Aravinthan D.T. Samuel, *Curriculum Vitae*

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Education

Harvard University	Cambridge, MA	Neuroscience	Postdoctoral Fellow, 1999-2003
Harvard University	Cambridge, MA	Biophysics	Ph.D., 1999
Harvard University	Cambridge, MA	Physics	B.A. 1993

Professional Appointments

2010 – present	Professor of Physics, Harvard University
2008 – 2010	Associate Professor of Physics, Harvard University
2003 – 2008	Assistant Professor of Physics, Harvard University

Honors

2008	NIH Director's Pioneer Award
2007	Dana Foundation Award in Brain and Immuno-imaging
2006	Presidential Early Career Award for Scientists and Engineers
2005	NSF CAREER Award
2005	McKnight Scholar
2004	Alfred P. Sloan Foundation Research Fellow
2000	Amgen Fellow of the Life Sciences Research Foundation

Research

I am interested in the motile behavior of small organisms. We use biophysics to understand how behavior is organized by underlying computational networks that transform sensory perception into motor decisions. I began studying the chemotactic behavior of *Escherichia coli* as a graduate student with Howard Berg. In our lab, we study navigational behaviors in the nematode *Caenorhabditis elegans* and the *Drosophila* larva. We build and use tools for quantitative behavioral analysis in defined stimulus environments, for optical neurophysiology of neural circuits, and for the structural reconstruction of neural circuits using electron microscopy. We seek the structure and function of networks that perform the computations needed for purposeful behavior.

Teaching

I developed three courses that constitute my main teaching activities at Harvard University.

Freshman Seminar 51x	Changing Perspectives: The Science of Optics in the Visual Arts
Physics 140	Introduction to the Physics of Living Systems
Physics/Neuro 141	The Physics of Sensory Systems in Biology

Publications

86. Hernandez-Nunez, L. *et al.* Opponent thermosensory cells use flexible cross-inhibition for context-dependent choice in *Drosophila* thermotaxis. *Science Advances,* in press (2021).

85. Ji, N. *et al.* Corollary discharge promotes a sustained motor state in a neural circuit for navigation. *eLife* **10** (2021).

84. Susoy, V. *et al.* Natural sensory context drives diverse brain-wide activity during *C. elegans* mating. *Cell,* in press (2021).

83. Vogt, K. *et al.* Internal state configures olfactory behavior and early sensory processing in *Drosophila* larvae. *Science Advances* **7** (2021).

82. Witvliet, D. *et al.* Connectomes across development reveal principles of brain maturation. *Nature,* in press (2021).

81. Yemini, E. *et al.* NeuroPAL: A Multicolor Atlas for Whole-Brain Neuronal Identification in *C. elegans*. *Cell* **184,** 272–288.e11 (2021).

80. Choi, J. *et al.* Probing and manipulating embryogenesis via nanoscale thermometry and temperature control. *Proceedings of the National Academy of Sciences of the United States of America* **117,** 14636–14641 (2020).

79. Mi, L. *et al.* Learning Guided Electron Microscopy with Active Acquisition. *MICCAI: International Conference on Medical Image Computing and Computer-Assisted Intervention, Lecture Notes in Computer Science* **12265,** 77–87 (2020).

78. Nejatbakhsh, A. *et al.* Demixing Calcium Imaging Data in *C. elegans* via Deformable Nonnegative Matrix Factorization. *MICCAI: International Conference on Medical Image Computing and Computer-Assisted Intervention, Lecture Notes in Computer Science* **12265,** 14–24 (2020).

77. Budelli, G. *et al.* Ionotropic Receptors Specify the Morphogenesis of Phasic Sensors Controlling Rapid Thermal Preference in *Drosophila*. *Neuron* **101,** 738–747.e3 (2019).

76. Calarco, J. A. & Samuel, A. D. Imaging whole nervous systems: insights into behavior from worms to fish. *Nature Methods* **16,** 14–15 (2019).

75. Si, G. *et al.* Structured Odorant Response Patterns across a Complete Olfactory Receptor Neuron Population. *Neuron* **101,** 950–962.e7 (2019).

74. Hawk, J. D. *et al.* Integration of Plasticity Mechanisms within a Single Sensory Neuron of *C. elegans* Actuates a Memory. *Neuron* **97,** 356–367.e4 (2018).

73. He, L., Si, G., Huang, J., Samuel, A. D. & Perrimon, N. Mechanical regulation of stem-cell differentiation by the stretch-activated Piezo channel. *Nature* **555,** 103–106 (2018).

72. Humberg, T. H. *et al.* Dedicated photoreceptor pathways in *Drosophila* larvae mediate navigation by processing either spatial or temporal cues. *Nature Communications* **9** (2018).

71. Mulcahy, B. *et al.* A pipeline for volume electron microscopy of the *Caenorhabditis elegans* nervous system. *Frontiers in Neural Circuits* **12,** 94 (2018).

70. Klein, M. *et al.* Exploratory search during directed navigation in *C. elegans* and *Drosophila* larva. *eLife* **6** (2017).

69. Berck, M. E. *et al.* The wiring diagram of a glomerular olfactory system. *eLife* **5** (2016).

68. Knecht, Z. A. *et al.* Distinct combinations of variant ionotropic glutamate receptors mediate thermosensation and hygrosensation in *Drosophila*. *eLife* **5** (2016).

67. Lim, M. A. *et al.* Neuroendocrine modulation sustains the *C. elegans* forward motor state. *eLife* **5** (2016).

66. Narayan, A. *et al.* Contrasting responses within a single neuron class enable sex-specific attraction in *Caenorhabditis elegans*. *Proceedings of the National Academy of Sciences of the United States of America* **113,** E1392–E1401 (2016).

65. Ni, L. *et al.* The ionotropic receptors IR21a and IR25a mediate cool sensing in *Drosophila*. *eLife* **5,** 1–12 (2016).

64. Shen, Y. *et al.* An extrasynaptic GABAergic signal modulates a pattern of forward movement in *Caenorhabditis elegans*. *eLife* **5,** e14197 (2016).

63. Van Giesen, L. *et al.* Multimodal stimulus coding by a gustatory sensory neuron in *Drosophila* larvae. *Nature Communications* **7,** 10687 (2016).

62. Venkatachalam, V. *et al.* Pan-neuronal imaging in roaming *Caenorhabditis elegans*. *Proceedings of the National Academy of Sciences of the United States of America* **113,** E1082–E1088 (2016).

61. Fang-Yen, C., Alkema, M. J. & Samuel, A. D. Illuminating neural circuits and behaviour in *Caenorhabditis elegans* with optogenetics. *Philosophical Transactions of the Royal Society B: Biological Sciences* **370,** 20140212 (2015).

60. Hernandez-Nunez, L. *et al.* Reverse-correlation analysis of navigation dynamics in *Drosophila* larva using optogenetics. *eLife* **4,** 9 (2015).

59. Kain, J. S. *et al.* Variability in thermal and phototactic preferences in *Drosophila* may reflect an adaptive bet-hedging strategy. *Evolution* **69,** 3171–3185 (2015).

58. Klein, M. *et al.* Sensory determinants of behavioral dynamics in *Drosophila* thermotaxis. *Proceedings of the National Academy of Sciences of the United States of America* **112,** E220–E229 (2015).

57. Zhen, M. & Samuel, A. D. *C. elegans* locomotion: Small circuits, complex functions. *Current Opinion in Neurobiology* **33,** 117–126 (2015).

56. Goodman, M. B. *et al.* Thermotaxis navigation behavior. *WormBook : the online review of C. elegans biology,* 1–10 (2014).

55. Luo, L. *et al.* Bidirectional thermotaxis in *Caenorhabditis elegans* is mediated by distinct sensorimotor strategies driven by the AFD thermosensory neurons. *Proceedings of the National Academy of Sciences of the United States of America* **111,** 2776–2781 (2014).

54. Luo, L. *et al.* Dynamic encoding of perception, memory, and movement in a *C. elegans* chemotaxis circuit. *Neuron* **82,** 1115–1128 (2014).

53. Donnelly, J. L. *et al.* Monoaminergic Orchestration of Motor Programs in a Complex *C. elegans* Behavior. *PLoS Biology* **11,** e1001529 (2013).

52. Kane, E. A. *et al.* Sensorimotor structure of *Drosophila* larva phototaxis. *Proceedings of the National Academy of Sciences of the United States of America* **110,** E3868–77 (2013).

51. Mathew, D. *et al.* Functional diversity among sensory receptors in a *Drosophila* olfactory circuit. *Proceedings of the National Academy of Sciences of the United States of America* **110,** E2134–43 (2013).

50. Reina, A., Subramaniam, A. B., Laromaine, A., Samuel, A. D. & Whitesides, G. M. Shifts in the Distribution of Mass Densities Is a Signature of Caloric Restriction in *Caenorhabditis elegans*. *PLoS ONE* **8,** e69651 (2013).

49. Smith, H. K. *et al.* Defining specificity determinants of cGMP mediated gustatory sensory transduction in *Caenorhabditis elegans*. *Genetics* **194,** 885–901 (2013).

48. Williams, D. C. *et al.* Rapid and Permanent Neuronal Inactivation InVivo via Subcellular Generation of Reactive Oxygen with the Use of KillerRed. *Cell Reports* **5,** 553–563 (2013).

47. Fang-Yen, C., Gabel, C. V., Samuel, A. D., Bargmann, C. I. & Avery, L. Laser Microsurgery in *Caenorhabditis elegans*. *Methods in Cell Biology* **107,** 177–206 (2012).

46. Gershow, M. *et al.* Controlling airborne cues to study small animal navigation. *Nature Methods* **9,** 290–296 (2012).

45. Gershow, M. *et al.* Controlling airborne cues to study small animal navigation. *Nature Methods* **9,** 290–296 (2012).

44. Omura, D. T., Clark, D. A., Samuel, A. D. & Horvitz, H. R. Dopamine signaling is essential for precise rates of locomotion by *C. elegans*. *PLoS ONE* **7,** e38649 (2012).

43. Pinan-Lucarre, B. *et al.* The core apoptotic executioner proteins CED-3 and CED-4 promote initiation of neuronal regeneration in *Caenorhabditis elegans*. *PLoS Biology* **10,** e1001331 (2012).

42. Stavoe, A. K. *et al.* Synaptic vesicle clustering requires a distinct MIG-10/lamellipodin isoform and ABI-1 downstream from Netrin. *Genes and Development* **26,** 2206–2221 (2012).

41. Wen, Q. *et al.* Proprioceptive Coupling within Motor Neurons Drives *C. elegans* Forward Locomotion. *Neuron* **76,** 750–761 (2012).

40. Lahiri, S. *et al.* Two alternating motor programs drive navigation in *Drosophila* larva. *PLoS ONE* **6,** e23180 (2011).

39. Leifer, A. M., Fang-Yen, C., Gershow, M., Alkema, M. J. & Samuel, A. D. Optogenetic manipulation of neural activity in freely moving *Caenorhabditis elegans*. *Nature Methods* **8,** 147–152 (2011).

38. Fang-Yen, C. *et al.* Biomechanical analysis of gait adaptation in the nematode *Caenorhabditis elegans*. *Proceedings of the National Academy of Sciences of the United States of America* **107,** 20323–20328 (2010).

37. Garrity, P. A., Goodman, M. B., Samuel, A. D. & Sengupta, P. Running hot and cold: Behavioral strategies, neural circuits, and the molecular machinery for thermotaxis in *C. elegans* and *Drosophila*. *Genes and Development* **24,** 2365–2382 (2010).

36. Ha, H.-I. *et al.* Functional Organization of a Neural Network for Aversive Olfactory Learning in *Caenorhabditis elegans*. *Neuron* **68,** 1173–1186 (2010).

35. Luo, L. *et al.* Navigational decision making in *Drosophila* thermotaxis. *Journal of Neuroscience* **30,** 4261–4272 (2010).

34. Fang-Yen, C., Avery, L. & Samuel, A. D. Two size-selective mechanisms specifically trap bacteria-sized food particles in *Caenorhabditis elegans*. *Proceedings of the National Academy of Sciences of the United States of America* **106,** 20093–20096 (2009).

33. Peidle, J. *et al.* Inexpensive microscopy for introductory laboratory courses. *American Journal of Physics* **77,** 931–938 (2009).

32. Sengupta, P. & Samuel, A. D. *Caenorhabditis elegans*: a model system for systems neuroscience. *Current Opinion in Neurobiology* **19,** 637–643 (2009).

31. Srivastava, N., Clark, D. A. & Samuel, A. D. Temporal analysis of stochastic turning behavior of swimming *C. elegans*. *Journal of Neurophysiology* **102,** 1172–1179 (2009).

30. Biron, D., Wasserman, S., Thomas, J. H., Samuel, A. D. & Sengupta, P. An olfactory neuron responds stochastically to temperature and modulates *Caenorhabditis elegans* thermotactic behavior. *Proceedings of the National Academy of Sciences of the United States of America* **105,** 11002–11007 (2008).

29. Gabel, C. V., Antoine, F., Chuang, C. F., Samuel, A. D. & Chang, C. Distinct cellular and molecular mechanisms mediate initial axon development and adult-stage axon regeneration in *C. elegans*. *Development* **135,** 1129–1136 (2008).

28. Hulme, S. E., Shevkoplyas, S. S. & Samuel, A. Microfluidics: Streamlining discovery in worm biology. *Nature Methods* **5,** 589–590 (2008).

27. Jung, S., Lee, S. & Samuel, A. Swimming *C. elegans* in a wet granular medium. *Chaos* **18** (2008).

26. Luo, L., Gabel, C. V., Ha, H. I., Zhang, Y. & Samuel, A. D. Olfactory behavior of swimming *C. elegans* analyzed by measuring motile responses to temporal variations of odorants. *Journal of Neurophysiology* **99,** 2617–2625 (2008).

25. Zhang, M. *et al.* A Self-Regulating Feed-Forward Circuit Controlling *C. elegans* Egg-Laying Behavior. *Current Biology* **18,** 1445–1455 (2008).

24. Chi, C. A. *et al.* Temperature and food mediate long-term thermotactic behavioral plasticity by association-independent mechanisms in *C. elegans*. *Journal of Experimental Biology* **210,** 4043–4052 (2007).

23. Clark, D. A., Gabel, C. V., Gabel, H. & Samuel, A. D. Temporal activity patterns in thermosensory neurons of freely moving *Caenorhabditis elegans* encode spatial thermal gradients. *Journal of Neuroscience* **27,** 6083–6090 (2007).

22. Clark, D. A., Gabel, C. V., Lee, T. M. & Samuel, A. D. Short-term adaptation and temporal processing in the cryophilic response of *Caenorhabditis elegans*. *Journal of Neurophysiology* **97,** 1903–1910 (2007).

21. Gabel, C. V. *et al.* Neural Circuits Mediate Electrosensory Behavior in *Caenorhabditis elegans*. *Journal of Neuroscience* **27,** 7586–7596 (2007).

20. Korta, J., Clark, D. A., Gabel, C. V., Mahadevan, L. & Samuel, A. D. Mechanosensation and mechanical load modulate the locomotory gait of swimming *C. elegans*. *Journal of Experimental Biology* **210,** 2383–2389 (2007).

19. Biron, D. *et al.* A diacylglycerol kinase modulates long-term thermotactic behavioral plasticity in *C. elegans*. *Nature Neuroscience* **9,** 1499–1505 (2006).

18. Chung, S. H., Clark, D. A., Gabel, C. V., Mazur, E. & Samuel, A. D. The role of the AFD neuron in *C. elegans* thermotaxis analyzed using femtosecond laser ablation. *BMC Neuroscience* **7,** 30 (2006).

17. Clark, D. A., Biron, D., Sengupta, P. & Samuel, A. D. The AFD sensory neurons encode multiple functions underlying thermotactic behavior in *Caenorhabditis elegans*. *Journal of Neuroscience* **26,** 7444–7451 (2006).

16. Luo, L., Clark, D. A., Biron, D., Mahadevan, L. & Samuel, A. D. T. Sensorimotor control during isothermal tracking in *Caenorhabditis elegans*. *The Journal of experimental biology* **209,** 4652–4662 (2006).

15. Samuel, A. D. T. *et al.* Femtosecond laser dissection in *C. elegans* neural circuits. *Commercial and Biomedical Applications of Ultrafast Lasers VI* **6108,** 610801 (2006).

14. Samuel, A. D. & Sengupta, P. Sensorimotor integration: Locating locomotion in neural circuits. *Current Biology* **15,** R341–R343 (2005).

13. Colosimo, M. E. *et al.* Identification of thermosensory and olfactory neuron-specific genes via expression profiling of single neuron types. *Current Biology* **14,** 2245–2251 (2004).

12. Samuel, A. D., Silva, R. A. & Murthy, V. N. Synaptic activity of the AFD neuron in *Caenorhabditis elegans* correlates with thermotactic memory. *Journal of Neuroscience* **23,** 373–376 (2003).

11. Samuel, A., Petersen, J. & Reese, T. Envelope structure of *Synechococcus* sp. WH8113, a nonflagellated swimming cyanobacterium. *BMC Microbiology* **1** (2001).

10. Samuel, A. D., Murthy, V. N. & Hengartner, M. O. Calcium dynamics during fertilization in *C. elegans*. *BMC Developmental Biology* **1,** 1–6 (2001).

9. Mahadevan, L., Ryu, W. S. & Samuel, A. D. Tumbling cards. *Physics of Fluids* **11,** 1–3 (1999).

8. Samuel, A. D. *et al.* Flagellar determinants of bacterial sensitivity to χ-phage. *Proceedings of the National Academy of Sciences of the United States of America* **96,** 9863–9866 (1999).

7. Turner, L., Samuel, A. D., Stern, A. S. & Berg, H. C. Temperature dependence of switching of the bacterial flagellar motor by the protein CheY(13DK106YW). *Biophysical Journal* **77,** 597–603 (1999).

6. Mahadevan, L., Ryu, W. S. & Samuel, A. D. Fluid 'rope trick' investigated. *Nature* **392,** 140 (1998).

5. Samuel, A. D. & Berg, H. C. Statistical kinetics of the bacterial flagellar motor. *Physical Review E - Statistical Physics, Plasmas, Fluids, and Related Interdisciplinary Topics* **55,** 7801–7804 (1997).

4. Ehlers, K. M., Samuel, A. D., Berg, H. C. & Montgomery, R. Do cyanobacteria swim using traveling surface waves? *Proceedings of the National Academy of Sciences of the United States of America* **93,** 8340–8343 (1996).

3. Samuel, A. D. & Berg, H. C. Torque-generating units of the bacterial flagellar motor step independently. *Biophysical Journal* **71,** 918–923 (1996).

2. Stone, H. A. & Samuel, A. D. Propulsion of Microorganisms by Surface Distortions. *Physical Review Letters* **77,** 4102–4104 (1996).

1. Samuel, A. D. & Berg, H. C. Fluctuation analysis of rotational speeds of the bacterial flagellar motor. *Proceedings of the National Academy of Sciences of the United States of America* **92,** 3502–3506 (1995).