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)

2017-18

• 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, Minseung Choi, Alex Gogliettiino, Sasi Madugula, Gabriel Mel, Kasra Naftchi-Ardebili, Aran Nayebi, John Wen

Doctoral Dissertation Advisor (AC)
Dongsoo Lee, Josh Melander, Kyrstyn Ong, Javier Weddington

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

• Neurosciences (Phd Program)

Publications

PUBLICATIONS

• Ultrasound Elicits Behavioral Responses through Mechanical Effects on Neurons and Ion Channels in a Simple Nervous System JOURNAL OF NEUROSCIENCE
  2018; 38 (12): 3081–91

• A Communication-Theoretic Formulation of a Continuous Linear-Nonlinear Model of Retinal Ganglion Cells IEEE
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• Optimal Information Transmission by Overlapping Retinal Cell Mosaics IEEE
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• Synchronized amplification of local information transmission by peripheral retinal input ELIFE
  Jadzinsky, P. D., Baccus, S. A.
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• Critical and maximally informative encoding between neural populations in the retina. *Proceedings of the National Academy of Sciences of the United States of America*
  Kastner, D. B., Baccus, S. A., Sharpee, T. O.
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• Insights from the retina into the diverse and general computations of adaptation, detection, and prediction *CURRENT OPINION IN NEUROBIOLOGY*
  Kastner, D. B., Baccus, S. A.
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• Spatial segregation of adaptation and predictive sensitization in retinal ganglion cells. *Neuron*
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• Transformation of visual signals by inhibitory interneurons in retinal circuits. *Annual review of neuroscience*
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• Coordinated dynamic encoding in the retina using opposing forms of plasticity *NATURE NEUROSCIENCE*
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• Timing and computation in inner retinal circuitry *ANNUAL REVIEW OF PHYSIOLOGY*
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• From a whisper to a roar: Adaptation to the mean and variance of naturalistic sounds *NEURON*
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Palanker, D., Huie, P., Vankov, A., Asher, A., Baccus, S.  
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