*Curriculum Vitae* **Nathaniel B. Sawtell** January 19, 2016

## A. FIELD OF SPECIALIZATION

The goal of my research is to understand how the nervous system learns and stores internal models of the causal relations that govern interactions between an organism and the world. Our studies of weakly electric fish have provided a detailed mechanistic understanding of how predictions about the sensory consequences an animal's own behavior are generated at the level of neurons, circuits, and synaptic plasticity. These studies shed light on the fundamental issues of how the nervous system distinguishes self-generated from external sources of sensory input and how motor systems affect sensory processing. Predictions of motor actions by internal models are critical for an organism's ability to maintain a stable representation of the external world while actively moving, and for carrying out rapid motor tasks with a high degree of precision. The structures that generate internal models in electric fish are similar in their evolution, development, gene expression, and circuitry to the cerebellum. Hence our studies also bear directly on cerebellar function. In particular, our work has provided the first experimental evidence for longstanding theories regarding the computations performed by cerebellar granule cells. Ongoing work in the laboratory seeks to leverage insights gained from studies of electric fish to understand how internal models are generated in the mammalian brain. Our initial studies focus on the dorsal cochlear nucleus--a circuit in the auditory brainstem that is hypothesized to filter out self-generated sounds. Understanding neural mechanisms underlying internal models may yield insight into pathological mechanisms underlying neuropsychiatric disease. Tinnitus, or ringing in the ears, is linked to hyperactivity in dorsal cochlear nucleus neurons and may represent a failure to suppress self-generated sounds. Autism has been linked to both abnormal development of the cerebellum and an inability to filter out irrelevant sensory stimuli. Finally, auditory hallucinations in schizophrenia are hypothesized to be due to a failure of the mechanisms that normally serve to distinguish self-generated from external sources of sensory stimulation. Thus, insights from our research may yield novel approaches to treating these devastating disorders.

## B. EDUCATION

**Brown University** B.S. in Neuroscience with honors (magna cum laude), 1993-1997

**Brown University** Ph.D. in Neuroscience, 1997-2002
Dissertation title: Cellular and biochemical mechanisms of experience-dependent plasticity in the mouse visual cortex
Dissertation advisor: Prof. Mark F. Bear

## C. POSITIONS HELD SINCE BACHELORS CONFERRED

06/2002 – 08/2007 **Oregon Health & Science University**, **Neurological Sciences Institute**, Postdoctoral Fellow with Dr. Curtis Bell

09/2007 – 06/2009 **Oregon Health & Science University, Neurological Sciences Institute**
Senior Research Associate

07/2009 – 04/2016 **Columbia University, Dept. of Neuroscience,** Assistant Professor

04/2016 - present **Columbia University, Dept. of Neuroscience,** Associate Professor

## D. TEACHING EXPERIENCE

1. Courses Taught

Survey of Neuroscience (Columbia University doctoral course; instructor 2010-2014)
Issues in Neural Circuitry (Columbia University doctoral course; co-director 2011, 2014)
The Body in Health & Disease II (Columbia University medical student course; instructor 2010-2014)
Neuroethology (Columbia University doctoral course; instructor 2011)
Ignorance (Columbia University undergraduate course; instructor 2011)
Professional Skills (Columbia University doctoral course; instructor 2012-2015)
Developmental and Systems Neurobiology (Columbia University undergraduate course; instructor 2013)
Woods Hole Methods in Computational Neuroscience Course (instructor; 2014)
Systems Neuroscience (Vollum Institute, Oregon Health & Science University doctoral course; instructor 2014, 2015)

2. Mentoring Experience

† denotes candidate assisted student/postdoc in applying for a successfully funded fellowship from National Institute of Health or National Science Foundation

**Postdoctoral Researchers**
Dr. Karina Alvina (2009-2011)

**Sponsor of Ph.D. dissertations at Columbia University**
Tim Requarth† (2009-2014) "*Neural mechanisms for sensory predictions in a cerebellum-like structure*"
Karina Scalise (2010-2015) "*A comparative approach to cerebellar circuit function*"
Shobhit Singla† (MD/PhD; 2011-present, expected defense 06/2016, "*Adaptive cancellation of self-generated sounds by cerebellum-like circuitry in the auditory system*")
Armen Enikolopov (2012-present, expected defense 12/2016, "*Subtracting negative images of self-generated sensory input improves neural and behavioral detection of external stimuli*")
Rick Warren (2015-present)
Kathryn Birkenbach (2015-present)

## E. PUBLICATIONS

### PUBLISHED PEER-REVIEWED RESEARCH ARTICLES

* denotes candidate as senior author

1. Requarth, T. Kaifosh, P. and Sawtell N.B.* (2014) A role for mixed corollary discharge and proprioceptive signals in predicting the sensory consequences of movements. **J Neurosci.** 34:16103-16.

2. Requarth, T. and Sawtell N.B.* (2014) Plastic corollary discharge predicts sensory consequences of movements in a cerebellum-like circuit. **Neuron** 82:896-907.

3. Alvina K., Sawtell N.B.* (2014) Sensory processing and corollary discharge effects in posterior caudal lobe Purkinje cells in a weakly electric mormyrid fish. **J Neurophysiol.** 112:328-39.

4. Kennedy, A., Wayne, G., Kaifosh, P., Alvina, A., Abbott, L.F., and Sawtell, N.B.* (2014) A temporal basis for predicting the sensory consequences of motor commands in an electric fish. **Nat. Neurosci.** 17:416-422.

5. Sawtell, N.B.* (2010) Multimodal integration in granule cells as a basis for associative plasticity and sensory prediction in a cerebellum-like circuit. **Neuron** 66:573-584.

6. Sawtell, N.B.* and Williams, A. (2008) Transformations of electrosensory encoding associated with an adaptive filter. **J. Neuroscience** 28:1598-1612. (Faculty of 1000 selection; featured in *This Week in the Journal*)

7. Sawtell, N.B., Williams, A., and Bell, C. (2007) Central control of dendritic spikes shapes the responses of Purkinje-like cells through spike timing-dependent synaptic plasticity. **J. Neuroscience** 27:1552-65. (Faculty of 1000 selection)

8. Sawtell, N.B., Williams, A., von der Emde, G., Roberts, P.D., and Bell, C. (2006) Effects of sensing behavior on a latency code. **J. Neuroscience** 32:8221-34. (Faculty of 1000 selection)

9. Frenkel, M., Sawtell, N.B., Diogo, A.C., Yoon, B., Neve, R., and Bear, M.F. (2006) Instructive effects of visual experience in mouse visual cortex. **Neuron** 51(3):339-49.

10. Roberts, P.D., Portfors, C.V., Sawtell, N.B. and Felix R. (2006) Model of auditory prediction in the dorsal cochlear nucleus via spike-timing dependent plasticity. **Neurocomputing 69**:1191–1194

11. Roberts, P.D., Lafferriere, G., Sawtell, N.B., Williams, A., and Bell, C.C. (2006) Dynamic regulation of spike-timing dependent plasticity in electrosensory processing. **Neurocomputing 69**: 1195–1198.

12. Sawtell, N.B., Mohr, C. and Bell C. (2005) Recurrent Feedback in the Mormyrid Electrosensory System: Cells of the Preeminential and Lateral Toral Nuclei. **J. Neurophysiology** 93(4):2090-103.

13. Sawtell, N.B., Frenkel, M., Nakazawa, K., Philpot, B.D., Tonegawa, S., and Bear, M.F. (2003) NMDA Receptor-Dependent Ocular Dominance Plasticity in Adult Visual Cortex. **Neuron** 38(6):977-85. (Previewed article)

14. Philpot, B.D., M.P. Weisberg, M.S. Ramos, N.B. Sawtell, Y.-P. Tang, J.Z. Tsien, and M.F. Bear. (2001) Effect of Transgenic Overexpression of NR2B on NMDA Receptor Function and Synaptic Plasticity in Visual Cortex. **Neuropharmacology** 41: 762-70.

15. Sawtell, N.B., K.M. Huber, J.C. Roder, and M.F. Bear. (1999) Induction of NMDA Receptor-Dependent Long-Term Depression in Visual Cortex Does Not Require Metabotropic Glutamate Receptors**. J. Neurophysiology** 82: 3594-3597.

16. Huber, K.M., N.B. Sawtell and M.F. Bear. (1998) Effects of the Metabotropic Glutamate Receptor Antagonist MCPG on Phosphoinositide Turnover and Synaptic Plasticity in Visual Cortex. **J. Neuroscience** 18: 1-9.

17. Huber, K.M., N.B. Sawtell and M.F. Bear. (1998) Brain-derived Neurotrophic Factor Alters the Synaptic Modification Threshold in Visual Cortex. **Neuropharmacology** 37: 571-79.

**PUBLISHED REVIEWS**

1. Sawtell, N.B. and Abbott L.F. Strength in more than numbers. (2015) **Nat. Neurosci.** 18: 614-616.

2. Sawtell, N.B. and Bell, C.C. Cerebellum-like structures, in Handbook of the Cerebellum and Cerebellar Disorders, M. Manto, D.L. Gruol, J.D. Schmahmann, N. Koibuchi, F. Rossi (eds.), Springer (2013).

3. Requarth, T. and Sawtell, N.B.* (2011) Neural mechanisms for filtering self-generated sensory signals in cerebellum-like circuits. **Curr. Opin. Neurobiol.** 21(4):602-8.

4. Sawtell, N.B. and Bell, C.C. (2008) Adaptive electrosensory processing in cerebellum-like structures: links to cerebellar learning. **J. Physiol. (Paris)** 102: 223-32.

5. Bell, C., Han V.Z., and Sawtell, N.B. (2008) Cerebellum-like structures and their relevance for sensory processing and cerebellar function. **Annual Review of Neuroscience** 31: 1-24.

6. Sawtell, N.B., Williams, A., and Bell C. (2005) From sparks to spikes: information processing in the electrosensory systems of fish. **Curr. Opin. Neurobiol.**15:437-443.

7. Crozier, R., Philpot, B.D., Sawtell, N.B., and Bear, M.F. Activity-dependent regulation of glutamatergic synaptic transmission in the cerebral cortex, in The Newest Cognitive Neurosciences, 3rd edition, Michael S. Gazzaniga (Ed.), MIT Press November (2004).

## F. FUNDING SOURCES

**Current**

Neural Mechanisms for Predicting the Sensory Consequences of Behavior
Source: The Irma T. Hirschl/Monique Weill-Caulier Trust
02/2016- 01/2021 Total costs: $175,000 role: PI

From sensation to perception: cellular and circuit mechanisms underlying prey detection in an electric fish
Source: NSF Collaborative Research in Computational Neuroscience (IOS-1430065)
09/01/2014 – 08/31/2017 Total Direct Costs: $466,137 role: PI (co-PI Larry Abbott)

Role for granule cells in adaptive processing in a cerebellum-like circuit
Source: National Institute of Neurological Disorders & Stroke (R01NS075023)
07/1/2012 – 05/31/2016 Total Direct Costs: $1,140,641 role: PI

**Past**

Mechanisms for sensory prediction in cerebellar circuits
Source: McKnight Foundation
07/1/2011 – 06/30/2015 Total Direct Costs: $225,000 role: PI

Mechanisms for sensory prediction in a cerebellum-like circuit
Source: National Science Foundation (IOS-1025849)
08/15/2010 – 07/31/2014 Total Direct Costs: $259,415 role: PI

Mechanisms for adaptive sensory processing in cerebellum-like circuits
Source: Alfred P. Sloan Foundation
09/15/2011 – 09/15/2013 Total Direct Costs: $50,000 role: PI

Learning and processing of electrosensory patterns in mormyrid electric fish
Source: NSF Collaborative Research in Computational Neuroscience (IIS-0827722)
09/01/2008 – 08/31/2012 Total Direct Costs: $469,331 role: co-PI

Developing population imaging and electrophysiological methods for studying cerebellar and hippocampal circuits in behaving animals
Source: Kavli Institute for Brain Science
01/01/2011 – 12/31/2011 Total Direct Costs: $50,000 role: co-PI

Descending inputs and the decoding of temporally encoded sensory information
Source: National Science Foundation (IOB-0618212)
04/01/2009 – 09/30/2010 Total Direct Costs: $102,401 role: PI

## G. NO PATENTS HELD OR PENDING

## H. AWARDS & HONORS

2011 Alfred P. Sloan Research Fellow
2011 McKnight Scholar Award
2016 Irma T. Hirschl Career Scientist Award

**INVITED SEMINARS**

11/2015 Champalimaud Neuroscience Programme
10/2015 Brooklyn College
08/2015 Cerebellum Gordon Research Conference
06/2015 Gatsby computational neuroscience unit tri-centers meeting
04/2015 McGovern Institute Symposium on Internal models, MIT
11/2014 Salk Institute
09/2014 Keynote lecture with Larry Abbott at Bernstein Conference, Gottingen, Germany
06/2014 McKnight Foundation Conference on Neuroscience
03/2014 Neural Control of Movement, invited session: "Predicting with the Cerebellum"
02/2014 University of North Carolina, Dept. of Cell Biology & Physiology
01/2014 Harvard University, Center for Brain Science
05/2013 Corollary Discharge Workshop, Janelia Farms Research Campus
04/2013 Case Western Reserve University, Department of Neuroscience
01/2012 Nagoya University Global COE Symposium
11/2011 Cornell University, Department of Neurobiology and Behavior
12/2011 Cold Spring Harbor Meeting Evolution of Neural Circuits and Behavior
09/2011 Ascona Assembly and Function of Neural Circuits Meeting
09/2011 Cerebellum Gordon Research Conference
06/2011 Janelia Farms Research Campus
05/2011 University of Chicago, Department of Neurobiology
04/2011 Cold Spring Harbor Meeting From Molecules to Circuits & Behavior
04/2010 McGill University, Department of Physiology
03/2010 Rockefeller University, Neuroscience Seminar Series
02/2008 University of Wisconsin, Madison, Department of Physiology
02/2008 University of Connecticut, Department of Physiology and Neurobiology
12/2007 George Mason University, Krasnow Institute for Advanced Study
06/2007 Electrosensory Systems, satellite to the 8th International Congress of Neuroethology, Vancouver, Canada

Upcoming:
02/2016 West Virginia University, Department of Biology
04/2016 University of Southern California, Department of Biological Sciences
05/2016 New York University Medical Center, Center for Neural Science
05/2016 Rockefeller University, Neuroscience Seminar Series

## I. SERVICE

1. University/Department Service

Neuroscience Faculty Search committee (member 2010)
Neuroscience Doctoral Program Admission committee (member 2012-14; co-chair 2015-2016)
Neuroscience Doctoral Program Retreat Planning committee (member 2011)

Thesis/Qualifying Exam committees are listed in section "D.2. Mentoring Experience" above.

2. Scientific Community Service

- **Grant Reviewer**

Israeli Science Foundation, National Science Foundation Collaborative Research in Computational Neuroscience (panel 03/2015); Human Frontiers Science Program

- **Journal Reviewer**

*Cerebellum, Current Biology, Elife, Journal of Neurophysiology, Journal of Neuroscience, Journal of Physiology, Nature Communications, Nature Neuroscience, Neuron, PLoS Biology, PLoS Computational Biology, Proceedings of the National Academy of Science*

- **Conference Organizer**

Computational & Systems Neuroscience (COSYNE) meeting (program committee 2014)