We study how the circuitry of the retina translates the visual scene into electrical impulses in the optic nerve. Visual perception is initiated by the molecules, cells and synapses of the retina, acting together to process and compress visual information into a sequence of spikes in a population of nerve fibers. One of the largest gaps in neuroscience lies in the explaining of systems-level processes like visual processing in terms of cellular-level mechanisms. This problem is tractable in the retina because of its experimental accessibility, and the substantial amount already known about basic retinal cell types and functions.

Our goal is to extract general principles of computation in neural circuits, and to explain specific retinal visual processes such as adaptation to contrast and image statistics, and the detection of moving objects. To do this, we use a versatile set of experimental and theoretical techniques. While projecting visual scenes from a video monitor onto the isolated retina, an extracellular multielectrode array is used to record a substantial fraction of the output of a small patch of retina. Simultaneously, we record intracellularly from retinal interneurons in order to monitor and perturb single cells as the circuit operates. To measure the activity of both populations of interneurons and output neurons, we record visual responses optically using two-photon imaging while simultaneously recording with a multielectrode array. Finally, all of this data is assembled and interpreted in the context of mathematical models to predict and explain the output of the retinal circuit.
An additional focus of the lab is to develop approaches to stimulate the nervous system using focused ultrasound. Recent studies have shown that ultrasound can activate the retina with high spatial and temporal precision. This technology holds promise as a noninvasive tool to study the brain and treat diseases of the nervous system both in the retina and elsewhere in the brain.

Teaching

COURSES

2019-20
- The Nervous System: NBIO 206 (Win)

2018-19
- Mathematical Tools for Neuroscience: NBIO 228 (Win)
- Neuroscience Computational Core: NEPR 208 (Spr)
- The Nervous System: NBIO 206 (Win)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)
- Tyler Benster, Luke Brezovec, Mihyun Choi, Minseung Choi, Alex Gogliettino, Austin Kuo, Sasi Madugula, Raymond McKoy, Gabriel Mel, Kasra Naftchi-Ardebili, John Wen

Doctoral Dissertation Advisor (AC)
- Xuehao Ding, Dongsoo Lee, Josh Melander, Eric Nguyen, Kyrstyn Ong, Javier Weddington

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS
- Neurosciences (Phd Program)

Publications

PUBLICATIONS

- How inhibitory neurons increase information transmission under threshold modulation. *Cell reports*
  Hsu, W. M., Kastner, D. B., Baccus, S. A., Sharpee, T. O.
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- Adaptation of Inhibition Mediates Retinal Sensitization. *Current biology : CB*
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- Radiation force as a physical mechanism for ultrasonic neurostimulation of the ex vivo retina. *The Journal of neuroscience : the official journal of the Society for Neuroscience*
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- From deep learning to mechanistic understanding in neuroscience: the structure of retinal prediction. *NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2019*

- Adaptive feature detection from differential processing in parallel retinal pathways. *PLoS computational biology*
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Optimal Information Transmission by Overlapping Retinal Cell Mosaics
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Suh, B., Baccus, S. A.
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Kastner, D. B., Baccus, S. A.
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Jadzinsky, P. D., Baccus, S. A.
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