

CURRICULUM VITAE

Name: Michael Patrick Kavanaugh

Position: Professor of Neuroscience, University of Montana
mpk@mclaughlinresearch.org
(406) 531-3444

Education:

1981 A.B. Biology
Washington University
St. Louis, Missouri

1986 Ph.D. Biochemistry
Oregon Health Sciences University
Portland, Oregon

Research background and interests:

Biophysics and neurophysiology, molecular and genetic mechanisms underlying brain disease

Professional experience:

1987-1993 Postdoctoral Fellow, Neurophysiology, Vollum Institute, OHSU
1993-1997 Assistant Professor, Vollum Institute, OHSU
1997-2003 Associate Professor, Vollum Institute, OHSU
2000-2003 Associate Director, OHSU Neuroscience Graduate Program
2003- Professor of Neuroscience, University of Montana
2008-2016 Director, NIH Center of Biomedical Research Excellence, University of Montana Center for Structural and Functional Neuroscience
2016-2021 Director, McLaughlin Research Institute

Selected awards/appointments:

1986-1987 Medical Research Foundation of Oregon Predoctoral Fellowship
1988-1991 NIH NRSA Postdoctoral Fellowship
1993 Senior Wellcome Fellowship, Oxford University
1998-2001 Klingenstein Neuroscience Fellow
1998 Vice Chair, Gordon Conference on Physiology of Membrane Transport

1999-2002	Member, NIH MDCN4 Study Section
1999	Chair, FASEB Conference, Amino Acid and Neurotransmitter Transporters
2000	Chair, Gordon Conference on Physiology of Membrane Transport
2000-2003	Councilor, Society of General Physiologists
2003-2009	Lecturer, International School of Biophysics, Erice Italy
2004-2006	NIH Review Panel: Biophysics of Synapses, Channels, and Transporters
2006-2008	NIH Review Panel: Neurotransporters, Receptors and Calcium
2010-2014	Co-Director, International School of Biophysics, Channels and Transporters, Erice, Italy
2010-2016	NIH Review Panel for Biophysical, Physiological, Pharmacological, and Bioengineering Neuroscience Fellowships
2011-2012	Visiting Scientist, Vollum Institute, Oregon Health and Science University
2021	Chief Scientific Officer, McLaughlin Research Institute

Current research grants:

NIH R01MH110646 PI, Homeostatic control of the NMDAR co-agonist D-serine by SLC1A4 (2018-2023)

NIH R01AG050425 co-I, Entorhinal-hippocampal circuit dysfunction in AD mice (2018-2023)

NIH RF1AG056151 co-I, Tauopathy in AD and FTD: molecular determinants of phenotypic diversity (2018-2022)

NIH 5R21AG061719 co-I, Investigating the effect of APO-E4 expression on AD-relevant tauopathy (2020-2021)

SLC6A1 Foundation, Development of gene therapies for pediatric epilepsy (2022-2025)

Completed research grants:

NIH R15GM088799 PI, Human Glutamate Transporter Structure (2014-2018)

NIH R25DA033032 PI, The Big Sky Brain Project (2011-2015)

NIH R15GM088789 PI, High-Level Expression of Human EAAT3 for Biochemical and Structural Analysis (2011-2012)

NIH R01NS033270 PI, Physiology and Biophysics of Glutamate Transport (1995-2011)

NIH R21 DA02486 PI, Characterization and Use of Fluorescent Endocannabinoid Transporter Substrates (2008-2010)

NIH P20 RR015583 PI, Center of Biomedical Research Excellence in Neuroscience (2008-2010)

NIH P20RR015583-10S1 COBRE CSFN Translational Neuroscience Core (2009-2011)
US/Israeli Binational Science Foundation co-PI, Structure-Function of Glutamate Transporters (2000-2004)
Klingenstein Fellowship in the Neurosciences, (1998-2001)
Wellcome Senior Fellowship, Oxford University (1993, declined)
NIH R01GM48709 Basic Amino Acid Transporters PI, (1993-1997)
NIH F32 Postdoctoral Fellowship, Pro-opioid Processing Enzymes (1988-1991)

Current Board Membership:

2015- Advisory Board, SpectrUM, University of Montana
2017- Scientific Advisor, Sea Pharmaceuticals
2017- Advisory Board, University of South Dakota Center for Brain and Behavior Research

Peer-reviewed Publications:

([google scholar](#) citations: >17K, h-index=60)

Manuscripts related to neurological disease/neuropathology:

Calderón-Garcidueñas, L., Mora-Tiscareño, A., Styner, M., Gómez-Garza, G., Zhu, H., Torres-Jardón, R., Carlos, E., Solorio-López, E., Medina-Cortina, H., Kavanaugh, M., D'Angiulli, A. (2012) White matter hyperintensities, systemic inflammation, brain growth, and cognitive functions in children exposed to air pollution. **J. Alzheimers Dis.** 31, 183–191.

Calderón-Garcidueñas, L., Franco-Lira, M., Mora-Tiscareño, A., Medina-Cortina, H., Torres-Jardón, R., Kavanaugh, MP (2013) Early Alzheimer's and Parkinson's disease pathology in urban children. **Biomed Res Int** 2013, 161687.

Rau, T.F., Lu, Q., Sharma, S., Sun, X., Leary, G., Beckman, M.L., Hou, Y., Wainwright, M.S., Kavanaugh, M., Poulsen, D.J., Black, S.M. (2012) Oxygen glucose deprivation in rat hippocampal slice cultures results in alterations in carnitine homeostasis and mitochondrial dysfunction. **PLoS ONE** 7, e40881.

Calderón-Garcidueñas L, Kavanaugh M, Block M, D'Angiulli A, Delgado-Chávez R, Torres-Jardón R, et al. (2012) Neuroinflammation, hyperphosphorylated tau, diffuse amyloid plaques, and down-regulation of the cellular prion protein in air pollution exposed children and young adults. **J. Alzheimers Dis.** 28 93–107.

Stone, E., Hoffman, K., Kavanaugh, M., (2012) Identifying neurotransmitter spill-over in hippocampal field recordings. **Math Biosci** 240, 169–186

Calderón-Garcidueñas, L, Serrano-Sierra, A., Torres-Jardón, R, Zhu, H, Yuan, Y, Smith, D., Delgado-Chávez, R., Cross, JV, Medina-Cortina, H., Kavanaugh, MP, Guilarte, T.R. (2013) The impact of environmental metals in young urbanites' brains. **Exp. Toxicol. Pathol.** 65, 503–511.

Sun W., Shchepakin D., Kalachev LV, Kavanaugh MP (2014) Glutamate transporter control of ambient glutamate levels. **Neurochem Int** 73, 146.

Calderón-Garcidueñas, L., Cross, J.V., Franco-Lira, M., Aragón-Flores, M., Kavanaugh, MP, Torres-Jardón, R., Chao, C.-K., Thompson, C., Chang, J., Zhu, H., D'Angiulli, A. (2013). Brain immune interactions and air pollution: macrophage inhibitory factor (MIF), prion cellular protein (PrP(C)), Interleukin-6 (IL-6), interleukin 1 receptor antagonist (IL-1Ra), and interleukin-2 (IL-2) in cerebrospinal fluid and MIF in serum differentiate urban children exposed to severe vs. low air pollution. **Front Neurosci** 7, 183-189.

Staniszewski A, Zhang H, Asam K, Pitstick R, Kavanaugh MP, Arancio O, Nichol(Is RE. (2020) Reduced Expression of the PP2A Methyltransferase, PME-1, or the PP2A Methyltransferase, LCMT-1, Alters Sensitivity to Beta-Amyloid-Induced Cognitive and Electrophysiological Impairments in Mice. **J Neurosci.** 40:4596-4608

Minikel EV, Zhao HT, Le J, O'Moore J, Pitstick R, Graffam S, Carlson GA, Kavanaugh MP, Kriz J, Kim JB, Ma J, Wille H, Aiken J, McKenzie D, Doh-Ura K, Beck M, O'Keefe R, Stathopoulos J, Caron T, Schreiber SL, Carroll JB, Kordasiewicz HB, Cabin DE, Vallabh SM. (2020) Prion protein lowering is a disease-modifying therapy across prion disease stages, strains and endpoints. **Nucleic Acids Res.** 48(19):10615-10631

Gnanaprakash, M, Staniszewski A, Zhang H, Pitstick R, Kavanaugh MP, Arancio O, and Nicholls RE (2021) Leucine carboxyl methyltransferase 1 overexpression protects against cognitive and electrophysiological impairments in Tg2576 APP transgenic mice. **J. Alzheimer's Disease** 79: 1813-1829

Manuscripts in reverse chronological order:

Gnanaprakash, M, Staniszewski A, Zhang H, Pitstick R, Kavanaugh MP, Arancio O, and Nicholls RE (2021) Leucine carboxyl methyltransferase 1 overexpression protects

against cognitive and electrophysiological impairments in Tg2576 APP transgenic mice,. **J. Alzheimer's Disease** 79: 1813-1829

Miller CG, Kundert JA, Prigge JR, Amato JA, Perez AE, Kavanaugh MP, Orlicky, DJ, Shearn, CT, and Schmidt EE. (2021) Supplemental ascorbate diminishes DNA damage yet depletes glutathione and increases acute liver failure in a mouse model of hepatic antioxidant system disruption. **Antioxidants** 10(3):359

Staniszewski A, Zhang H, Asam K, Pitstick R, Kavanaugh MP, Arancio O, Nichols RE. (2020) Reduced Expression of the PP2A Methyltransferase, PME-1, or the PP2A Methyltransferase, LCMT-1, Alters Sensitivity to Beta-Amyloid-Induced Cognitive and Electrophysiological Impairments in Mice. **J Neurosci.** 40:4596-4608

Minikel EV, Zhao HT, Le J, O'Moore J, Pitstick R, Graffam S, Carlson GA, Kavanaugh MP, Kriz J, Kim JB, Ma J, Wille H, Aiken J, McKenzie D, Doh-Ura K, Beck M, O'Keefe R, Stathopoulos J, Caron T, Schreiber SL, Carroll JB, Kordasiewicz HB, Cabin DE, Vallabh SM. (2020) Prion protein lowering is a disease-modifying therapy across prion disease stages, strains and endpoints. **Nucleic Acids Res.** 48(19):10615-10631

Shchepakina D, Kalachev L, Kavanaugh MP (2019) Modeling of excitatory amino acid transporters and clearance of the synaptic cleft on millisecond time scales. **Math. Model. Nat. Phenom.** 14(4):407.

Shchepakina D., Kalachev L., Kavanaugh M. (2019) Modeling of Excitatory Amino Acid Transporters. In: Korobeinikov A., Caubergh M., Lázaro T., Sardanyés J. (eds) **Trends in Mathematics**, vol 11., Birkhäuser

Cheng B, Shchepakina D, Kavanaugh MP, Trauner D. Photoswitchable Inhibitor of a Glutamate Transporter. **ACS Chem Neurosci.** 2017 Aug 16;8(8):1668-1672.

Foster, A.C., Farnsworth, J., Lind, G.E., Li, Y-X., Yang, J., Dang, V., Penjwini, M., Viswanath, V., Staubli, U., Kavanaugh, MP (2016) D-Serine is a substrate for neutral amino acid transporters ASCT1 and ASCT2, and is transported by both sub-types in rat hippocampal astrocyte cultures. **PLoS ONE** 11:e0156551.

Sun W., Shchepakina D., Kalachev L.V., Kavanaugh MP (2014) Glutamate transporter control of ambient glutamate levels. **Neurochem Int** 73, 146.

Andrews J.C., Fernández MP, Yu Q., Leary G.P., Leung A.K., Kavanaugh MP, Kravitz E.A., Certel S.J. (2014) Octopamine neuromodulation regulates Gr32a-linked aggression and courtship pathways in *Drosophila* males. **PLoS Genet** 10(5):e1004356

Calderón-Garcidueñas, L., Cross, J.V., Franco-Lira, M., Aragón-Flores, M., Kavanaugh, MP, Torres-Jardón, R., Chao, C.-K., Thompson, C., Chang, J., Zhu, H., D'Angiulli, A. (2013). Brain immune interactions and air pollution: macrophage inhibitory factor (MIF), prion cellular protein (PrP(C)), Interleukin-6 (IL-6), interleukin 1 receptor antagonist (IL-1Ra), and interleukin-2 (IL-2) in cerebrospinal fluid and MIF in serum differentiate urban children exposed to severe vs. low air pollution. **Front Neurosci** 7, 183-189.

Wang, H., Rascoe, A.M., Holley, D.C., Gouaux, E., Kavanaugh, MP (2013) Novel dicarboxylate selectivity in an insect glutamate transporter homolog. **PLoS ONE** 8, e70947.

Calderón-Garcidueñas, L., Franco-Lira, M., Mora-Tiscareño, A., Medina-Cortina, H., Torres-Jardón, R., Kavanaugh, MP (2013) Early Alzheimer's and Parkinson's disease pathology in urban children. **Biomed Res Int** 2013, 161687.

Calderón-Garcidueñas, L., Serrano-Sierra, A., Torres-Jardón, R., Zhu, H., Yuan, Y., Smith, D., Delgado-Chávez, R., Cross, J.V., Medina-Cortina, H., Kavanaugh, M., Guilarte, T.R. (2013) The impact of environmental metals in young urbanites' brains. **Exp. Toxicol. Pathol.** 65, 503–511.

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Leary, G.P., Allen, J.E., Bunger, P.L., Luginbill, J.B., Linn, C.E., Jr, Macallister, I.E., Kavanaugh, MP, and Wanner, K.W. (2012). Single mutation to a sex pheromone receptor provides adaptive specificity between closely related moth species. **Proc. Natl. Acad. Sci. U.S.A.** 109, 14081–14086.

Rau, T.F., Lu, Q., Sharma, S., Sun, X., Leary, G., Beckman, M.L., Hou, Y., Wainwright, M.S., Kavanaugh, M., Poulsen, D.J., Black, S.M. (2012) Oxygen glucose deprivation in rat hippocampal slice cultures results in alterations in carnitine homeostasis and mitochondrial dysfunction. **PLoS ONE** 7, e40881.

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Leary GP, Holley DC, Stone EF, Lyda BR, Kalachev LV, Kavanaugh MP (2011) The central cavity in trimeric glutamate transporters restricts ligand diffusion. **Proc. Natl. Acad. Sci. U.S.A.** 108:14980–5

Sun W, Hoffman KM, Holley DC, Kavanaugh MP (2011) Specificity and actions of an arylaspartate inhibitor of glutamate transport at the Schaffer collateral-CA1 pyramidal cell synapse. **PLoS ONE** 6:e23765

Holley DC, Kavanaugh MP (2009) Interactions of alkali cations with glutamate transporters. **Philos. Trans. R. Soc. Lond., B, Biol. Sci** 364:155-161

Leary GP, Stone EF, Holley DC, Kavanaugh MP (2007) The glutamate and chloride permeation pathways are colocalized in individual neuronal glutamate transporter subunits. **J. Neurosci** 27:2938-2942

Esslinger CS, Agarwal S, Gerdes J, Wilson PA, Davis ES, Awes AN, O'Brien E, Mavencamp T, Koch HP, Poulsen DJ, Rhoderick JF, Chamberlin AR, Kavanaugh MP, Bridges RJ (2005) The substituted aspartate analogue L-beta-threo-benzyl-aspartate preferentially inhibits the neuronal excitatory amino acid transporter EAAT3. **Neuropharmacology** 49:850-861

Larsson HP, Tzingounis AV, Koch HP, Kavanaugh MP (2004) Fluorometric measurements of conformational changes in glutamate transporters. **Proc. Natl. Acad. Sci. U.S.A** 101:3951-3956

Stein A, Vaseduvan G, Carter NS, Ullman B, Landfear SM, Kavanaugh MP (2003) Equilibrative nucleoside transporter family members from *Leishmania donovani* are electrogenic proton symporters. **J. Biol. Chem** 278:35127-35134

Chaudhry FA, Schmitz D, Reimer RJ, Larsson P, Gray AT, Nicoll R, Kavanaugh M, Edwards RH (2002) Glutamine uptake by neurons: interaction of protons with system A transporters. **J. Neurosci** 22:62-72

Borre L, Kavanaugh MP, Kanner BI (2002) Dynamic equilibrium between coupled and uncoupled modes of a neuronal glutamate transporter. **J. Biol. Chem** 277:13501-13507

Kanner BI, Kavanaugh MP, Bendahan A (2001) Molecular characterization of substrate-binding sites in the glutamate transporter family. **Biochem. Soc. Trans** 29:707-710

Taylor CS, Marin M, Nouri A, Kavanaugh MP, and Kabat, D. (2001) Truncated forms of the dual function human ASCT2 neutral amino acid transporter/retroviral receptor are translationally initiated at multiple alternative CUG and GUG codons. **J. Biol. Chem** 276:27221-30

Chaudhry FA, Krizaj D, Larsson P, Reimer RJ, Wreden C, Storm-Mathisen J, Copenhagen D, Kavanaugh M, Edwards RH (2001) Coupled and uncoupled proton movement by amino acid transport system N. **EMBO J** 20:7041-7051

Bendahan A, Armon A, Madani N, Kavanaugh MP, Kanner BI (2000) Arginine 447 plays a pivotal role in substrate interactions in a neuronal glutamate transporter. **J. Biol. Chem** 275:37436-37442

Eskandari S, Kreman M, Kavanaugh MP, Wright EM, Zampighi GA (2000) Pentameric assembly of a neuronal glutamate transporter. **Proc. Natl. Acad. Sci. U.S.A** 97:8641-8646

Otis TS, Kavanaugh MP (2000) Isolation of current components and partial reaction cycles in the glial glutamate transporter EAAT2. **J. Neurosci** 20:2749-2757

Koch HP, Kavanaugh MP, Esslinger CS, Zerangue N, Humphrey JM, Amara SG, Chamberlin AR, Bridges RJ (1999) Differentiation of substrate and nonsubstrate inhibitors of the high-affinity, sodium-dependent glutamate transporters. **Mol. Pharmacol** 56:1095-1104

Bridges RJ, Kavanaugh MP, Chamberlin AR (1999) A pharmacological review of competitive inhibitors and substrates of high-affinity, sodium-dependent glutamate transport in the central nervous system. **Curr. Pharm. Design** 5:363-379

Siciliano SJ, Kuhmann SE, Weng Y, Madani N, Springer MS, Lineberger JE, Danzeisen R, Miller MD, Kavanaugh MP, DeMartino JA, Kabat D (1999) A critical site in the core of the CCR5 chemokine receptor required for binding and infectivity of human immunodeficiency virus type 1. **J. Biol. Chem** 274:1905-1913

Lin CL, Tzingounis AV, Jin L, Furuta A, Kavanaugh MP, Rothstein JD (1998) Molecular cloning and expression of the rat EAAT4 glutamate transporter subtype. **Brain Res. Mol. Brain Res** 63:174-179

Esslinger CS, Koch HP, Kavanaugh MP, Philips DP, Chamberlin AR, Thompson CM, Bridges RJ (1998) Structural determinants of substrates and inhibitors: probing glutamate transporters with 2,4-methanopyrrolidine-2,4-dicarboxylate. **Bioorg. Med. Chem. Lett** 8:3101-3106

Wadiche JI, Kavanaugh MP (1998) Macroscopic and microscopic properties of a cloned glutamate transporter/chloride channel. **J. Neurosci** 18:7650-7661

Tzingounis AV, Lin CL, Rothstein JD, Kavanaugh MP (1998) Arachidonic acid activates a proton current in the rat glutamate transporter EAAT4. **J. Biol. Chem** 273:17315-17317

Madani N, Kozak SL, Kavanaugh MP, Kabat D (1998) gp120 envelope glycoproteins of human immunodeficiency viruses competitively antagonize signaling by coreceptors CXCR4 and CCR5. **Proc. Natl. Acad. Sci. U.S.A** 95:8005-8010

Zarbiv R, Grunewald M, Kavanaugh MP, Kanner BI (1998) Cysteine scanning of the surroundings of an alkali-ion binding site of the glutamate transporter GLT-1 reveals a conformationally sensitive residue. **J. Biol. Chem** 273:14231-14237

Eliasof S, Arriza JL, Leighton BH, Amara SG, Kavanaugh MP (1998) Localization and function of five glutamate transporters cloned from the salamander retina. **Vision Res** 38:1443-1454

Zhang Y, Bendahan A, Zerbiv R, Kavanaugh MP, Kanner BI (1998) Molecular determinant of ion selectivity of a (Na⁺ + K⁺)-coupled rat brain glutamate transporter. **Proc. Natl. Acad. Sci. U.S.A** 95:751-755

Eliasof S, Arriza JL, Leighton BH, Kavanaugh MP, Amara SG (1998) Excitatory amino acid transporters of the salamander retina: identification, localization, and function. **J. Neurosci** 18:698-712

Wang GJ, Chung HJ, Schnuer J, Pratt K, Zable AC, Kavanaugh MP, Rosenberg PA (1998) High affinity glutamate transport in rat cortical neurons in culture. **Mol. Pharmacol** 53:88-96

Seyfang A, Kavanaugh MP, Landfear SM (1997) Aspartate 19 and glutamate 121 are critical for transport function of the myo-inositol/H⁺ symporter from *Leishmania donovani*. **J. Biol. Chem** 272:24210-24215

Otis TS, Kavanaugh MP, Jahr CE (1997) Postsynaptic glutamate transport at the climbing fiber-Purkinje cell synapse. **Science** 277:1515-1518

Zhu SJ, Kavanaugh MP, Sonders MS, Amara SG, Zahniser NR (1997) Activation of protein kinase C inhibits uptake, currents and binding associated with the human dopamine transporter expressed in *Xenopus* oocytes. **J. Pharmacol. Exp. Ther** 282:1358-1365

Bismuth Y, Kavanaugh MP, Kanner BI (1997) Tyrosine 140 of the gamma-aminobutyric acid transporter GAT-1 plays a critical role in neurotransmitter recognition. **J. Biol. Chem** 272:16096-16102

Kavanaugh MP, Bendahan A, Zerangue N, Zhang Y, Kanner BI (1997) Mutation of an amino acid residue influencing potassium coupling in the glutamate transporter GLT-1 induces obligate exchange. **J. Biol. Chem** 272:1703-1708

Arriza JL, Eliasof S, Kavanaugh MP, Amara SG (1997) Excitatory amino acid transporter 5, a retinal glutamate transporter coupled to a chloride conductance. **Proc. Natl. Acad. Sci. U.S.A** 94:4155-4160

Sonders MS, Zhu SJ, Zahniser NR, Kavanaugh MP, Amara SG (1997) Multiple ionic conductances of the human dopamine transporter: the actions of dopamine and psychostimulants. **J. Neurosci** 17:960-974

Zerangue N, Kavanaugh MP (1996) ASCT-1 is a neutral amino acid exchanger with chloride channel activity. **J. Biol. Chem** 271:27991-27994

Zerangue N, Kavanaugh MP (1996) Flux coupling in a neuronal glutamate transporter. **Nature** 383:634-637

Wang H, Klamo E, Kuhmann SE, Kozak SL, Kavanaugh MP, Kabat D (1996) Modulation of ecotropic murine retroviruses by N-linked glycosylation of the cell surface receptor/ amino acid transporter. **J. Virol** 70:6884-6891

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Zerangue N, Kavanaugh MP (1996) Interaction of L-cysteine with a human excitatory amino acid transporter. **J. Physiol. (Lond.)** 493 (Pt 2):419-423

Drew ME, Langford CK, Klamo EM, Russell DG, Kavanaugh MP, Landfear SM (1995) Functional expression of a myo-inositol/H⁺ symporter from *Leishmania donovani*. **Mol. Cell. Biol** 15:5508-5515

Langford CK, Kavanaugh MP, Stenberg PE, Drew ME, Zhang W, Landfear SM (1995) Functional expression and subcellular localization of a high-K_m hexose transporter from *Leishmania donovani*. **Biochemistry** 34:11814-11821

Wadiche JI, Amara SG, Kavanaugh MP (1995) Ion fluxes associated with excitatory amino acid transport. **Neuron** 15:721-728

Vandenberg RJ, Arriza JL, Amara SG, Kavanaugh MP (1995) Constitutive ion fluxes and substrate binding domains of human glutamate transporters. **J. Biol. Chem** 270:17668-17671

Sanchez MA, Zeoli D, Klamo EM, Kavanaugh MP, Landfear SM (1995) A family of putative receptor-adenylate cyclases from *Leishmania donovani*. **J. Biol. Chem** 270:17551-17558

Fairman WA, Vandenberg RJ, Arriza JL, Kavanaugh MP, Amara SG (1995) An excitatory amino-acid transporter with properties of a ligand-gated chloride channel. **Nature** 375:599-603

Kozak SL, Siess DC, Kavanaugh MP, Miller AD, Kabat D (1995) The envelope glycoprotein of an amphotropic murine retrovirus binds specifically to the cellular receptor/phosphate transporter of susceptible species. **J. Virol** 69:3433-3440

Wadiche JI, Arriza JL, Amara SG, Kavanaugh MP (1995) Kinetics of a human glutamate transporter. **Neuron** 14:1019-1027

Pessia M, Bond CT, Kavanaugh MP, Adelman JP (1995) Contributions of the C-terminal domain to gating properties of inward rectifier potassium channels. **Neuron** 14:1039-1045

Zerangue N, Arriza JL, Amara SG, Kavanaugh MP (1995) Differential modulation of human glutamate transporter subtypes by arachidonic acid. **J. Biol. Chem** 270:6433-6435

Arriza JL, Fairman WA, Wadiche JI, Murdoch GH, Kavanaugh MP, Amara SG (1994) Functional comparisons of three glutamate transporter subtypes cloned from human motor cortex. **J. Neurosci** 14:5559-5569

Wang H, Kavanaugh MP, Kabat D (1994) A critical site in the cell surface receptor for ecotropic murine retroviruses required for amino acid transport but not for viral reception. **Virology** 202:1058-1060

Kavanaugh MP, Miller DG, Zhang W, Law W, Kozak SL, Kabat D, Miller AD (1994) Cell-surface receptors for gibbon ape leukemia virus and amphotropic murine retrovirus are inducible sodium-dependent phosphate symporters. **Proc. Natl. Acad. Sci. U.S.A** 91:7071-7075

Langford CK, Little BM, Kavanaugh MP, Landfear SM (1994) Functional expression of two glucose transporter isoforms from the parasitic protozoan *Leishmania enriettii*. **J. Biol. Chem** 269:17939-17943

Kavanaugh MP, Wang H, Boyd CA, North RA, Kabat D (1994) Cell surface receptor for ecotropic host-range mouse retroviruses: a cationic amino acid transporter. **Arch. Virol.**9:485-494

Kavanaugh MP, Wang H, Zhang Z, Zhang W, Wu YN, Dechant E, North RA, Kabat D (1994) Control of cationic amino acid transport and retroviral receptor functions in a membrane protein family. **J. Biol. Chem** 269:15445-15450

Bond CT, Pessia M, Xia XM, Lagrutta A, Kavanaugh MP, Adelman JP (1994) Cloning and expression of a family of inward rectifier potassium channels. **Receptors and Channels** 2:183-191

Arriza JL, Kavanaugh MP, Fairman WA, Wu YN, Murdoch GH, North RA, Amara SG (1993) Cloning and expression of a human neutral amino acid transporter with structural similarity to the glutamate transporter gene family. **J. Biol. Chem** 268:15329-15332

Kavanaugh MP (1993) Voltage-dependence of facilitated flux mediated by the system y⁺ basic amino acid transporter. **Biochemistry** 32:5781-5785

Hurst RS, Kavanaugh MP, Yakel J, Adelman JP, North RA (1992) Cooperative interactions among subunits of a voltage-dependent potassium channel. Evidence from expression of concatenated cDNAs. **J. Biol. Chem** 267:23742-23745

Wang H, Dechant E, Kavanaugh M, North RA, Kabat D (1992) Effects of ecotropic murine retroviruses on the dual-function cell surface receptor/basic amino acid transporter. **J. Biol. Chem** 267:23617-23624

Kavanaugh MP, Arriza JL, North RA, Amara SG (1992) Electrogenic uptake of gamma-aminobutyric acid by a cloned transporter expressed in *Xenopus* oocytes. **J. Biol. Chem** 267:22007-22009

Adelman JP, Shen KZ, Kavanaugh MP, Warren RA, Wu YN, Lagrutta A, Bond CT, North RA (1992) Calcium-activated potassium channels expressed from cloned complementary DNAs. **Neuron** 9:209-216

Busch AE, Kavanaugh MP, Varnum MD, Adelman JP, North RA (1992) Regulation by second messengers of the slowly activating, voltage-dependent potassium current expressed in *Xenopus* oocytes. **J. Physiol. (Lond.)** 450:491-502

Kavanaugh MP, Hurst RS, Yakel J, Varnum MD, Adelman JP, North RA (1992) Multiple subunits of a voltage-dependent potassium channel contribute to the binding site for tetraethylammonium. **Neuron** 8:493-497

Hurst RS, Busch AE, Kavanaugh MP, Osborne PB, North RA, Adelman JP (1991) Identification of amino acid residues involved in dendrotoxin block of rat voltage-dependent potassium channels. **Mol. Pharmacol** 40:572-576

Busch AE, Hurst RS, North RA, Adelman JP, Kavanaugh MP (1991) Current inactivation involves a histidine residue in the pore of the rat lymphocyte potassium channel RGK5. **Biochem. Biophys. Res. Commun** 179:1384-1390

Wang H, Kavanaugh MP, North RA, Kabat D (1991) Cell-surface receptor for ecotropic murine retroviruses is a basic amino-acid transporter. **Nature** 352:729-731

Kavanaugh MP, Christie MJ, Osborne PB, Busch AE, Shen KZ, Wu YN, Seeburg PH, Adelman JP, North RA (1991)(a) Transmitter regulation of voltage-dependent K⁺ channels expressed in *Xenopus* oocytes. **Biochem. J.** 277 (Pt 3):899-902

Kavanaugh MP, Varnum MD, Osborne PB, Christie MJ, Busch AE, Adelman JP, North RA (1991) Interaction between tetraethylammonium and amino acid residues in the pore of cloned voltage-dependent potassium channels. **J. Biol. Chem** 266:7583-7587

Kavanaugh MP, Parker J, Bobker DH, Keana JF, Weber E (1989) Solubilization and characterization of sigma-receptors from guinea pig brain membranes. **J. Neurochem** 53:1575-1580

Galligan JJ, Campbell BG, Kavanaugh MP, Weber E, North RA (1989) 1,3-Di(2-tolyl)guanidine blocks nicotinic response in guinea pig myenteric neurons. **J. Pharmacol. Exp. Ther** 251:169-174

Kavanaugh MP, Perutz MF, Fermi G, Shih DT, Jones RT (1989) Structure and function of human hemoglobin covalently labeled with periodate-oxidized adenosine triphosphate. **J. Biol. Chem** 264:11009-11013

Kavanaugh MP, Tester BA, Weber E (1989) Interaction of MK-801 with the nicotinic acetylcholine receptor-associated ion channel from electroplax. **Eur. J. Pharmacol** 164:397-398

Kavanaugh MP, Shih DT, Jones RT (1988) Affinity labeling of hemoglobin with 4,4'-diisothiocyanostilbene-2,2'-disulfonate: covalent cross-linking in the 2,3-diphosphoglycerate binding site. **Biochemistry** 27:1804-1808

Kavanaugh MP, Tester BC, Scherz MW, Keana JF, Weber E (1988) Identification of the binding subunit of the sigma-type opiate receptor by photoaffinity labeling with 1-(4-azido-2-methyl[6-3H]phenyl)-3-(2-methyl[4,6-3H]phenyl)guanidine. **Proc. Natl. Acad. Sci. U.S.A** 85:2844-2848

Book Chapters and Invited Reviews:

Kavanaugh, MP (2009) Electrophysiology of glial glutamate transporters. In: **Encyclopedia of Neuroscience** Volume 4 pp 805-809 Oxford: Academic Press

Kavanaugh, MP (2004) Accessing a transporter structure. **Nature** 431:752-753

Tzingounis, A., Larsson, HP, Kavanaugh, MP (2000) Voltage clamp and fluorometric techniques for studying glutamate transporter function. In: **Transmembrane Transporters** (Wiley-Liss; Quick, M., ed.) pp 203-216 2002

Otis, TS, Kavanaugh, MP (1999) Glutamate transporters and their contributions to excitatory synaptic transmission. In: *Ionotropic glutamate in the CNS* (Springer; Jonas, P., Monyer, H., eds), pp 419-440

Kavanaugh MP (1998) Neurotransmitter transport: models in flux. **Proc. Natl. Acad. Sci. U.S.A** 95:12737-12738

Cha, A., Zerangue, N., Kavanaugh, M. and Bezanilla, F. (1998) Fluorescence measurements of ion transport processes in *Xenopus* oocytes. **Methods in Enzymology** 296 566-577

Kavanaugh MP, Kabat D (1996) Identification and characterization of a widely expressed phosphate transporter/retrovirus receptor family. **Kidney Int** 49:959-963

Patents:

Radiolabeled inhibitors of the amino acid transporters ASCT1 and ASCT2 Esslinger, C.S., Kavanaugh, MP, Lyda, B., Natale, N.R. US Patent 9,512,074

Inhibitors of the amino acid transporters ASCT1 and ASCT2 Esslinger, C.S., Kavanaugh, MP, Lyda, B., Natale, N.R. US Patent 8,895,607

Excitatory amino acid transporter gene and uses. Amara, S.G., Arriza, J.L., and Kavanaugh, MP U.S. Patent 5,882,926

Excitatory amino acid transporter gene and uses Amara, S.G., Arriza, J.L., Eliasof, S., and Kavanaugh, MP U.S. Patent 5,989,825

Excitatory amino acid transporter EAAT 5 protein from homo sapiens. Amara, S.G., Arriza, J.L., Eliasof, S., and Kavanaugh, MP U.S. Patent 6,284,505

Ph.D. Students and Postdoctoral Fellows trained:

Jacques Wadiche, Ph.D. student (current: Associate Professor, Department of Neurobiology, University of Alabama Birmingham)

Anastassios Tzingounis Ph.D. student (current: Professor, Physiology and Neurobiology, University of Connecticut)

Navid Madani, Ph.D. postdoc (current: Senior Scientist, Dana Farber Institute, Harvard Medical School)

Scott Eliasof, Ph.D. postdoc (current: Senior VP of Research, Frequency Therapeutics)

Tom Otis, Ph.D. postdoc (current: CSO, Sainsbury Wellcome Center, Professor of Neuroscience, University College London)

Gregory Leary Ph.D. student (current: postdoctoral fellow, Kavanaugh lab)

Katie Hoffman, Ph.D. student (current: Assistant Professor, University of Montana)

David Holley, Ph.D. student (current: Computational Core Facility Director, University of Montana)

Weinan Sun, Ph.D. student (current: postdoctoral fellow, Janelia Farm/HHMI)

Denis Schchepakin, Ph.D. student (current: postdoctoral fellow, Expecisor)

Lauren Cornelison, BA (current: PhD student, Kavanaugh lab)

Andrea Grindeland, DVM (current: postdoctoral fellow, Kavanaugh lab)

Selected Invited Lectures:

1992 Johns Hopkins University, Department of Neuroscience

1993 Oxford University, Department of Physiology

1994 Glaxo Institute for Molecular Biology, Geneva, Switzerland

1997 Gordon Conference, Mechanisms of Membrane Transport Proteins, Plymouth, NH

1997 Gordon Conference, Ligand Recognition and Molecular Gating, Plymouth, NH

1998 Gordon Conference, Synaptic Transmission, Holderness, NH

1998 Gordon Conference, Membrane Transport Proteins, Tilton, NH

1998 Gordon Conference, Ion Channels, Tilton, NH

1999 FASEB Conference Chair, Amino Acid and Neurotransmitter Transporters

1999 Gordon Conference, Ligand Recognition and Molecular Gating, Ventura, CA

2000 Gordon Conference Chair, Membrane Transport Proteins, New London, CT

2000 FASEB International Meeting on Amino Acid, Amine, Peptide, Drug, and Nucleoside Transporters, Barcelona, Spain

2001 Merck Division of Neuropharmacology, Whitehouse Station, NJ

2001 University of Alabama-Birmingham, Neurobiology Grad Program Annual Retreat

2001 Conference on Biomedical Research on Transporters, Interlaken, Switzerland

2002 Vanderbilt University, Department of Neuroscience

2002 Wyeth-Ayerst, Neuropharmacology and Neurophysiology Division, Princeton, NJ

2002 Neurocrine Biosciences, San Diego, CA

2003 Hebrew University, Department of Biochemistry

2003 FASEB Conference, New Perspectives in Transporter Biology

2004 International Symposium on Membrane Transport, Cambridge University

2005 University of Chile, Center for Biophysics and Molecular Physiology, Valdivia, Chile

2006 Symposium on Transporters and Channels, Biophysical Society Annual Meeting

2007 Conference on Transporters in Disease and Drug Development, Bern, Switzerland

2007 Gordon Conference on Cannabinoid Function in the CNS, Les Diablerets, Switzerland

2008 International School of Biophysics, Erice, Italy

2008 University of Perugia, Department of Physiology, Perugia, Italy

2008 Gordon Conference on Ion Channels, Tilton, NH
2008 Royal Society Meeting, Membrane Transport in Flux, London
2010 Virginia Commonwealth University, Department of Physiology
2010 Toyo University, Bio-Nano Electronics Research, Tokyo, Japan
2010 University of Pecs Department of Neurobiology, Pecs, Hungary
2011 International School of Biophysics, Erice, Italy
2011 Vollum Institute, Portland, OR
2012 EMBN Workshop on Membrane Proteins, University of Groningen, Netherlands
2013 ISN-ASN Neurochemistry Satellite Conference, Cancun, Mexico
2014 WWAMI Annual Science in Medicine Lecture, University of Washington, Seattle,
2015 Department of Neuroscience, University Of Massachusetts, Worcester, MA
2015 Symposium Lecture on Neurotransmitter Transport, Ann. Meeting Society for
Biophysics 2015 International Society for Neurochemistry, Symposium on Transport,
Cairns, Australia 2015 University of Sydney, Dept. of Pharmacology, Sydney, Australia
2016 Keynote Lecture, Illinois State University Graduate Research Symposium
2018 Dept. of Pharmacy, School of Pharmacy, University of Washington
2018 Charles River Laboratories, San Francisco, CA
2020 Alzheimer's Foundation of America Symposium: AD mechanisms: identifying
drugable targets
2021 Providence Health Systems Webinar on Alzheimer's disease: past, present, and
future (with Lee Hood)