Joshua Brendan Melander, PhD

Contact Information

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Research Interests

Trained in deep mechanistic modeling of biological circuits, I carry that rigor across the boundary between living and artificial computation.

Networks, read like neurons
Biological interpretation of artificial neural networks

Explaining what deep networks compute with the causal, circuit-level methods of neuroscience: sparse features and superposition, circuits and attribution, and new architectures extending and improving transformers.

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Neurons, run like networks
Biocomputing and neural modeling

Engineering living human neural tissue into substrates that learn and compute: custom-wired circuits in neural organoids.

Scientific Training

Postdoc Stanford University, California *2026–present*

PI: Dr. Sergiu Pasca, Pasca Lab
Computation × neural organoids

PhD Stanford University, California *2017–2025*

Neuroscience Graduate Program
Advisor: Dr. Stephen Baccus
Deep models of the retina and causal frameworks from neuroscience for AI interpretability
Rotations: Dr. Daniel Yamins, Dr. Karl Deisseroth, Dr. Stephen Baccus

Summer Course Marine Biological Laboratory, Massachusetts *2023*

Methods in Computational Neuroscience
Studied recurrent-neural-network gating with Dr. Haim Sompolinsky

Post-Bac Vollum Institute, Oregon *2014–2017*

Research Assistant
Advisors: Dr. Haining Zhong and Dr. Tianyi Mao

B.S. Whitman College, Washington *2010–2014*

Biochemistry, Biophysics, and Molecular Biology
Magna Cum Laude, Honors Thesis
Advisors: Dr. Christopher Wallace and Dr. Ginger Withers

Select Publications

Melander, J.B., Alaoui, Z., Liu, S., Ganguli, S., Baccus, S. (2026) Causal interpretation of neural network computations with contribution decomposition (CODEC). *International Conference on Learning Representations (ICLR).* [pdf] [code]

Ding, X., Lee, D., **Melander, J.B.**, Sivulka, G., Ganguli, S., Baccus, S. (2023) Information geometry of the retinal representation manifold. *Advances in Neural Information Processing Systems (NeurIPS).*

Maheswaranathan, N., McIntosh, L., . . . , **Melander, J.B.**, Nayebi, A., Brezovec, L., Wang, J., Ganguli, S., Baccus, S. (2023) Interpreting the retinal neural code for natural scenes: from computations to neurons. *Neuron* 111, 2742–2755.

Melander, J.B.*, Nayebi, A.*, Jongbloets, B., Fortin, D., Qin, M., Ganguli, S., Mao, T., Zhong, H. (2021) Distinct *in vivo* dynamics of excitatory synapses onto cortical pyramidal neurons and parvalbumin-positive interneurons. *Cell Reports* 37 (6), 109972. [pdf]

Maheswaranathan, N., McIntosh, L., Tanaka, H., Grant, S., Kastner, D., **Melander, J.B.**, Brezovec, L., Nayebi, A., Wang, J., Ganguli, S., Baccus, S. (2019) The dynamic neural code of the retina for natural scenes. *bioRxiv* 430943.

Fortin, D., **Melander, J.B.**, Jongbloets, B., Xiong, W., Guo, C., Mao, T., Zhong, H. (2019) High-contrast visualization of endogenous proteins for live imaging. *Microscopy and Microanalysis* 25 (S2), 1250–1251.

Ma, L., Jongbloets, B., Xiong, W., **Melander, J.B.**, Qin, M., Lameyer, T., Harrison, M., Zemelman, B., Mao, T., Zhong, H. (2018) A highly sensitive A-kinase activity reporter for imaging neuromodulatory events in awake mice. *Neuron* 99 (4), 665–679.

Fortin, D., Tillo, S., Yang, G., Rah, J., **Melander, J.B.**, Bai, S., Solar-Cedeno, O., Qin, M., Zemelman, B., Guo, C., Mao, T., Zhong, H. (2014) Live imaging of endogenous PSD-95 using ENABLED: a conditional strategy to fluorescently label endogenous proteins. *Journal of Neuroscience* 34 (50), 16698–16712.

Open-Source Software

bscope: neural-network functional microscopy

PyTorch library for recording activations, gradients, and contributions in any model (CNNs, MLPs, ViTs), with attribution methods, causal ablations including attention-head disruption, and sparse autoencoders. Code for CODEC (ICLR 2026).

Select Conference Presentations

Melander, J.B., Jolley, H., Miller, T., Withers, G., Wallace C. (2012) Coordinated cellular responses to experience-dependent plasticity. Murdock College Science Research Conference, Walla Walla, WA (Poster)

Melander, J.B., Withers, G., Wallace C. (2013) Quantitative analysis of immunohistochemical markers of the induction of plasticity at the synapse and nucleus. Undergraduate poster session, Society for Neuroscience Annual Meeting, San Diego, CA (Poster)

Melander, J.B., Jongbloets, B., Qin, M., Zhong, H., Mao, T. (2016) Imaging neuromodulation *in vivo*. BRAIN Initiative Investigators Meeting, Bethesda, MD (Poster)

Melander, J.B., Qin, M., Zhong, H., Mao, T. (2017) Chronic *in vivo* imaging of excitatory shaft synapses onto cortical interneurons. Dendrite Gordon Research Conference, Lucca, Italy (Poster)

Melander, J.B., Nayebi, A., Jongbloets, B., Fortin, D., Qin, M., Ganguli, S., Mao, T., Zhong, H. (2018) Chronic *in vivo* imaging of excitatory synapses onto pyramidal and interneurons. Society for Neuroscience Conference, San Diego, CA (Poster)

Nayebi, A.*, **Melander, J.B.***, Jongbloets, B., Mao, T., Zhong, H., Ganguli, S. (2019) Measuring and modeling the weight dynamics of many synapses onto diverse cell-types *in vivo*. COSYNE, Lisbon, Portugal (Talk)

Awards

Alfred D. Abshire Scholar Research Award (2012)

Walter Brattain Academic Scholarship Award (2010–2014)

Oregon Developmental Biology Collaboration Award (2017)

Stanford Mind, Brain, Computation and Technology (Admittance, 2020)

Admitted to "Methods in Computational Neuroscience" summer session at Marine Biological Laboratory (2023)

Teaching

Neurobiology (Biology 325), Whitman College (2013)

Laboratory TA: Organized staining, microscopy and electrophysiology exercises for students enrolled in Neurobiology labs

Genetics (Biology 303), Whitman College (2014)

Writing Fellow: Mentored other students taking Genetics in basic skills of scientific writing and figure preparation

Biophysics (BBMB 335), Whitman College (2014)

Laboratory TA: Organized computational exercises in protein folding simulation and visualization (Coot, QtMG), as well as wet-lab exercises including denaturation and biofilm assays

MATLAB and Microscopy Study Group, Vollum Institute (2016)

Lecturer: Taught general principles of classic machine-learning algorithms and implemented them in custom MATLAB scripts for a small study group of neurobiologists

CNJCx: Practical Python, Stanford University (2020)

Organizer, Director: A six-week curated virtual course designed to overcome the hurdles often faced by new programmers when approaching Python. Included numerous guest speakers, including professors and professional game designers. Supported by the Stanford Computational Neuroscience Journal Club and Stanford Mind, Brain, Computation, and Technology.

Mentorship

Zaki Alaoui

Now: REACH scholar at Stanford University

Prachi Shah

Then: community-college intern in Baccus Lab
Now: undergraduate at UCI

Srinidhi Naidu

Then: high-school student in Baccus Lab
Now: Undergraduate, University of Washington Neuroscience, Tuthill Lab