 – Present

Ruth L. Kirschstein Institutional National Research Service Award (T32)

Draper Laboratory Fellowship August 2015 – May 2021

NIH Brain Initiative Course on Models and Neurobiology July 2016

PEER-REVIEWED JOURNAL ARTICLES

M. Flavin,* R. Macaluso,* J. Cornman,* M. Park, J.-Y. Yoo, S. Bandapalli, T. Saxena, F. Al-Najjar, A. Akhtar, A. Jayaraman, J. Rogers (*equal contribution), "Sensory substitution with a multimodal somatosensory interface," submission planned March 2024.

J. Shin*, **M. Flavin**,* S. Li,* A. Huang, W. Sung, T. Huang, J.-K. Chang, J. Rogers (*equal contribution), "Continuous measurements of trans-epidermal water loss in a skin-mounted device," submission planned March 2024.

M. Flavin,* K. Ha,* Z. Guo,* S. Li,* J. Kim,* T. Saxena, F. Al-Najjar, S. Bandapalli, C. Fan, D. Bai, Z. Zhang, J. Yoo, M. Park, J. Shin, A. Huang, H. Shin, Y. Huang, Z. Xie, H. Jiang, J. Rogers (*equal contribution), "Bioelastic state recovery for haptic sensory substitution," under first revision in *Nature*, 2023.

E. Flavin, M. Chung, S. Hwang, **M. Flavin**, “Developing the area measurement reasoning of elementary students with augmented reality activities,” submission planned March 2024.

E. Flavin, S. Hwang, **M. Flavin**, “The effects of augmented reality use on mathematics achievement of K–12 students: A meta-analysis,” under review in *International Journal of Science and Mathematics Education*, Oct. 2023.

E. Flavin, S. Hwang, **M. Flavin**, “Multi-dimensional engagement of Haitian immigrant parents in mathematics education,” under review in *Educational Studies in Mathematics*, Sep. 2023.

M. Flavin,* J. Fernandes,* R. AlQabandi, E. Adams, J. Han, B. Al-Anzi (*equal contribution), “Numerical modeling of plunging jets of brine: mass transport and implications for desalination plant outfalls,” *Desalination*, vol. 568, 116996, Dec. 2023.

M. Park, J.-Y. Yoo, T. Yang, Y. Hwan Jung, A. Vázquez-Guardado, S. Li, J.-H. Kim, J. Shin, W.-Y. Maeng, G. Lee, S. Yoo, H. Luan, J.-T. Kim, H.-S. Shin, **M. Flavin**, H.-J. Yoon, N. Miljkovic, Y. Huang, W. King, and J. Rogers, “Skin-integrated systems for power efficient, programmable thermal sensations across large body areas,” in *Proceedings from the National Academy of Sciences of the United States of America*, vol. 120, no. 6, e2217828120, Jan. 2023.

M. Flavin, C. Lissandrello, J. Han, “Real-time, dynamic monitoring of selectively driven ion-concentration polarization,” in *Electrochimica Acta*, vol. 426, 140770, Sep. 2022.

M. Flavin, M. Paul, X. Lim, C. Lissandrello, R. Ajemian, S. Lin, J. Han, “Electrochemical modulation enhances the selectivity of peripheral neurostimulation in vivo,” in *Proceedings from the National Academy of Sciences of the United States of America*, vol. 119, no. 23, e2117764119, June 2022.

J. Yoon, **M. Flavin**, J. Han, “Current efficiency and selectivity reduction caused by co-ion leakage in electro-membrane processes,” in *Water Research*, vol. 201, 117351, Aug. 2021.

M. Flavin, M. Paul, X. Lim, S. Abdulhamed, C. Lissandrello, R. Ajemian, S. Lin, J. Han, “Rapid and low cost manufacturing of cuff electrodes,” in *Frontiers in Neuroscience*, vol. 16, 628778, Feb. 2021.

M. Flavin, D. Freeman, J. Han, “Interfacial ion transfer and current limiting in neutral-carrier ion-selective membranes: A detailed numerical model,” in *Journal of Membrane Science*, vol. 572, pp. 374-381, Feb. 2019.

K. I. Jang, H. U. Chung, S. Xu, C. H. Lee, H. Luan, J. Jeong, H. Cheng, G. T. Kim, S. Y. Han, J. W. Lee, J. Kim, M. Cho, F. Miao, Y. Yang, H. N. Jung, **M. Flavin**, H. Liu, G. W. Kong, K. J. Yu, S. I. Rhee, J. Chung, B. Kim, M. H. Yun, J. Y. Kim, Y. M. Song, U. Paik, Y. Zhang, Y. Huang, J. A. Rogers, “Soft network composite materials with deterministic, bio-Inspired designs,” in *Nature Communications*, vol. 18, no. 6, 6566, Mar. 2015.

S. Xu,* Z. Yan,* K. Jang, W. Huang, H. Fu, J. Kim, Z. Wei, **M. Flavin**, J. McCracken, R. Wang, A. Badea, H. Liu, D. Xiao, G. Zhou, J. Lee, H. U. Chung, H. Cheng, W. Ren, A. Banks, X. Li, U. Paik, R. G. Nuzzo, Y. Huang, Y. Zhang, J. A. Rogers, “Assembly of micro/nanomaterials into complex, three-dimensional architectures by compressive buckling,” in *Science*, vol. 347, no. 6218, pp. 154-159, Jan. 2015. (Cover Figure)

S. Xu,* Y. Zhang,* L. Jia,* K. E. Mattewson,* K. Jang, J. Kim, H. Fu, X. Huang, P. Chava, R. Wang, S. Bhole, L. Wang, Y. J. Na, Y. Guan, **M. Flavin**, Z. Han, Y. Huang, J. A. Rogers, “Soft microfluidic assemblies of sensors, circuits, and radios for the skin,” in *Science*, vol. 344, no. 6179, pp. 70-74, Apr. 2014.

PATENTS

J. Han, D. Freeman, **M. Flavin**, U.S. Patent Application 17/741,921, “Architectures and Methods for Electrochemical Neuromodulation,” 2022.

CLINICAL TRIALS

Multimodal haptic feedback for plantar sensory substitution April 20 – Present

Northwestern IRB # STU00218277

<https://clinicaltrials.gov/study/NCT06232512>

Role: Investigator

Evaluation of haptic feedback in a novel acoustomechanic device for behavioral scratch modification in atopic dermatitis Feb. 6 – Present

Northwestern IRB # STU0021480

Role: Investigator

CONFERENCE AND SEMINAR

E. Flavin, **M. Flavin**, “Developing an augmented reality system for embodied mathematics learning,” under review in the North American Chapter of the International Group for the Psychology of Mathematics Education, 2024, Cleveland, Ohio.

M. Flavin, K. Ha, Z. Guo, S. Li, J. Kim, Y. Huang, Z. Xie, H. Jiang, J. Rogers, “Neural mechatronics and mixed reality for patient healthcare,” presented (as a poster) at Gordon Robotics 2024, Ventura, California.

M. Flavin, J. Rogers, “Multimodal augmented reality,” presented (orally) at Sustainable Laboratory Showcase 2023, Chicago, Illinois.

M. Flavin, M. Paul, X. Lim, S. Abdulhamed, C. Lissandrello, R. Ajemian, S. Lin, J. Han. “Selective nerve conduction block via focal delivery of high-frequency alternating current from a radial electrode array,” presented (as a poster) at Gordon Bioelectronics 2019, Andover, New Hampshire.

M. Flavin, M. Paul, X. Lim, R. Ajemian, S. Lin, D. Freeman, J. Han, “Focal Manipulation of Neural Interstitial Ion Concentration Using Ion-Selective Membrane Electrodes,” presented (orally) at the Fall meeting of the Material Research Society, 2017, Boston, Massachusetts.

M. Flavin, D. Freeman, J. Han, “Electrochemical neuromodulation using cuff electrodes modified with ion-selective membrane electrodes,” presented (as a poster) at Neuroscience 2017, Washington D.C.

M. Flavin, D. Freeman, J. Han, “Mathematical Modeling of Ion Selective Membrane Systems Subject to Electrical Polarization,” presented (orally) at the 232nd Electrochemical Society Meeting, 2017, New Orleans, Louisiana.

PROFESSIONAL AND EDITORIAL SERVICE

IEEE-EMBS BSN 2024 October 2024

Publications Co-chair, Organizing committee,

Kellog-Q residency February 2024 – Present

Mentoring two MBA students

PNAS Journal Club Panelist October 2022 – Present

Contributed to selections for PNAS's journal club segment

See: <https://www.pnas.org/journal-club/journal-club-panelists>

Peer review June 2022 – Present

Reviewed articles for *npj Digital Medicine* and *Science Advances*

Undergraduate student mentor (Northwestern University) December 2021 – Present

Led and trained six undergraduate students

Undergraduate student mentor (MIT) August 2015 – May 2021

Hired, trained, and mentored two undergraduate students

TEACHING ACTIVITY

Northwestern Teaching Assistant

Bioelectronics Lab (BME 354)

Spring 2024

Outreach

Fairview Elementary Third Grade Class (<https://twitter.com/dist57/status/1722418763155263993>)

Nov. 8, 2023

STEM for ALL Brockton Math education program

Spring 2023

Guest Lecturer (Northwestern)

Designing Product Interactions (DSGN 495-21)

Evanston, IL

Wearable Electronics (COMP_ENG 395, 495)

Fall 2022

Spring 2023

MIT Teaching Assistant

Biological Systems Modeling (20.334)

Cambridge, MA

Cellular Neurophysiology and Computing (9.21)

Fall 2021

Biological Systems Modeling (20.334)

Fall 2020

Fall 2017

MIT BE Data Lab

Fellow

Cambridge, MA

March 2020 – May 2021

TECHNICAL SKILLS

- Clean-room fabrication: photolithography, thin-film deposition, reactive-ion and wet etching
- Electrochemical characterization: electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), ion-selective electrode (ISE) potentiometry, inductively-coupled plasma atomic emission spectroscopy (ICP-AES)
- Fluorescence microscopy: widefield, confocal, two-photon, fluorescence lifetime imaging microscopy (FLIM)
- Biological wet-lab: microarray fabrication, cell culturing, EDC/NHS protein functionalization, plasmid amplification and transfection
- Rapid prototyping: CNC milling, 3D printing (FDM and SLA)
- Animal preparations: *ex vivo* bullfrog sciatic nerve, acute *in vivo* rat sciatic nerve, rat hippocampal neuron culture, rat dorsal root ganglion culture
- Embedded electronics design: fPCB design and fabrication, Bluetooth Low-energy (BLE) embedded software, mobile integration
- Numerical simulation: COMSOL Multiphysics, NEURON
- Programming languages (see <https://github.com/mflav>): Python, C, C++, Java, SystemVerilog, Haskell, Julia, Swift
- Mathematical packages: Mathematica, Matlab
- DAQ control: Labview, TDT RPvdsEx/Synapse
- CAD: SolidWorks, AutoCAD, Adobe Illustrator, EAGLE, Blender, Unity
- Other: fabrication and operation of microfluidic devices, GNU/Linux software development, statistical/machine learning

LANGUAGES

Spanish (emergent)

German (emergent)

Korean (emergent)

OTHER ACTIVITY

MIT bouldering wall

Volunteer staff member

Cambridge, MA

September 2015 – May 2021

ADDITIONAL INFORMATION

Google scholar: <https://scholar.google.com/citations?user=3VgPQZoAAAAJ>

LinkedIn: <https://www.linkedin.com/in/matthew-flavin-a6b52250/>

Github: <https://github.com/mflav>

ORCID: <https://orcid.org/0000-0001-6636-0445>

Homepage: <https://flavinresearch.io>

REFERENCES

References available upon request