Curriculum Vitae
William A. Catterall

Current Position and Address

Professor and Emeritus Chair, Department of Pharmacology
University of Washington, Seattle, Washington USA 98195-7280

Personal

Born in Providence, RI, USA on October 12, 1946. Married to Christine E. Catterall; two children.

Education

B.A. (Chemistry), Brown University, Providence, Rhode Island, June, l968
Ph.D. (Physiological Chemistry), Johns Hopkins School of Medicine, Baltimore, Maryland, June, l972

Postgraduate Training

Muscular Dystrophy Association Postdoctoral Research Fellow with Dr. Marshall Nirenberg, Laboratory of Biochemical Genetics, NHLBI, NIH, l972-l974

Professional Appointments

Staff Fellow and Research Chemist, Laboratory of Biochemical Genetics, NHLBI, NIH, l974-l977
Associate Professor, l977-l98l; Professor, Department of Pharmacology, University of Washington, Seattle, Washington, l98l-present
Chair, Department of Pharmacology, University of Washington, Seattle, Washington, l984-2016.
Pharmacology & Toxicology at UW was ranked 6th worldwide by US News & World Report in 2015.

University of Washington Administrative Responsibilities

Chair, Interdisciplinary Committee on Neurobiology, University of Washington, 1986-present.
Director, Graduate Program in Neurobiology, 1986-1990.
Chair, Steering Committee, Undergraduate Neurobiology Program, 1998-present.
William Moody, Director, Professor of Biology.
UW Undergraduate Neurobiology was ranked 1st by the Society for Neuroscience in 2014.
Chair, Liaison Committee, Institute for Stem Cell & Regenerative Medicine, U of Washington, 2006-2016.
Randall T. Moon, Founding Director, Professor of Pharmacology
Chair, Liaison Committee, Institute for Drug Addiction Research, University of Washington.
Charles Chavkin, Director, Professor of Pharmacology
Chair, Liaison Committee, Institute for Biosignaling & Precision Therapies, University of Washington.
John D. Scott, Founding Director, Professor and Chair of Pharmacology, 2016.
Co-Chair, Research Planning Committee for South Lake Union Campus, 1998-2008.

Honors and Awards

Passano Foundation Young Scientist Award, l98l
Jacob Javits Neuroscience Investigator Awards, l984, 1991
Member, National Academy of Sciences, 1989
Sections of Physiology & Pharmacology and Cellular & Molecular Neuroscience
Chair, Section of Physiology & Pharmacology, 1998-2001
Basic Science Prize, American Heart Association, 1992
Member, Academia Europaea, 1994
Mathilde Solowey Award in Neuroscience, National Institutes of Health, 1995
H. B. Van Dyke Award in Pharmacology, Columbia University, 1995
McKnight Foundation Senior Neuroscience Investigator Award, 1997
Member, American Academy of Arts & Sciences, 2000
Member, National Academy of Medicine, 2000
Bristol-Myers Squibb Award for Distinguished Achievement in Neuroscience, 2003
Honorary Foreign Member, Royal Academy of Medicine of Belgium, 2004
Most cited ion channel researcher, www.ionchannels.org, 2004-2017
Foreign Member, The Royal Society, London, UK, 2008
Member, Washington State Academy of Science, 2008
Fellow, American Association for the Advancement of Science, 2010
Robert Schwab Award, American Clinical Neurophysiology Society, 2010

Gairdner International Award of Canada, 2010
Ilse & Helmut Wachter Stiftung, University of Innsbruck, 2010
George Palade Award, Wayne State University, 2011
Gordon K. Moe Award, Cardiac Electrophysiology Society, 2011
Docteur Honoris Causa, University of Aix-Marseille, France, 2011
Sharpey-Schafer Prize, The Physiological Society, UK, 2013
Biomedical Research Achievement Award, Leaders in Healthcare Program, Seattle Business Weekly, 2014
K. S. Cole Award in Membrane Biophysics, Biophysical Society, 2015
Norman Weiner Award, American Society for Pharmacology & Experimental Therapeutics, 2015
Robert Ruffolo Career Achievement Award, American Society for Pharmacology & Experimental Therapeutics, 2016
Pioneer Award, Winter Conference on Brain Research, 2017

Organizations

American Society of Biochemistry & Molecular Biology
American Society for Pharmacology & Experimental Therapeutics
Society for Neuroscience
Biophysical Society
Society of General Physiologists

Editorial Boards

Co-Head, Pharmacology, Faculty of 1000, 2016 to present
Editor, Ion Channel Database, IUPHAR/BPS *Guide to Pharmacology*, 2014 to 2016.
Editor, IUPHAR Ion Channel Database, 2008-2014.
Editor, IUPHAR Ion Channel Compendium, 2002, 2005.
Editor-in-Chief, *Molecular Pharmacology*, 1985 to 1990; Editorial Board, 1981 to 1985; 1998 to present
Editorial Board Member, *Channels*, 2006 to present
Editorial Board Member, *Journal of General Physiology*, 2004 to present
Editorial Board Member, *Neuron*, Founding Member of the Editorial Board, 1988 to present
Editorial Board Member, *Proceedings of the National Academy of Sciences*, 1996 to 2000
Editorial Board Member, *Cellular & Molecular Neurobiology*, 1981 to 1994
Editorial Board Member, *Journal of Biological Chemistry*, l983 to 1985, 1990 to 1993
Editorial Board Member, *Journal of Neuroscience*, 1984 to 1990
Special Topics Editor, *Annual Review of Physiology*, 1985 to 1987

National Committees and Service

Scientific Meetings

FASEB Theme Organizer, ASPET Theme on "Regulation of Ionic Channels," 1985-1986
Chair, Gordon Conference on Molecular Pharmacology, 1985
Co-Chair Keystone Conference on Regulation of Membrane Signaling Processes, 1990
Co-Chair, NHLBI/AAAS Conference on “Ion Channels in the Cardiovascular System,” 1992
Chair, ASBMB Satellite Conference on “Cellular Regulation by Protein Phosphorylation,” 1997
ASBMB Theme Organizer, Membrane Channels and Transporters, International Congress of Biochemistry, 1997
Chair, IUPHAR Focused Conference on Ion Channelopathies, 2010

Scientific Review

Neurobiology Review Panel, National Science Foundation, 1980-1983
Ad hoc Member, Physiology Study Section, National Institutes of Health
Board of Scientific Counselors, National Heart, Lung, & Blood Institute, NIH, 1991-1992
Howard Hughes Medical Institute
Neuroscience Review Panel, 1989-1991, 2007 to present
New Investigator Review Committee, 1993, 1996, 1999, 2004, 2009, 2012, 2015, 2018
Burroughs-Wellcome Fund
Advisory Committee, Experimental Therapeutics Award, 1991-1994; Chair, 1994-1995
Founding Chair, New Investigator Award in Basic Pharmacological Sciences, 1995-1997
Human Genome Organization
Corresponding Member for Sodium Channels, 2003 to present
Alliance for Cell Signaling

Myocyte Systems Committee, 2000-2002; External Advisory Board, 2003-2005
Pfizer Inc., Therapeutic Area Scientific Advisory Panel on Pain, 2008 to 2016; Chair, 2010 to 2016.

Scientific Societies

American Society for Biochemistry & Molecular Biology
Nominating Committee, 1987
Councilor, 1994-1997
American Society for Pharmacology & Experimental Therapeutics
Board of Publications Trustees, 1985 to 1998
Executive Committee, Molecular Pharmacology Division, 1995-1998
Award Committee, 2016-present
International Union of Pharmacology
Nomenclature Committee (Liaison for Ion Channels) 1999 to 2016
Neuroscience Research Program, Associate, 1986-1993
Society for Neuroscience, Nominating Committee, 1994
National Academy of Sciences
Presidential Nominating Committee, 1992
Biology Class Membership Committee, 1994, 1996, 1997, 1999-2001, 2003, 2005, 2011, 2015
Nominating Committee, Section of Physiology & Pharmacology, 1995-2001
Chair, Section of Physiology & Pharmacology, 1998-2001

Advisory Boards

Medical Advisory Board, Howard Hughes Medical Institute, 1991-1995
Board of Trustees, Virginia M. Bloedel Hearing Research Center, U of Washington, 1992-2016
Scientific Advisory Board, Neuromed Technologies, Vancouver, BC, 1998-2009
Scientific Advisory Board, Vollum Institute, Oregon Health Sciences University, 2000 to 2003
Scientific Advisory Board, Renovis Inc., 2006 to 2008
Scientific Advisory Board, Alberta Heritage Foundation for Medical Research, 2005 to 2009
External Advisory Committee, Pfizer Inc., 2010 to 2015

University of Washington: Selected Committees

Representative for Basic Sciences, Fred Hutchinson Cancer Center Affiliation Committee, 1990-1994
Search Committee Chair for appointment of Chairs of Immunology, 1988, 2009; Psychiatry & Behavioral Sciences, 1998; and Physiology & Biophysics, 2000. Search Committee member for appointment of Chairs of Neurology, Biochemistry, Microbiology, and Anesthesiology; Dean of Medicine; and Provost.
Member, Medical School Executive Committee, 1984 to 2016
Member, Medical School Executive Steering Committee, 1994 to 2015.

University of Washington Teaching

Basic principles of pharmacology: Phcol 401 for pharmacy students; Phcol 511 for graduate students.
Arrhythmias and antiarrhythmic drugs: HuBio 543 and CPR Course for medical students; Phcol 402 for pharmacy students; Phcol 511 for graduate students.
Anesthetics and antiepileptic drugs: Phcol 512 for graduate students.
Ion channel research and ion channelopathies: Phcol 529 for graduate students; Molecular Medicine for graduate students.

Research Interests

Electrical impulses generated by nerve and muscle cells are crucial in learning and memory in the brain, coordination of movement by muscles, contraction of the heart, regulation of the cardiovascular and endocrine systems, and many other physiological processes. These electrical impulses are generated by specialized protein molecules in the surface membrane of nerve, muscle, and endocrine cells called ion channels, which form narrow pores that allow the movement of tiny electrically charged molecules (ions) across the cell membrane. Dr. Catterall and his colleagues discovered the first ion channel protein molecule, the sodium channel, in 1980 and subsequently discovered the calcium channel protein in 1984. A family of 143 related ion channels is now known in humans. Subsequent research in Dr. Catterall's laboratory has given new insights into the structure/function relationships of these important signaling molecules, their physiological functions in the

nervous system and in the heart, their regulation by cellular signaling pathways, and their role as receptors for local anesthetics and drugs used to treat epilepsy, pain, hypertension, and cardiac arrhythmia. He and his collaborators recently determined the three-dimensional structure of a bacterial sodium channel at atomic resolution by x-ray crystallography. This bacterial channel is likely the ancestor of both sodium and calcium channels in vertebrates, so this new high-resolution structure provides a molecular template for future studies of both of these ion channel families. Dr. Catterall's recent work has also probed the pathophysiological mechanisms of sodium channel mutations that cause inherited forms of epilepsy and periodic paralysis and developed novel therapeutic approaches to these diseases.

In addition to this specific research area, Dr. Catterall is interested broadly in molecular pharmacology, cell signaling, and neuroscience. He has published over 500 research papers, review articles, book chapters, and reference works. His h-factor is 134. A complete Bibliography is available upon request.

Research Areas and Selected Publications Since 2000

Sodium and Calcium Channel Structure and Function

Review Articles

Catterall, W.A. (2000) From ionic currents to molecular mechanisms: The structure and function of voltage-gated sodium channels. *Neuron* **26**:13-25.

Cantrell, A.R. and Catterall, W.A. (2001) Neuromodulation of Na^+ channels: an unexpected form of cellular plasticity. *Nature Reviews/Neurosci*. **2**:397-407.

Yu, F. and Catterall, W.A. (2004) The VGL-chanome: a protein superfamily specialized for electrical signaling and ionic homeostasis. *Science STKE* **253**:re15, 5.

Catterall, W.A. (2010) Ion channel voltage sensors: structure, function, and pathophysiology. *Neuron* **67**:915-928.

Catterall, W.A. (2012) Voltage-gated sodium channels at 60: structure, function and pathophysiology. *J. Physiol.* **590**:2577-2589.

Catterall, W.A. (2014) Structure and function of voltage-gated sodium channels at atomic resolution. *Exp Physiol.* **99**:35-51.

Catterall, W.A., and Zheng, N. (2015) Deciphering voltage-gated Na^+ and Ca^{2+} channels by studying prokaryotic ancestors. *Trends Biochem Sci.* **40**:526-534.

Catterall, W.A. (2016) Finding channels. *J Biol Chem.* **290**:28357-28373. *An invited JBC Reflection Article.*

Catterall, W.A., Wisedchaisri, G., and Zheng, N. The chemical basis for electrical signaling. (2017) *Nature Chem Biol.* **13***:* 455-463.

Research Articles

Ratcliffe, C.F., Qu, Y., McCormick, K.A., Tibbs, V.C., Dixon, J.E., Scheuer, T., and Catterall, W.A. (2000). A sodium channel signaling complex modulated by associated receptor protein tyrosine phosphatase β. *Nature Neurosci.* **3**:437-444 .

Carr, D.B., Day, M., Cantrell, A.R., Held, J., Scheuer, T., Catterall, W.A., Surmeier, D.J. (2003) Transmitter modulation of slow, activity-dependent alterations in sodium channel availability endows neurons with a novel form of cellular plasticity. *Neuron* **39:**793-806.

Zhao, Y., Yarov-Yarovoy, V., Scheuer, T., Catterall, W.A. (2004) A gating hinge in Na^+ channels: a molecular switch for electrical signaling. *Neuron* **41**:859-865.

Bricelj, V.M., Connell, L., Konoki, K., MacQuarrie, S.P., Scheuer, T., Catterall, W.A., Trainer, V.L., (2005) Sodium channel mutation leading to saxitoxin resistance in clams increases risk of PSP. *Nature* **434:**763-767.

Sokolov, S., Scheuer, T., and Catterall W.A. (2005) Ion permeation through a voltage-sensitive gating pore in brain sodium channels having voltage sensor mutations. *Neuron* **47**:183-189.

Chen, Y., Yu, F., Surmeier, J.D., Scheuer, T., and Catterall, W.A. (2006) Neuromodulation of Na^+ channel slow inactivation via cAMP-dependent protein kinase and protein kinase C. *Neuron* **49:**409-420.

Yarov-Yarvoy, V., Baker, D. and Catterall, W.A. (2006) Voltage sensor conformations in the open and closed states in Rosetta structural models of K^+ channels. *Proc. Natl. Acad. Sci. USA* 103:7292 7297.

Cestele, S., Yarov-Yarovoy, V., Qu, Y., Sampieri, F., Scheuer, T., and Catterall, W.A. (2006) Structure and function of the voltage sensor of sodium channels probed by a β scorpion toxin. *J. Biol. Chem.* **281**:21332-21344.

DeCaen, P.G., Yarov-Yarovoy, V., Zhao, Y., Scheuer, T., and Catterall, W.A. (2008) Disulfide locking a sodium channel voltage sensor reveals ion pair formation during activation. *Proc. Natl. Acad. Sci. USA* 105:15142-15147.

DeCaen, P.G., Yarov-Yarovoy, V., Sharp, E.M., Scheuer, T., and Catterall, W.A. (2009) Sequential formation of ion pairs during activation of a sodium channel voltage sensor. *Proc. Natl. Acad. Sci. USA* **106**:22498-22503.

Payandeh, J., Scheuer, T., Zheng, N., and Catterall, W.A. (2011) The crystal structure of a voltage-gated sodium channel. *Nature* **475**:353-358.

DeCaen, P.G., Yarov-Yarovoy, V., Scheuer, T., and Catterall, W.A. (2011) Gating charge interactions with the S1 segment during activation of a Na^+ channel voltage sensor. *Proc. Natl. Acad. Sci. USA.* **108**:18825-18830.

Zhang, J.Z., Yarov-Yarovoy, V., Scheuer T, Karbat, I., Cohen, L., Gordon, D., Gurevitz, M., and Catterall, W.A. (2011) Structure-function map of the receptor site for β-scorpion toxins in domain II of voltage-gated sodium channels. *J. Biol. Chem.* **286**:33641-33651.

Wang, J., Yarov-Yarovoy, V., Kahn, R., Gordon, D., Gurevitz, M., Scheuer, T., and Catterall, W.A. (2011) Mapping the receptor site for α-scorpion toxins on a sodium channel voltage sensor. *Proc. Natl. Acad. Sci. USA.* **108**:15426-15431.

Zhang, J.Z., Yarov-Yarovoy, V., Scheuer, T., Karbat, I., Cohen, L., Gordon, D., Gurevitz, M., and Catterall, W.A. (2012) Mapping the interaction site for a beta-scorpion toxin in the pore module of domain III of voltage-gated sodium channels. *J. Biol. Chem.* **287**:30719-30728

Yarov-Yarovoy, V., DeCaen, P.G., Westenbroek, R.E., Pan, C.Y., Scheuer, T., Baker, D., and Catterall, W.A. (2012) Structural basis for gating charge movement in the voltage sensor of a sodium channel. *Proc. Natl. Acad. Sci. USA.* **109**:E93-102.

Payandeh, J., Gamal El-Din, T.M., Scheuer, T., Zheng, N., and Catterall, W.A. (2012) Crystal structure of a voltage-gated sodium channel in two potentially inactivated states. *Nature* **486**:135-139.

Chakrabarti, N., Ing, C., Payandeh, J., Zheng, N., Catterall. W.A., and Pomès, R. (2013) Catalysis of Na^+ permeation in the bacterial sodium channel Na_VAb. *Proc Natl Acad Sci USA.* **110**:11331-11336.

Tang, L., Gamal El-Din, T.M., Payandeh, J., Martinez, G.Q., Heard, T.M., Scheuer, T., Zheng, N., and Catterall, W.A. (2014) Structural basis for Ca^{2+} selectivity of a voltage-gated calcium channel. *Nature* **505**:56-61.

Tang, L., Gamal El-Din, T.M., Swanson, T.M., Pryde, D.C., Scheuer, T., Zheng, N., and Catterall, W.A. (2016) Structural basis for inhibition of a voltage-gated Ca^{2+} channel by Ca^{2+} antagonist drugs. *Nature* 537:117-121.

Lenaeus, M.J., Gamal El-Din, T.M., Ing, C., Ramanadane, K., Pomès, R., Zheng, N., and Catterall, W.A. (2017) Structures of closed and open states of a voltage-gated sodium channel. *Proc Natl Acad Sci USA.* **114**:E3051-E3060.

Sodium Channels and Disease: Periodic Paralysis, Epilepsy, and Autism

Review Articles

Catterall , W.A., Kalume, F., and Oakley, J.C. (2010) Na_V1.1 channels and epilepsy. *J. Physiol.* **588**:1849-1859.

Catterall, W.A. (2014) Sodium channels, inherited epilepsy, and antiepileptic drugs. *Annu Rev Pharmacol Toxicol.* **54**:317-38.

Research Articles

Yu, F.H., Mantegazza, M., Westenbroek, R.E. , Robbins, C.A., Kalume, F., Burton, K.A., Spain, W.J., McKnight, G.S., Scheuer, T. and Catterall, W.A. (2006) Reduced sodium current in GABAergic interneurons in a mouse model of severe myoclonic epilepsy of infancy. *Nature Neurosci.* **9:**1142-1149.

Sokolov, S., Scheuer, T., and Catterall, W.A. (2007) Gating pore current in an inherited ion channelopathy. *Nature* **446:**76-78.

Sokolov, S., Scheuer, T., and Catterall, W. A. (2008) Depolarization-activated gating pore current conducted by mutant sodium channels in potassium-sensitive normokalemic periodic paralysis. *Proc. Natl. Acad. Sci. USA.* 105:19980-

Oakley, J. C., Kalume, F., Yu, F. H., Scheuer, T., and Catterall, W.A. (2009) Temperature- and age-dependent seizures in a mouse model of severe myoclonic epilepsy in infancy. *Proc. Natl. Acad. Sci. USA* **106**:3994-3999.

Sokolov, S., Scheuer, T., and Catterall, W.A. (2010) Ion permeation and block of the gating pore in the voltage sensor of Na_V1.4 channels with hypokalemic periodic paralysis mutations. *J. Gen. Physiol.* **136**:225-36.

Cheah, C.S., Yu, F.H., Westenbroek, R.E., Kalume, F.K., Oakley, J.C., Potter, G.B., Rubenstein, J.L., and Catterall, W.A. (2012) Specific deletion of Na_V1.1 sodium channels in inhibitory interneurons causes seizures and premature death in a mouse model of Dravet syndrome. *Proc Natl Acad Sci U S A.* **109**:14646-14651.

Han, S., Tai, C., Westenbroek, R.E., Yu, F.H., Cheah, C.S., Potter, G.B., Rubenstein, J.L., Scheuer, T., de la Iglesia, H.O., and Catterall, W.A. (2012) Autistic-like behaviour in *Scn1a*$^{+/-}$ mice and rescue by enhanced GABA-mediated neurotransmission. *Nature* **489:**385-390.

Kalume, F., Westenbroek, R.E., Cheah, C.S., Yu, F.H., Oakley, J.C., Scheuer, T., and Catterall, W.A. (2013) Sudden unexpected death in a mouse model of Dravet Syndrome. *J Clin Invest.* **123**:1798-1808.

Han, S., Tai, C., Jones, C.J., Scheuer, T., and Catterall W.A. (2014) Enhancement of inhibitory neurotransmission by $GABA_A$ receptors having α2,3-subunits ameliorates behavioral deficits in a mouse model of autism. *Neuron* **81**:1282-1289.

Tai, C., Abe, Y., Westenbroek, R.E., Scheuer, T., and Catterall, W.A. (2014) Impaired excitability of somatostatin- and parvalbumin-expressing cortical interneurons in a mouse model of Dravet Syndrome. *Proc Natl Acad Sci USA.* **111**:E3139-3148.

Rubinstein, M., Westenbroek, R.E., Yu, F.H., Jones, C.J., Scheuer, T., and Catterall, W.A. (2015) Genetic background modulates impaired excitability of inhibitory neurons in a mouse model of Dravet Syndrome. *Neurobiol Dis.* **73**:106-117.

Kalume, F., Oakley, J.C., Westenbroek, R.E., Gile, J., de la Iglesia, H.O., Scheuer, T., and Catterall, W.A. (2015) Sleep impairment and reduced interneuron excitability in a mouse model of Dravet Syndrome. *Neurobiol Dis.* **77**:141-154.

Rubinstein, M., Han, S., Tai, C., Westenbroek, R.E., Hunker, A., Scheuer, T., and Catterall, W.A. (2015) Dissecting the phenotypes of Dravet Syndrome by gene deletion. *Brain* **138**:2219-2233.

Rubinstein, M., Patowary, A., Stanaway, I.B., McCord, E., Nesbitt, R.R., Archer, M., Scheuer, T., Nickerson, D, Raskind, W.H., Wijsman, E.M., Bernier, R., Catterall, W.A., and Brkanac, Z. (2016) Association of rare missense variants in the second intracellular loop of $Na_V1.7$ sodium channels with familial autism. *Mol Psychiatry* **23**:231-239.

Kaplan, J.S., Stella, N., Catterall, W.A., and Westenbroek, R.E. (2017) Cannabidiol attenuates seizures and social deficits in a mouse model of Dravet Syndrome. *Proc Natl Acad Sci USA.* **114**:11229-11234.

Calcium Channel Regulation and Synaptic Plasticity

Review Articles

Catterall, W.A. (2000) Structure and regulation of voltage-gated Ca^{2+} channels. *Annu. Rev. Cell Dev. Biol.* **16**:521-55.

Catterall, W.A., and Few, A.P. (2008) Calcium channel regulation and presynaptic plasticity. *Neuron* **59**:882-901.

Research Articles

Lee, A., Scheuer, T., and Catterall, W.A. (2000) Calcium/calmodulin-dependent facilitation and inactivation of P/Q-type calcium channels. *J. Neurosci.* **20**:6830-6838.

Lee, A., Westenbroek, R.E., Haeseleer, F., Palczewski, K.,Scheuer, T., and Catterall, W.A. (2002) Differential modulation of $Ca_V2.1$ channels by calmodulin and calcium-binding protein 1. *Nature Neurosci.* **5**:210-217.

Lee, A., Zhou, H., Scheuer, T., Catterall, W.A. (2003) Molecular determinants of Ca^{2+}/calmodulin-dependent regulation of $Ca_V2.1$ channels. *Proc. Natl. Acad. Sci. USA* **100:**16059-16064.

Jiang, X., Lautermilch, N.J., Watari, H., Westenbroek, R.E., Scheuer, T., and Catterall, W.A. (2008) Modulation of $Ca_V2.1$ channels by Ca^{2+}/calmodulin-dependent protein kinase II bound to the C-terminal domain. *Proc. Natl. Acad. Sci. USA* **105**:341-346.

Mochida, S., Few, A. Scheuer, T. and Catterall, W.A. (2008) Regulation of presynaptic $Ca_V2.1$ channels by Ca^{2+} sensor proteins mediates short-term synaptic plasticity. *Neuron* **57**:210-216.

Few, A.P., Nanou, E., Watari, H., Sullivan, J.M., Scheuer, T., and Catterall, W.A. (2012) Asynchronous Ca^{2+} current conducted by $Ca_V2.1$ and $Ca_V2.2$ channels and its implications for asynchronous neurotransmitter release. *Proc. Natl. Acad. Sci. U. S. A.* **109**:E452-460.

Leal, K., Mochida, S., Scheuer, T., and Catterall, W.A. (2012) Fine-tuning synaptic plasticity by modulation of $Ca_V2.1$ channels with Ca^{2+} sensor proteins. *Proc Natl Acad Sci U S A.* **109**:17069-17074.

Magupalli, V.G., Mochida, S., Yan, J., Jiang, X., Westenbroek, R.E., Nairn, A.C., Scheuer, T., and Catterall W.A. (2013) Ca^{2+}-independent activation of Ca^{2+}/calmodulin-dependent protein kinase II bound to the C-terminal domain of $Ca_V2.1$ calcium channels. *J Biol Chem.* **288**:4637-4648.

Yan, J., Leal, K., Magupalli, V.G., Nanou, E., Martinez, G.Q., Scheuer, T., and Catterall, W.A. (2014) Modulation of $Ca_V2.1$ channels by neuronal calcium sensor-1 induces short-term synaptic facilitation. *Mol. Cell. Neurosci.* **63**:124-131.

Nanou, E., Sullivan, J.M., Scheuer, T., and Catterall, W.A. (2016) Calcium sensor regulation of the $Ca_V2.1$ Ca^{2+} channel contributes to short-term synaptic plasticity in hippocampal neurons. *Proc Natl Acad Sci USA.* **113**:1062-1067.

Nanou, E., Yan, J., Whitehead, N.P., Kim, M.J., Froehner, S.C., Scheuer, T., and Catterall, W.A. (2016) Altered short-term synaptic plasticity and reduced muscle strength in mice with impaired regulation of presynaptic $Ca_V2.1$ Ca^{2+} channels. *Proc Natl Acad Sci USA.* **113**:1068-1073.

Nanou, E., Scheuer, T., and Catterall, W.A. (2016) Calcium sensor regulation of the $Ca_V2.1$ Ca^{2+} channel contributes to long-term potentiation and spatial learning. *Proc Natl Acad Sci USA.* 113:13209-13214.

Calcium Channel Regulation, Excitation-Contraction Coupling, and Heart Failure

Review Article

Catterall, W.A. (2015) Regulation of cardiac calcium channels in the fight-or-flight response. *Curr Mol Pharmacol.* 8:12-21. *A volume in honor of Professor Harald Reuter.*

Research Articles

Hulme, J.T., Lin, T.W.-C., Westenbroek, R.E., Scheuer, T., and Catterall, W.A. (2003) β-Adrenergic regulation requires direct anchoring of PKA to cardiac $Ca_V1.2$ channels via a leucine zipper interaction with A kinase-anchoring protein 15. *Proc. Natl. Acad. Sci. USA* **100:**13093-13098.

Hulme, J.T., Yarov-Yarovoy, V., Lin, Teddy W.-C., Scheuer, Todd and Catterall, W.A. (2006) Autoinhibitory control of the $Ca_v1.2$ channel by its proteolytically processed distal C-terminal domain. *J. Physiol.* **576:**87-102.

Emrick, M.A., Sadilek, M., Konoki, K., and Catterall, W.A. (2010) Beta-adrenergic-regulated phosphorylation of the skeletal muscle $Ca_V1.1$ channel in the fight-or-flight response. *Proc. Natl. Acad. Sci. U.S.A.* **107**:18712-18717.

Fuller, M.D., Emrick, M.A., Sadilek, M., Scheuer, T., and Catterall, W.A. (2010) Molecular mechanism of calcium channel regulation in the fight-or-flight response. *Science Signaling* **3 (141)**:ra70.

Fu, Y., Westenbroek, R.E., Yu, F.H., Clark, J.P. 3rd, Marshall, M.R., Scheuer, T., and Catterall, W.A. (2011) Deletion of the distal C-terminus of $Ca_V1.2$ channel leads to loss of beta-adrenergic regulation and heart failure in vivo. *J. Biol. Chem.* **286**:12617-12626.

Fu, Y., Westenbroek, R.E., Scheuer, T., and Catterall, W.A. (2013) Phosphorylation sites required for regulation of cardiac calcium channels in the fight-or-flight response. *Proc. Natl. Acad. Sci. USA.* **110**:19621-19626.

Fuller, M.D., Fu, Y., Scheuer, T., and Catterall, W.A. (2014) Differential regulation of $Ca_V1.2$ channels by cAMP-dependent protein kinase bound to A-kinase anchoring proteins 15 and 79/150. *J Gen Physiol.* **143**:315-324.

Fu, Y., Westenbroek, R.E., Scheuer, T., and Catterall, W.A. (2014) Basal and β-adrenergic regulation of the cardiac calcium channel $Ca_V1.2$ requires phosphorylation of serine 1700. *Proc. Natl. Acad. Sci. USA.* **111**:16598-16603.

Brunet, S., Emrick, M.A., Sadilek, M., Scheuer, T., and Catterall, W.A. (2015) Phosphorylation sites in the Hook domain of $Ca_V\beta$ subunits differentially modulate $Ca_V1.2$ channel function. *J Mol Cell Cardiol.* **87**:248-56.

Yang, L., Dai, D.F., Yuan, C., Westenbroek, R.E., Yu, H., West, N., de la Iglesia, H.O., and Catterall, W.A. (2016) Loss of β-adrenergic-stimulated phosphorylation of $Ca_V1.2$ channels on Ser1700 leads to heart failure. *Proc Natl Acad Sci USA.* 113:E7976-E7985.

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Major Invited Lectureships (Selected)

1984 Plenary Lecture, Japanese Pharmacological Society, Kyoto
Plenary Lecture, International Congress of Pharmacology, London

1985 University Lecture in Neuroscience, University of Texas Southwestern Medical Center, Dallas

1986 Grass Foundation Lecture in Neuroscience, University of Kansas, Kansas City
Jack R. Cooper Lecture in Pharmacology, Yale University

1991 Burroughs-Wellcome Lecture in Pharmacology, University of South Alabama

1992 Nora Eccles Harrison Lecture in Cardiovascular Sciences, University of Utah
Annual Graduate Lecture, State University of New York Health Science Center, Brooklyn, NY
Sixth Dante J. Chiarandini Memorial Lecture, New York University Medical Center
Monsanto Friday Evening Lecture, Marine Biological Laboratory, Woods Hole, Massachusetts
Thirteenth Peter F. Curran Lecture in Physiology, Yale University

1993 Sterling Drug Lecture in Pharmacology, Boston University School of Medicine

1994 Burroughs-Wellcome Lecture in Pharmacology, Michigan State University
Anton J. Carlson Memorial Lecture, University of Chicago

1995 Mathilde Solowey Award Lecture in Neuroscience, National Institutes of Health
Robert M. Berne Lecture in Cardiovascular Sciences, University of Virginia
H. B. van Dyke Award Lecture in Pharmacology, Columbia University

1997 Theodore Koppanyi Lecture in Pharmacology, Georgetown University Medical Center

1998 Jacques and Giselle Weisman Lecture, Hebrew University of Jerusalem
Louis Goodman Lecture in Pharmacology, Oregon Heath Science University

1999 Danish Society for Pharmacology & Toxicology Lectureship in honor of Professor J. C. Skou, University of Aarhus, Denmark
Grass Foundation Lecture in Neuroscience, University of Pittsburgh
Hong Lecture in Physiology, University of Illinois at Urbana-Champaign
Pan American Biochemical Society Lecture, International Congress of Biochemistry, Nice, France

2000 University Lecture in Neuroscience, University of Texas Southwestern Medical Center, Dallas
Arthur Briggs Lecture in Physiology, University of Texas, San Antonio

Distinguished Scientist Lecture in Physiology and Biophysics, University of Iowa

2001 Frederick Scheuler Distinguished Lecture in Pharmacology, Tulane University School of Medicine

2002 Distinguished Scientist Lecture, National Institute of Environmental Health Sciences, North Carolina

Plenary Lecture, Combined Meeting of The Physiological Society, the German Physiological Society, and the Scandinavian Physiological Society, Tubingen, Germany

Nobel Forum Lecture, Karolinska Institute, Stockholm, Sweden

2003 Keynote Lecture, FASEB Conference on Ion Channel Regulation, Tucson, AZ

Bristol-Myers Squibb Award Lecture in Neuroscience, Wallingford, CT

2004 Keynote Lecture, Opening Symposium, University of Colorado Health Science Center at Fitzsimons, Denver, CO

2006 Keynote Lecture, 10th Swiss Receptor Symposium, Basel, Switzerland

2007 CBL Endowed Lectureship in Biological Chemistry, Johns Hopkins University

Brain Awareness Public Lecture, University of Manitoba, Winnipeg, Canada

2008 First Annual Biology and Pharmacology Lectureship, McMaster University

Commencement Address and Distinguished Scientist Lecture, School of Biomedical Sciences, State University of New York, Buffalo

Opening Lecture, 23rd Annual Meeting of FESBE, the Federation of Societies of Experimental Biology of Brazil, Aguas de Lindoia, Sao Paolo, Brazil

2009 Annual Distinguished Science in Medicine Lecture, University of Washington

Keynote Lecture, FASEB Conference on Ion Channel Regulation, Snowmass, CO

Keynote Lecture, French Ion Channel Meeting, Giens, France

2010 Robert Schwab Award Lecture, American Clinical Neurophysiology Society, San Diego

Molecular Medicine Public Lecture, University of Washington

Philip Bard Lecture in Medical Physiology, Johns Hopkins University

Keynote Lecture, Second International Conference on Calcium Channels, Placencia, Belize

Gairdner Award Lecture, Toronto, Ontario, Canada

Wachter Award Lecture, University of Innsbruck, Innsbruck, Austria

2011 George Palade Lectureship and Medal, Wayne State University, Detroit, MI

Keynote Lecture, Ion Channels as Drug Targets, San Francisco, CA

Nobel Forum Lecture, Karolinska Institute, Stockholm, Sweden

Gordon K. Moe Award and Lecture, Cardiac Electrophysiology Society, Orlando, Florida

Keynote Lecture, Sodium Channels as Drug Targets, Royal Danish Academy of Sciences, Copenhagen

Keynote Lecture, Award Ceremony for Degrees of Honoris Causa, University of Aix-Marseille, France

2012 Keynote Lecture, European Calcium Channel Conference, Alpach, Austria

Keynote Lecture, Gordon Conference on Membrane Transport, Les Diablerets, Switzerland

Brookhart Lecture, Oregon Health & Science University, Portland, Oregon

2013 Keynote Lecture, FASEB Conference on Ion Channel Regulation, Bahamas

Sharpey-Schafer Prize Lecture, International Union of Physiology, Birmingham, UK

Opening Lecture on Sodium Channel Structure and Function at the Atomic Level, Hodgkin-Huxley Honorary Symposium, Cambridge, UK

Keynote Lecture, Neuroscience Day, University of Victoria, BC

Mission Bay Lecture, University of California at San Francisco, CA

2014 Keynote Lecture, Ion Channels as Drug Targets, San Francisco, CA

Inaugural Toshio Narahashi Memorial Lecture, Northwestern University, Chicago, IL

Opening Lecture, Nebraska Neuroscience Day, Creighton University, Omaha, NE

Theodore Brody Lecture in Pharmacology, Michigan State University, MI

2015 Norman Weiner Lecture, American Society for Pharmacology & Experimental Therapeutics, EB2015, Boston

Forbes Endowed Lecture, Grass Foundation, Marine Biological Laboratories, Woods Hole, MA

Dean's Lecture, Virginia Commonwealth University, Richmond, VA

2016 Opening Lecture, Symposium in Honor of Professor Michel Lazdunski, Nice, France
Opening Lecture, Symposium in Honor of Professor Palmer Taylor, University of California at San Diego
Koster Memorial Lecture, Washington University, St. Louis
Plenary Lecture, Ion Channel Drug Discovery & Precision Medicine, Guangzhou, China
Peter Garland Lecture, University of Dundee, Scotland

2017 Plenary Opening Lecture, Winter Conference on Brain Research, Big Sky, Montana
Hotchkiss Brain Science Lecture, University of Calgary, Calgary, Alberta, Canada
Molecular Structure & Function Lecture, The Hospital for Sick Children, U of Toronto, Canada
Theodor Svedberg Lecture, University of Uppsala, Uppsala, Sweden
Molecular Endocrinology Lecture, Karolinska Institute, Stockholm, Sweden
Plenary Lecture, FASEB Conference on Ion Channel Regulation, Steamboat Springs, Colorado
Annual Research Day Lecture, Davis Heart & Lung Institute, Ohio State University, Columbus, Ohio
Neuroscience Lecture, Rutgers University, Piscataway, NJ