Curriculum Vita -- Anita L. Zimmerman
February 18, 2024

1. Name, position, academic department (s)

Anita L. Zimmerman, Ph.D.
Professor of Medical Science
Molecular Microbiology & Immunology

2. Education

1978 A.B. Zoology, University of California, Berkeley, California.

1982 Ph.D., Physiology and Biophysics, University of Miami Medical School, Miami, Florida; thesis: Kinetics of Intracellular and Cell-to-cell Diffusion of Fluorescent Tracers. Advisors: Drs. Birgit Rose and Karl Magleby.

3. Professional appointments

1974-1977 Staff Research Associate, University of California Medical Center, San Francisco and the Lawrence Livermore Laboratory, Livermore, California.

1983-1987 Postdoctoral Fellow/Research Associate, Department of Neurobiology, Stanford Medical Center, Stanford, California. Advisor: Dr. Denis Baylor.

1987-1994 Assistant Professor of Medical Science, Section of Physiology, Brown University, Providence, Rhode Island.

1994-2005 Associate Professor of Medical Science (tenured), Molecular Pharmacology, Physiology & Biotechnology, Brown University, Providence, Rhode Island.

1994-1995 Visiting Scientist, on sabbatic leave in the Department of Physiology & Biophysics, University of Washington, Seattle, Washington. September, 1994 - June, 1995.

2005-6/2021 Professor of Medical Science (tenured), Molecular Pharmacology, Physiology & Biotechnology, Brown University, Providence, Rhode Island.

2008-6/2021 Vice Chair, Molecular Pharmacology, Physiology & Biotechnology Brown University, Providence, Rhode Island.

7/2021-pres. Professor of Medical Science (tenured), Molecular Microbiology & Immunology Brown University, Providence, Rhode Island.

4. Completed Research, Scholarship and/or Creative Work:

a. chapters in books

Zimmerman, A.L. Cyclic nucleotide gated ion channels. **In**: Cell Physiology Source Book: A Molecular Approach (Essentials of Membrane Biophysics is the new subtitle for 4th edition, 2012). N. Sperelakis, editor. Academic Press (chapter 36 in 1st edition, 1995; chapter 46 in 2nd edition,

1998; chapter 47 in 3rd edition, 2001, Chapter 35 in 4th edition, 2012).

Zimmerman, A.L. Visual transduction. **In**: Cell Physiology Source Book: A Molecular Approach (Essentials of Membrane Biophysics is the new subtitle for 4th edition, 2012). N. Sperelakis, editor. Academic Press (chapter 37 in 1st edition, 1995; chapter 47 in 2nd edition, 1998; chapter 48 in 3rd edition, 2001; Chapter 38 in 4th edition, 2012).

b. refereed journal articles

Zimmerman, A.L., King, E.B., Barrett, D.L. and Petrakis, N.L. The incidence and significance of intracytoplasmic calcifications in nipple aspirate specimens. *Acta Cytol.* **21:** 685-692 (1977).

Jensen, R.H., Bigbee, W.L., Zimmerman, A.L. and King, E.B. Plasminogen activator as a diagnostic marker for preneoplastic cells in human gynecologic specimens. *Acta Cytol.* **23:** 105 (1979).

Schwarzmann, G., Weigandt, H., Rose, B., Zimmerman, A.L., Ben-Haim, D. and Loewenstein, W.R. Diameter of the cell-to-cell junctional membrane channels as probed with neutral molecules. *Science* **213:** 551-553 (1981).

Tedeschi, B., Wilson, D.L., Zimmerman, A.L. and Perry, G.W. Are axonally transported proteins released from sciatic nerves? *Brain Research* **211:** 175-178 (1981).

Zimmerman, A.L. and Rose, B. Permeability properties of cell-to-cell channels: Kinetics of fluorescent tracer diffusion through a cell junction. *J. Membrane Biol.* **84:** 269-283 (1985).

Zimmerman, A.L., Yamanaka, G., Eckstein, F., Baylor, D.A. and Stryer, L. Interaction of hydrolysis-resistant analogs of cyclic GMP with the phosphodiesterase and light-sensitive channel of retinal rod outer segments. *Proc. Natl. Acad. Sci. USA* **82:** 8813-8817 (1985).

Zimmerman, A.L. and Baylor, D.A. The cyclic GMP-sensitive conductance of retinal rods consists of aqueous pores. *Nature* **321:** 70-72 (1986).

Karpen, J.W., Zimmerman, A.L., Stryer, L. and Baylor, D.A. Gating kinetics of the cyclic-GMP- activated channel of retinal rods: flash photolysis and voltage-jump studies. *Proc. Natl. Acad. Sci. USA.* **85:** 1287-1291 (1988).

Zimmerman, A.L., Karpen, J.W. and Baylor, D.A. Hindered diffusion in excised membrane patches from retinal rod outer segments. *Biophys. J.* **54:** 351-355 (1988).

Zimmerman, A.L., Karpen, J.W., Kantrowitz-Gordon, S., Tsai, C-S. S., Baylor, D.A. and Stryer, L. Workings of the cGMP-activated channels of retinal rods. *Neuroscience Research*, Suppl. 12, S165 - S174 (1990).

Zimmerman, A.L. and Baylor, D.A. Cation interactions within the cyclic GMP-activated channel of retinal rods from the tiger salamander. *J.Physiol.* **449**: 759-783 (1992).

Gordon, S.E., Brautigan, D.L. and Zimmerman, A.L. Protein phosphatases modulate the apparent agonist affinity of the light-regulated ion channel in retinal rods. *Neuron* 9: 739-748 (1992).

Gordon, S.E., Downing-Park, J. and Zimmerman, A.L. Modulation of the cGMP-gated ion channel in frog rods by calmodulin and an endogenous inhibitory factor. *J. Physiol.* **486**: 533-546 (1995).

Gordon, S.E., Downing-Park, J., Tam, B. and Zimmerman, A.L. Diacylglycerol analogs inhibit the rod cGMP-gated channel by a phosphorylation-independent mechanism. *Biophys. J.* **69**: 409-417 (1995).

Zimmerman, A.L. Cyclic nucleotide-gated channels. *Current Opinion in Neurobiology* **5**: 296-303 (1995).

Crary, J.I., Gordon, S.E. and Zimmerman, A.L. Perfusion system components release agents that distort functional properties of rod cyclic nucleotide-gated ion channels. *Visual Neuroscience* **15**: 1189-1193 (1998).

Crary, J.I., Dean, D.M., Nguitragool, W., Kurshan, Peri T. and Zimmerman, A.L. Mechanism of Inhibition of Cyclic Nucleotide-Gated Ion Channels by Diacylglycerol. *J. Gen. Physiol.* **116**: 755-768 (2000).

Crary, J.I., Dean, D.M., Maroof, F. and Zimmerman, A.L. Mutation of a single residue in the S2-S3 loop of CNG channels alters the gating properties and sensitivity to inhibitors. *J. Gen. Physiol.* **116**: 769-779 (2000).

Dean, D.M., Nguitragool, W., Miri, A., McCabe, S.L. and Zimmerman, A.L. All-*trans*-retinal shuts down rod cyclic nucleotide-gated ion channels: a novel role for photoreceptor retinoids in the response to bright light? *Proc. Natl. Acad. Sci. USA* **99**: 8372-8377 (2002).

Zimmerman, A.L. Two B or not two B? Questioning the rotational symmetry of tetrameric ion channels. *Neuron* **36**: 997-999 (2002). This was an invited, but peer-reviewed, minireview.

McCabe, S.L., Pelosi, D.M., Tetreault, M., Miri, A., Nguitragool, W., Kovithvathanaphong, P., Mahajan, R. and Zimmerman, A.L. All-*trans*-retinal is a closed-state inhibitor of rod cyclic nucleotide-gated ion channels. *J. Gen. Physiol.* **123**: 521-531 (2004).

Zimmerman, A.L. Capturing ion channel gating: a little salt on the tail does the trick. *J. Gen. Physiol.* **124**: 627-629 (2004). Invited paper, but reviewed.

Yeh, J.I., Zimmt, M. B., and Zimmerman, A. L. Nanowiring of a Redox Enzyme by Metallized Peptides. Rapid communication, *Biosensors & Bioelectronics* **21**: 973-978 (2005).

Horrigan, D.M., Tetreault, M.L., Tsomaia, N., Vasileiou, C., Borhan, B., Mierke, D.F., Crouch, R.K. and Zimmerman, A.L. Defining the retinoid binding site in the rod cyclic nucleotide-gated channel. *J. Gen. Physiol.* **126**: 453-460 (2005).

Tetreault, M.L., Henry, D., Horrigan, D.M., Matthews, G. and Zimmerman, A.L. Characterization of a novel cyclic nucleotide-gated channel from zebrafish brain. *Biochem. Biophys. Res. Comm*. **348**: 441-449 (2006).

He, Q., Alexeev, D., Estevez, M.E., McCabe, S.L., Calvert, P.D., Ong, D.E., Cornwall, M.C., Zimmerman, A.L. and Makino, C.L. Cyclic nucleotide-gated ion channels in rod photoreceptors are protected from retinoid inhibition. *J. Gen. Physiol*. **128**: 473-485 (2006).

Tetreault, M.L., Horrigan, D.M., Kim, J.A. and Zimmerman, A.L. Retinoids restore normal cGMP sensitivity of mutant ion channels associated with cone dystrophy. *Molecular Vision* **12**: 1699-1705 (2006).

Zimmerman, A.L. The sweet smell of success: conclusive evidence that cyclic AMP hydrolysis does not trigger fast adaptation in olfactory receptor cells. *J. Gen. Physiol*. **128**: 149-151 (2006). Invited paper, but peer reviewed.

Isayama, T., McCabe England, S.L., Crouch, R.K., Zimmerman, A.L. and Makino, C.L. Beta- ionone activates and bleaches visual pigment in salamander photoreceptors. *Visual Neuroscience* **26**: 267-274 (2009). PMCID: PMC3220273.

Khan, S., Perry, C., Tetreault, M.L., Henry, D., Trimmer, J.S., Zimmerman, A.L. and Matthews, G. A novel cyclic nucleotide-gated ion channel enriched in synaptic terminals of isotocin neurons in zebrafish brain and pituitary. *Neuroscience* **165:** 79-89 (2010). PMCID: PMC2789987.

Bellono, N.W., Kammel, L.G., Zimmerman, A.L. and Oancea, E. UV light phototransduction activates transient receptor potential A1 ion channels in human melanocytes. *Proc. Natl. Acad. Sci. USA.* **110:** 2383-2388 (2013); Epub, Jan 23, 2013. PMCID: PMC3568351.

c. non-refereed journal articles

King, E.B., Zimmerman, A.L., Barrett, D.L., Petrakis, N.L. and King, M.C. Cytopathology of abnormal mammary duct epithelium. **In:** Proceedings of the Third International Symposium on Detection and Prevention of Cancer. New York, April 29, 1976.

Karpen, J.W., Zimmerman, A.L., Stryer, L., and Baylor, D.A. Molecular mechanics of the cyclic GMP-activated channel of retinal rods. **In:** Cold Spring Harbor Symposium on Quantitative Biology, Vol. 53 (1988).

d. abstracts

King, E.B., Zimmerman, A.L., Barrett, D.L. and Petrakis, N.L. Cytopathology of duct epithelial abnormalities in the breast. *Acta Cytol. Abstr.* **19:** 586 (1975).

Zimmerman, A.L. and Rose, B. Kinetics of intracellular and cell-to cell (transjunctional) diffusion of fluorescent tracers. *Biophys. J.* **37:** 286a (1982).

Zimmerman, A.L. and Rose, B. Analysis of cell-to-cell diffusion kinetics: changes in junctional permeability without accompanying changes in selectivity. *Biophys. J.* **41:** 216a (1983).

Zimmerman, A.L. and Baylor, D.A. Electrical properties of the light-sensitive conductance of salamander retinal rods. *Biophys. J.* **47:** 357a (1985).

Zimmerman, A.L. and Baylor, D.A. Gating and conduction in the light-sensitive channels of retinal rods. *Biophys. J.* **49:** 408a (1986).

Zimmerman, A.L. and Baylor, D.A. Interactions of Cations with the cyclic GMP-sensitive channel of retinal rods. *Biophys. J.* **51:** 17a (1987).

Karpen, J.W., Zimmerman, A.L., Stryer, L. and Baylor, D.A. Gating kinetics of the cGMP-activated channel of retinal rods. *Biophys. J.* **53:** 37a (1988).

Zimmerman, A.L. and Baylor, D.A. Ionic permeation in the cGMP-activated channel of retinal rods. *Biophys. J.* **53:** 472a (1988).

Kantrowitz-Gordon, S.E. and Zimmerman, A.L. Long-term changes in the cGMP-activated conductance in excised patches from rod outer segments. *Biophys. J.* **59:** 533a (1991).

Gordon, S.E. and Zimmerman, A.L. An increase in cyclic GMP sensitivity of rod outer segment channels following patch excision is reversibly blocked by a phosphatase inhibitor. *Invest. Ophthal. Vis. Sci.* **33:** 1104 (1992).

Gordon, S.E. and Zimmerman, A.L. Diacylglycerol analogs suppress the cyclic GMP-activated conductance in rod outer segment patches in the absence of ATP. *Biophys. J.* **64:** A217 (1993).

Zimmerman, A.L. and Gordon, S.E. Phosphorylation-independent suppression of the cyclic GMP- activated conductance in rod outer segment patches by diacylglycerol analogs. *Invest. Ophthal. Vis. Sci.* **34:** 1068 (1993).

Gordon, S.E. and Zimmerman, A.L. Modulation of the rod cGMP-gated ion channel by calmodulin and an endogenous factor distinct from calmodulin. *Biophys. J.* **66:** 355a (1994).

Gordon, S.E., Crary, J.I. and Zimmerman, A.L. Do perfusion-related conditions contribute to the apparent differences between cloned and native cyclic nucleotide-gated channels? *Biophys. J.* **74**: A385 (1998).

Crary, J.I., Maroof, F. and Zimmerman, A.L. Differential Inhibition of olfactory and rod cyclic nucleotide-gated channels by diacylglycerol. *Biophys. J.* **76**: A349 (1999).

Zimmerman, A.L., Crary, J.I. and Maroof, F. Degree of inhibition of different cyclic nucleotide- gated ion channels by diacylglycerol does not merely depend on efficacy of channel opening. *Invest. Ophthal. Vis. Sci.* **40:** 1258 (1999).

Crary, J.I., Dean, D.M. and Zimmerman, A.L. A point mutation in olfactory CNG channels dramatically increases inhibition by diacylglycerol. *Biophys. J.* **78**: 148A (2000).

Crary, J.I., Dean, D.M., Nguitragool, W. and Zimmerman, A.L. A point mutation in the S2-S3 loop of the olfactory cyclic nucleotide-gated ion channel alters its sensitivity to agonists, voltage and inhibitors *J. Gen. Physiol*. **116**(1):10A (2000).

Zimmerman, A. L. and Dean, D. All-*trans* retinal and all-*trans* retinol inhibit cloned wild-type rod cyclic nucleotide-gated ion channels. *Invest. Ophthal. Vis. Sci.* **42:** 1995 (2001).

Nguitragool, W., Miri, A., McCabe, S.L., Dean, D.M. and Zimmerman, A.L. Retinoids shut down rod cyclic nucleotide-gated ion channels. *Biophys. J.* **82**: 277A (2002).

McCabe, S.L., Pelosi, D.M., Miri, A., Nguitragool, W., Kovithvathanaphong, P., Mahajan, R. and Zimmerman, A.L. Inhibition of cyclic nucleotide-gated (CNG) channels by all-*trans*-retinal. *Biophys. J.* **84**: 400A (2003).

McCabe, S.L., Calvert, P., Makino, C.L. and Zimmerman, A.L. Is retinoid inhibition of photoreceptor cyclic nucleotide-gated (CNG) channels physiologically relevant? *Biophys. J.* **86**: 292A (2004)

Pelosi, D.M., Tetreault, M.L., McCabe, S.L. and Zimmerman, A.L. All-trans-retinal is a closed-state inhibitor of rod cyclic nucleotide-gated (CNG) channels. *Biophys. J.* **86**: 292-293A (2004).

McCabe, S.L., He, Q., Calvert, P.D., Makino, C.L. and Zimmerman, A.L. Retinoid inhibition of cyclic nucleotide-gated (CNG) channels in isolated photoreceptors. *Biophys. J.* **88**: 508A (2005).

Tetreault, M.L., Rothschild, J. and Zimmerman, A.L. All-trans-retinal inhibits CNG channels but not Shaker channels. *Biophys. J.* **88**: 295A (2005).

Horrigan, D.M., Tetreault, M.L., Tsomaia, N., Vasileiou, C., Borhan, B., Mierke, D.F., Crouch, R.K. and Zimmerman, A.L. Defining the retinoid binding site in the rod CNG (CNGA1) channel. *Biophys. J.* **90**: 1214A (2006).

Tetreault, M.L., Henry, D., Matthews, G.G. and Zimmerman, A.L. Characterization of a Novel Cyclic Nucleotide-gated Channel from Zebrafish Brain. *Biophys. J.* **90**: 51A (2006).

Isayama, T., Okada, T., Looney, J., Crouch, R., Zimmerman, A.L. and Makino, C.L. An additional retinoid binding site in rhodopsin. *Biophys. J.* **96**: 528a (2009).

Wong, K.Y., Garcia-Jimenez, M.L., Berson, D.M. and Zimmerman, A.L. With a little help from their friends: rods show partial recovery from a full bleach without pigment epithelium. Presented as a poster at the annual meeting of the Society for Neuroscience, poster 164.20/U16 (2009).

Bellono, N.W., Kammel, L.G., Zimmerman, A.L. and Oancea, E. Ultraviolet light phototransduction activates TRPA1 to mediate melanin synthesis in human melanocytes. *Biophys. J.* **104:** 454a (2013).

Isayama, T., Wu, J., Miyazono, S., Lee, V., Levine, E.S., Makino, E.R., Zimmerman, A.L. and Makino, C.L. Modulating the phototransduction cascade with small molecules. Presented at the annual meeting of the Association for Research in Vision and Ophthalmology (ARVO) (2013).

Isayama, T., Wu, J., Lee, V., Zimmerman, A.L. and Makino, C.L. Cysteine targets multiple phototransduction components. Presented at the annual meeting of the Association for Research in Vision and Ophthalmology (ARVO) (2014).

e. invited lectures

i. invited research seminars

1986 Minisymposium on "Internal Transmitter Mechanisms in Retinal Rods", Biophysical Society Annual Meeting, San Francisco, California, February 9-13.

1987 Massachusetts General Hospital, Department of Neurology, Boston, Massachusetts, February 5.

Brandeis University, Graduate Department of Biochemistry, Waltham, Massachusetts, February 10.

FASEB meeting on the "Biology and Chemistry of Vision", Copper Mountain, Colorado, July 26-31.

University of North Carolina Medical School, Department of Pharmacology, Chapel Hill, North Carolina, October 13.

Harvard Medical School, Department of Neurobiology, Boston, Massachusetts, December 14.

1989 University of Connecticut School of Medicine, Department of Physiology, Farmington, Connecticut, March 16.

Taniguchi Foundation International Symposium on Molecular Mechanisms of Sensory Transduction, Katata, Japan, November 27 - December 1. One of nineteen participants (one of six from the U.S.A.).

1990 University of Massachusetts at Amherst, Department of Zoology, March 9.

Rush University, Physiology Department, Chicago, Illinois, November 5.

1991 University of California at San Francisco, Department of Ophthalmology, March 1.

Brown University, Neurosciences Graduate Seminar Series, October 31.

State University of New York at Stony Brook, Department of Neurobiology, November 19.

Harvard Medical School, Department of Neurobiology, Boston, Massachusetts, December 10.

1992 University of Washington, Department of Physiology & Biophysics, Seattle, Washington, January 9.

Stanford University Medical School, Department of Neurobiology, Stanford, California, January 13.

University of California, Department of Animal Physiology, Davis, California, January 14.

California Institute of Technology, Division of Biology, Pasadena, January 15.

Harvard Medical School, Department of Ophthalmology, Massachusetts Eye & Ear Hospital, Boston, Massachusetts, December 11.

1993 University of Miami Medical School, Department of Physiology & Biophysics, Miami, Florida, February 11.

Harvard Medical School, Department of Neurobiology, Boston, Massachusetts, February 25.

FASEB meeting on the "Biology and Chemistry of Vision", Copper Mountain, Colorado, June 20-25.

Marine Biological Laboratory, Woods Hole, Massachusetts, November 10.

Division of Renal Diseases, Rhode Island Hospital, November 19.

1998 Smith-Kettlewell Research Institute, San Francisco, California, January.

1999 SISSA International School for Advanced Studies, Trieste, Italy, November 5.

2000 Department of Physiology & Biophysics, University of Washington, Seattle, January 27.

Department of Neurobiology, Stanford University Medical School, Stanford, January 29.

Chair, Symposium on "Sensational Molecules: Mechanisms of Sensory Transduction." Annual Biophysical Society meeting, New Orleans, Louisiana, February 16.

2001 Columbia University, Molecular Biophysics Seminar on "Gating and Modulation of Cyclic Nucleotide-gated Ion Channels", May 4.

2002 Harvard Medical School, Ophthalmology, Boston, Massachusetts, November 15.

2003 Department of Physiology & Pharmacology, Oregon Health & Science University, Portland, Oregon, April 24.

Neuroscience Graduate Program, University of California, San Francisco, April 25. MRC Laboratory of Molecular Biology, Cambridge, England, November 17.

Institut für Biologische Informationsverarbeitung, Jülich, Germany, November 18. International School for Advanced Studies (SISSA), Trieste, Italy, November 21.

2004 Department of Biochemistry and Molecular Biology, University of New Hampshire, Durham, April 9.

Department of Physiology & Biophysics, Boston University School of Medicine, November 2.

2005 FASEB Summer Research Conference on the Biology and Chemistry of Vision, June 19.

2007 Department of Neuroscience, Tufts University, Boston, MA, March 28.

2009 Ion channels in sensory transduction and brain function, New Scientist Program, Brown University, October 15.

2010 Session chair, Ion Channels Gordon Conference, Tilton, NH, July 11-16.

ii. invited guest lectures in courses

1979-1981 Graduate teaching assistant for mammalian physiology and cell physiology/biophysics for first-year medical students and graduate students at the University of Miami Medical School.

1983-1984 Teaching assistant for an introductory neurobiology course for first-year medical students at Stanford University Medical School.

1987 Guest lecturer in a graduate level course in membrane biophysics (BI 265) at Brown University.

1987, 1991, 1993 Guest lecturer in a graduate level course in cellular neurophysiology (Neurobiology 220) at Harvard Medical School, Department of Neurobiology. Lectures on visual transduction.

1990, 1993, Guest lecturer in the Neurobiology course of the Boston University

1996, 1997, 1998 Marine Program at the Marine Biological Laboratory in Woods Hole, Massachusetts. Lectures on G-proteins, visual transduction and cyclic nucleotide-gated ion channels.

1990-1993 Guest lecturer in a graduate level course on sensory transduction (Biology 222) at Harvard University, Department of Cellular & Developmental Biology.

1992, 1996, 2001
Lecturer in an introductory physiology course at Pfizer.

1996, 1999 Guest lecturer for the Neurobiology summer course at the Marine Biological Laboratory in Woods Hole, Massachusetts. Lectures on cyclic nucleotide gated ion channels.

2002 Guest lecturer in BN 102 (Principles of Neurobiology), Brown University.

Guest lecturer in BN 110 (Cell Physiology & Biophysics), Brown University (Julie Kauer was course director).

Guest lecturer in BI 217 (Receptors, Channels & Signalling), Brown University.

2003 Guest lecturer in sensory physiology, SISSA, Trieste, Italy, November 24.

Guest lecturer in visual transduction, SISSA, Trieste, Italy, November 25.

2004 Guest lecturer in BI 127/227 (Advanced Biochemistry), Brown University.

2005, 2006 Guest lecturer in BI 194/PH 199 (Selected Topics in Molecular Biophysics), Brown University.

2005 – 2011. Guest lecturer in NEUR 2030 (formerly BN 203; Cellular Neuroscience), Brown University.

2005 – 2007 Guest lecturer in BI 217 (Molec. Pharm. and Physiol.), Brown University.

2007, 2008, Guest lecturer in PHYS 2620 (formerly PH 262; Special Topics in Physics -- 2012 Molecular Biophysics), Brown University.

2010 Guest lecturer on ion channels, Connecticut College, February 22.

2020 Guest lecturer on visual transduction and ion channels, Harvard, September 29

5. Research interests

Over the last few decades, my research has focused on the area of molecular & cellular neuroscience, in particular on the function and regulation of ion channels and their role in sensory transduction and brain function. Essentially every function in the body is controlled by the activity of ion channels, which are membrane proteins that change their conformation in response to chemical and electrical signals, allowing specific ions to enter or exit cells as needed. Ion channels are critically involved in functions as diverse as nerve impulses in the brain, the beating of the heart, visual perception, muscle contraction, learning and memory, hormone secretion and embryonic development. They are also the targets of many drugs, such as those used to treat pain and heart disease; and genetic defects in ion channels can cause devastating diseases, such as cystic fibrosis. Our work has centered mainly on nonselective cation channels that are opened by direct interaction with cyclic nucleotides (CNG channels), by other intracellular messengers (TRP channels) and by voltage (HCN channels). Since these particular ion channels contain pores that allow the passage of Ca^{2+} and Na^{+} into cells, their activity tends to make the membrane potential more positive and to increase intracellular Ca^{2+}, leading to cell excitation and triggering a variety of cell functions.

My major technical expertise is electrophysiology (especially patch clamp), in recordings from ion channels in their native membranes and cells, as well as in heterologous expression systems (e.g., *Xenopus* frog eggs expressing cloned ion channels). I have closed my lab and now only serve as a consultant to colleagues interested in my areas of expertise.

6. Service

a. service to Brown

1990-1994	Sophomore advisor
1990-present	Biology concentration advisor
1993	Member, Neuroscience faculty search committee.
1999	Member, faculty search committee, Molecular Pharmacology, Physiology & Biotechnology
1999	Member, Provost search committee
1999-2005	Member, Institutional Animal Care and Use Committee (IACUC).
2001-3/2006	Member, Graduate Program Committee, Molecular Pharmacology & Physiology
2002-2004	Associate Director, Brown University MD/PhD program
2002-3/2006	Co-director, Graduate Program, Molecular Pharmacology & Physiology
2002-2007	Member, Financial Aid Planning Committee, Brown University Medical School
2004-3/2006	Member, Brown Medical School Curriculum Committee
2005-2007	Director, Brown University MD/PhD program

2008-2021	Vice Chair, Department of Molecular Pharmacology, Physiology & Biotechnology
2009~2011	Steering Committee, Brown Neuroscience Graduate Program
2009-2012	Member, Brown Diversity Advisory Board
2010-2012	Vice Chair, Brown Diversity Advisory Board
2010-2014	Director, Molecular Pharmacology & Physiology (MPP) Graduate Program
2010-2021	Member, Graduate Program Committee, MPP Graduate Program
2011	Member and Affirmative Action Representative, Search Committee for Pharmacogenomics Faculty Position, MPPB
2012-2013	Co-chair, Curriculum Working Group, Primary Care-Population Health Program at Albert Medical School
2014-2015	Associate Director, Molecular Pharmacology & Physiology (MPP) Graduate Program
2015-2022	Director, Molecular Pharmacology & Physiology (MPP) Graduate Program
2014-2022	IMSD Scientific Writing Module (first with Julie Kauer; then with Rashid Zia, 2017; then with Derek Stein, 2018, 2020 & 2022 -- tends to be offered every other year)
8/2017	Co-facilitator (with Dr. Michelle Dawson) for a workshop in the first annual Graduate Students of Color (GSOC) Orientation. Workshop Title: Focusing Your Professional Activities to Build a Strong CV (Sciences); Topic: building and maintaining a strong CV and communicating your skills and activities.
2018-present	Participation in activities to facilitate diversity and inclusion in the Graduate School: Brandeis visiting HUG students, TRIO program, Jan 2018 Diversity Preview Day, October, 2018 - 2023 UConn Scholars visit, Feb 2019 Virtual NIH recruitment event for HUGs Various IMSD events, including application reviews, external reviews, panels First-Gen Lunches sponsored by Biomed OGPS Super Monday events
2018	Member, Faculty/Staff Diversity and Inclusion Graduate School Advisory Committee
2021-present	Member, Biology Curriculum Committee
2021-present	Member, Education Appointment and Promotion Committee (BUE Office)
2021	Co-chair, MMI DIAP committee
2021	Member, Search Committee for MMI Lecturer

2021-present Member, IMSD Selection Committee

2021-2022 MD/PhD Admissions Committee, representative for the MPP, then TSGP program

2022 RCR instructor -- mentor/mentee relationships

2022-present Chair, MMI DIAP committee

2022-present Member, MMI senior faculty committee on faculty appointments and promotions

2022-present Member, TSGP Graduate Program Committee, Admissions Committee, DIAP Committee

2022-6/2023 Co-Director, Therapeutic Sciences Graduate Program (TSGP)

2023-present Director for Student Support & Inclusion, Therapeutic Sciences Graduate Program (TSGP), switched to this role after stepping down as co-director beginning July 1, 2023

b. service to the scientific profession

i. grant review service

1988 Ad Hoc reviewer for Alberta Heritage Foundation for Medical Research (Canada).

1990 Ad Hoc reviewer for the Medical Research Council of Canada.

1991 Ad Hoc reviewer for the Visual Sciences B Study Section (AHR-S1) of the National Eye Institute, NIH.

1993-1994 Member, NIH Behavior & Neurosciences Study Section 1, until its dissolution.

1994 Ad Hoc reviewer for the Visual Sciences A Study Section and for the Visual Sciences C Study Section, National Eye Institute, NIH.

1996 Ad Hoc reviewer for a Special Emphasis Panel for the Visual Sciences A Study Section, National Eye Institute, NIH.

2005 Ad Hoc reviewer for the Retinal Studies Special Emphasis Panel, NIH.

2005-2007 One of two Brown Medical School representatives to the Group in Graduate Research, Education and Training of the Association of American Medical Colleges (AAMC).

2006, 2008 Ad Hoc reviewer for a Retinopathy Special Emphasis Panel (NIH, NEI).

2011-2020 NST-2 study section, NIH/NINDS -- initially ad hoc, regular member 2012-2017; then ad hoc again beginning in March of 2017.

2013-2020 Ad Hoc reviewer for NIH/NINDS Loan Repayment Applications

ii. Editorial boards, journal review service

2006-2017 Member, Editorial Board, *Journal of General Physiology*

1987-present, ad hoc reviewer for the following journals at various times:

Biochimica et Biophysica Acta
American Journal of Physiology
Biochemistry
Biophysical Journal
Bioorganic and Medicinal Chem. Letters
Current Pharmaceutical Design
European Journal of Physiology
Invest. Ophthal. Vis. Sci.
Journal of Experimental Biology
Journal of Experimental Zoology
Journal of General Physiology
Journal of Membrane Biology
Journal of Neurophysiology
Journal of Neuroscience
Journal of Physiology (London)
Nature Communications
Neuron
Proc. Natl. Acad. Sci.
Proceedings of the Royal Society
Science
Visual Neuroscience

iii. society offices

1998-2001 Elected Member of the General Council of the Biophysical Society
Elected Member of Council for the Society of General Physiology.
Member, Biophysical Society Committee on Biophysical Discussions.
Member, Biophysical Society Public Affairs Committee

2009-2014 Biophysical Society Awards Committee

iv. society memberships:

Biophysical Society
Society of General Physiologists

c. service to the community

1991 Speaker at the New England Biology Teachers' Conference, presenting current topics in neurobiology to high school biology teachers.

1999 Workshop on "From Genetic Engineering to Bioelectricity: Making Frog Eggs Work for Us" in "Discovering Biotechnology Day", sponsored at Brown by Johns Hopkins University Institute for Academic Advancement of Youth.

2001 Speaker at the Barrington High School Career Day workshop, spring, 2001.

2012-present Poster Judge, New England Science Symposium (NESS), Diversity and Community Partnership at Harvard Medical School, held every spring (a HUG event).

2021-present Panel member in the Harvard BSCP Skills Workshop: Getting into Graduate School and Succeeding (Biomedical Science Careers Program, BSCP) -- a HUG event.

7. Academic honors, research grants, fellowships, honorary societies

Current and pending grants:

2021-2026 NIH NIGMS T32, GM139793 (MPI until 8/1/23; other PIs are Elena Oancea [contact PI] and Sean Lawler, both still current MPIs) "Interdisciplinary Training in Pharmacological Sciences". 7/1/21-6/30/26. This grant replaces NIH NIGMS T32 GM077995, since NIGMS required new applications this year, instead of continuing renewals, due to significant changes in their T32 policies. I removed myself as an MPI 8/1/23 because I had resigned as TSGP co-DGS.

Past grants, awards and honors:

1983-1985 NIH training grant award, #NS-07158, for postdoctoral research.

1988-2007 NIH research grant, R01 EY07774 (National Eye Institute), "Properties of light-modulated ion channels in the retina." PI.

1997-1999 RI American Heart, "Modulation of ion channels in the sino-atrial node of the heart. PI.

1998 Salomon Faculty Research Award, "Molecular mechanism of modulation of cyclic nucleotide-gated ion channels by Ca^{2+}/calmodulin." PI.

1998 Rhode Island Foundation Research Grant, "Molecular mechanism of modulation of cyclic nucleotide-gated ion channels by Ca^{2+}/calmodulin." PI.

2002-present Dean's Excellence in Teaching Award for outstanding teaching in the first-year medical curriculum, received award for many years during this period.

2007-2008 Maren Foundation Award for equipment, "Request for equipment for a novel tissue preparation to study vision." PI.

2007-2008 Maren Research Seed Award from MPPB, "The RPE/retinal slice: a new preparation for studying photoreceptor responses to bright light in health and disease." PI.

2009 Brown Advance Scientific Leadership Award.

2011 Brown Graduate School Faculty Award for Advising and Mentoring.

2013-2016 NIH NIGMS MARC Ancillary Training Activities (T36) training grant entitled, "TRAINing for success in biomedical research careers." (Co-Investigator; PI: Andrew Campbell) 8/15/13-8/14/16.

2013-2018 NIH R01 NIAMSD 1 R01 AR066318-01 (Co-investigator; PI: Elena Oancea), "Ion channel and calcium signaling in ultraviolet light transduction in human skin." 9/1/13-8/31/18.

2016-2021 NIH NIGMS T32, GM077995 (Co-I; PI: Elena Oancea; past PIs, Ed Hawrot, then Julie Kauer), for MPP, "Predoctoral Training Program in Trans-disciplinary Pharmacological

Sciences". 7/1/10-6/30/21.

8. Teaching (last three years)

(Temporary, replacing Carlos Aizenman during his sabbatical, Fall of 2023): Co-instructor (with course director, Anne Hart) in NEUR 2030, which is a core course for first-year Neuroscience graduate students. I gave three 2.5-hour lectures and three 2.5-hour workshop sessions (total 15 hours), and provided a problem set and some exam questions. In designing my lectures and workshops, I adapted the materials I use for my other courses to be more appropriate for neuroscience students, and integrated some of Carlos Aizenman's materials as well.

Co-instructor in BIOL 2170, core lecture course on Pharmacology and Physiology for first-year students in the Therapeutic Sciences Graduate Program (TSGP); also offered to other graduate students (PhD and Master's) and to upper-level undergraduates with permission. Has been offered every fall, but beginning in AY2022-2023, it became offered in the spring instead. Diana Horrigan is course director for this course. Wayne Bowen is also a co-instructor (as an emeritus adjunct).

Co-instructor in a cell physiology/biophysics course (BIOL 1100) for upper-level undergraduates and graduate students. Taught every spring. Until 2015, I taught it every other year, alternating with Julie Kauer, but beginning in 2015, I now teach it every spring. Enrollment ~25-30 students (enrollment is limited to 30). Beginning in 2016, Diana Horrigan became the course director for this course.

Lecturer in BIOL 3642, Integrated Medical Sciences I: Scientific Foundations of Medicine. Taught every fall to the first-year medical school class (approximately 12 student contact hours, including more than 7 lecture hours, plus office hours, exam and exam review session). My teaching in this course now begins in early August and ends at the end of the month. I also provide a review session and office hours for Gateway Masters students.

2020-2024: MPP/TSGP PhD thesis committee member for Donald Koroma (defended 2021), Carlos Toro (current).

9. Date of the preparation of the document: February 18, 2024.