

Stanford



Gregory Scherrer

Assistant Professor of Anesthesiology, Perioperative and Pain Medicine, of Neurosurgery and, by courtesy, of Molecular and Cellular Physiology

CONTACT INFORMATION

- **Alternate Contact**

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Bio

ACADEMIC APPOINTMENTS

- Assistant Professor, Anesthesiology, Perioperative and Pain Medicine
- Assistant Professor, Neurosurgery
- Assistant Professor (By courtesy), Molecular & Cellular Physiology
- Member, Bio-X
- Member, Wu Tsai Neurosciences Institute

ADMINISTRATIVE APPOINTMENTS

- Robertson Investigator, New York Stem Cell Foundation, (2017- present)
- Assistant Professor, Stanford University, (2012- present)

HONORS AND AWARDS

- Elected Active Member, Association of University Anesthesiologists (AUA) (2018)
- Keynote Speaker, American Society for Pharmacology and Experimental Therapeutics (ASPET) MAPS Meeting (2018)
- Mini-Convention Speaker: Frontiers in Addiction Research, NIH NIDA-NIAAA (2018)
- Robertson Investigator In Neurosciences, New York Stem Cell Foundation (2017)
- INRC Young Investigator Award, International Narcotics Research Conference (2015)
- Neurosensory Research Award, Department of Defense (2014)
- Rita Allen Foundation Scholar, Rita Allen Foundation - American Pain Society (2014)
- K99/R00 Pathway to Independence Award, National Institutes of Health - National Institute on Drug Abuse (2011)
- International Postdoctoral Fellowship, International Association for the Study of Pain (2009)

BOARDS, ADVISORY COMMITTEES, PROFESSIONAL ORGANIZATIONS

- Advisory Board member, Mission LISA, a project synthesizing big data to understand the Opioid Crisis (2018 - present)
- Co-founder, Epiodyne, a startup aiming at developing biased opioid agonists with reduced adverse effects for the treatment of pain (2017 - present)

PROFESSIONAL EDUCATION

- Postdoc. (2), Columbia University, MacDermott Laboratory , Spinal Cord Physiology (2012)
- Postdoc. (1), UCSF, Basbaum Laboratory , Neurobiology of Pain (2009)
- Ph.D., Louis Pasteur University of Strasbourg , Cellular and Molecular Biology (2005)
- Pharm.D., Louis Pasteur University of Strasbourg , Molecular Pharmacology (2001)

LINKS

- Scherrer Lab: <https://www.scherrerlab.com/>

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

Pain and Opioids

Our laboratory investigates the neural mechanisms that underlie the sensory and affective dimensions of pain experience. We also study how opioids interfere with these mechanisms to provide pain relief, but also deleterious effects such as tolerance, addiction and respiratory depression. Our goal is to better understand the neural basis of pain experience and opioid effects to discover novel treatments that block pain more efficiently and safely than current opioid drugs.

Physiological Acute Pain versus Chronic Pathological Pain.

Pain is normally an acute sensory and emotional state that we experience when our body is exposed to noxious and potentially damaging stimuli (e.g., noxious heat of an open flame). The unpleasantness of pain drives us to engage in adaptive behaviors for avoiding these stimuli and favoring healing. However, when chronic, pain is a disease that severely affects the quality of life of many patients. Thus, injuries or diseases (e.g., trauma, diabetes, arthritis, cancer) induce neuroplasticity in somatosensory circuits that lead to chronic pain: pain can then be perceived in the absence of actual stimuli (spontaneous pain), and normally innocuous stimuli such as light touch can generate excruciating pain (allodynia).

Pain & Opioid Epidemic: Two Outstanding and Related Problems.

The magnitude of pain in the United States is outstanding, with more than 116 million Americans suffering from chronic pain. The lack of effective alternative treatments resulted in a dramatic increase in opioid prescription in the past two decades, driving an alarming augmentation in cases of transitions to addiction and deaths from opioid overdose, a phenomenon termed the Opioid Epidemic. In the US today, hydrocodone tops all prescriptions, and deaths from opioid overdose represents the first cause of accidental death, ahead of car accidents. Elucidating pain mechanisms is urgently needed to develop novel analgesic therapies and end the Opioid Epidemic.

Our Approach.

The members of the Scherrer Laboratory aim to elucidate the mechanisms by which our nervous system generates pain, at the neural circuit, cellular, and molecular levels. We want to identify the pathological changes that occur within neural circuits when chronic pain develops, for discovering new molecular targets to treat this disease. One of our approaches is to gain understanding of how our endogenous opioid system modulates pain thresholds. Opioid receptors mediate the effects of opioid pain killers, such as morphine. By determining how opioids generate analgesia and detrimental side effects (e.g. tolerance, addiction, respiratory depression), we hope to develop more efficient and safer analgesics for the treatment of chronic pain. These studies will also identify novel approaches to counteract opioid side effects and battle the current Opioid Epidemic. To reach our goals, we combine a variety of experimental approaches including molecular and cellular biology, neuroanatomy, electrophysiology, opto- and pharmacogenetics, in vivo calcium imaging and behavior.

Teaching

COURSES

2018-19

- Neurosciences Anatomy Core: NEPR 205 (Spr)

2017-18

- Neurosciences Anatomy Core: NEPR 205 (Spr)

STANFORD ADVISEES

Postdoctoral Faculty Sponsor

Daniel Berg, Nicole Mercer Lindsay

Postdoctoral Research Mentor

Daniel Berg, Nicole Mercer Lindsay

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Anesthesia (Fellowship Program)
- Molecular and Cellular Physiology (Phd Program)
- Neurosciences (Phd Program)

Publications

PUBLICATIONS

- **Synapse-specific Opioid Modulation of Thalamo-cortico-striatal Circuits.** *eLife*
Birdsong, W. T., Jongbloets, B. C., Engeln, K. A., Wang, D., Scherrer, G., Mao, T.
2019; 8
- **An amygdalar neural ensemble that encodes the unpleasantness of pain.** *Science (New York, N.Y.)*
Corder, G., Ahanonu, B., Grewe, B. F., Wang, D., Schnitzer, M. J., Scherrer, G.
2019; 363 (6424): 276–81
- **Endogenous and Exogenous Opioids in Pain.** *Annual review of neuroscience*
Corder, G., Castro, D. C., Bruchas, M. R., Scherrer, G.
2018
- **Functional Divergence of Delta and Mu Opioid Receptor Organization in CNS Pain Circuits** *NEURON*
Wang, D., Tawfik, V. L., Corder, G., Low, S. A., Francois, A., Basbaum, A. I., Scherrer, G.
2018; 98 (1): 90–+
- **Beware of Undertow: Opioid Drugs Generate Additional Waves of Intracellular Signaling.** *Neuron*
Wang, D., Berg, D. J., Scherrer, G.
2018; 98 (5): 870–72
- **A Brainstem-Spinal Cord Inhibitory Circuit for Mechanical Pain Modulation by GABA and Enkephalins.** *Neuron*
François, A., Low, S. A., Sypek, E. I., Christensen, A. J., Sotoudeh, C., Beier, K. T., Ramakrishnan, C., Ritola, K. D., Sharif-Naeini, R., Deisseroth, K., Delp, S. L., Malenka, R. C., Luo, et al
2017; 93 (4): 822-839 e6
- **Loss of mu opioid receptor signaling in nociceptors, but not microglia, abrogates morphine tolerance without disrupting analgesia** *NATURE MEDICINE*
Corder, G., Tawfik, V. L., Wang, D., Sypek, E. I., Low, S. A., Dickinson, J. R., Sotoudeh, C., Clark, J. D., Barres, B. A., Bohlen, C. J., Scherrer, G.
2017; 23 (2): 164-173

- **In Vivo Interrogation of Spinal Mechanosensory Circuits.** *Cell reports*
Christensen, A. J., Iyer, S. M., François, A., Vyas, S., Ramakrishnan, C., Vesuna, S., Deisseroth, K., Scherrer, G., Delp, S. L.
2016; 17 (6): 1699-1710
- **Structure-based discovery of opioid analgesics with reduced side effects** *NATURE*
Manglik, A., Lin, H., Aryal, D. K., McCorvy, J. D., Dengler, D., Corder, G., Levit, A., Kling, R. C., Bernat, V., Huebner, H., Huang, X., Sassano, M. F., Giguere, et al
2016; 537 (7619): 185-?
- **Enhanced dendritic integration by ih reduction in the anterior cingulate cortex increases nociception.** *Neuron*
Dickinson, J. R., Scherrer, G.
2015; 86 (1): 4-6
- **GINIP, a G(alpha i)-Interacting Protein, Functions as a Key Modulator of Peripheral GABA(B) Receptor-Mediated Analgesia** *NEURON*
Gaillard, S., Lo Re, L., Mantilleri, A., Hepp, R., Urien, L., Malapert, P., Alonso, S., Deage, M., Kambrun, C., Landry, M., Low, S. A., Alloui, A., Lambolez, et al
2014; 84 (1): 123-136
- **Delta Opioid Receptors Presynaptically Regulate Cutaneous Mechanosensory Neuron Input to the Spinal Cord Dorsal Horn** *NEURON*
Bardoni, R., Tawfik, V. L., Wang, D., Francois, A., Solorzano, C., Shuster, S. A., Choudhury, P., Betelli, C., Cassidy, C., Smith, K., de Nooij, J. C., Mennicken, F., O'Donnell, et al
2014; 81 (6): 1312-1327
- **GINIP, a G*β*-interacting protein, functions as a key modulator of peripheral GABAB receptor-mediated analgesia.** *Neuron*
Gaillard, S., Lo Re, L., Mantilleri, A., Hepp, R., Urien, L., Malapert, P., Alonso, S., Deage, M., Kambrun, C., Landry, M., Low, S. A., Alloui, A., Lambolez, et al
2014; 84 (1): 123-36
- **Cellular and Molecular Mechanisms of Pain** *CELL*
Basbaum, A. I., Bautista, D. M., Scherrer, G., Julius, D.
2009; 139 (2): 267-284
- **Dissociation of the Opioid Receptor Mechanisms that Control Mechanical and Heat Pain** *CELL*
Scherrer, G., Imamachi, N., Cao, Y., Contet, C., Mennicken, F., O'Donnell, D., Kieffer, B. L., Basbaum, A. I.
2009; 137 (6): 1148-1159
- **Kappa Opioid Receptor Distribution and Function in Primary Afferents** *NEURON*
Snyder, L. M., Chiang, M. C., Loeza-Alcocer, E., Omori, Y., Hachisuka, J., Sheahan, T. D., Gale, J. R., Adelman, P. C., Sypek, E. I., Fulton, S. A., Friedman, R. L., Wright, M. C., Duque, et al
2018; 99 (6): 1274+
- **Optical Activation of TrkA Signaling.** *ACS synthetic biology*
Duan, L., Hope, J. M., Guo, S., Ong, Q., Francois, A., Kaplan, L., Scherrer, G., Cui, B.
2018
- **Delta Opioid Receptor Expression and Function in Primary Afferent Somatosensory Neurons.** *Handbook of experimental pharmacology*
Francois, A., Scherrer, G.
2018; 247: 87-114
- **Inhibition Mediated by Glycinergic and GABAergic Receptors on Excitatory Neurons in Mouse Superficial Dorsal Horn Is Location-Specific but Modified by Inflammation.** *journal of neuroscience*
Takazawa, T., Choudhury, P., Tong, C., Conway, C. M., Scherrer, G., Flood, P. D., Mukai, J., MacDermott, A. B.
2017; 37 (9): 2336-2348
- **Structure-based discovery of opioid analgesics with reduced side effects.** *Nature*
Manglik, A., Lin, H., Aryal, D. K., McCorvy, J. D., Dengler, D., Corder, G., Levit, A., Kling, R. C., Bernat, V., Hübner, H., Huang, X., Sassano, M. F., Giguère, et al
2016; 537 (7619): 185-190
- **Ensuring transparency and minimization of methodologic bias in preclinical pain research: PPRECISE considerations** *PAIN*
Andrews, N. A., Latremoliere, A., Basbaum, A. I., Mogil, J. S., Porreca, F., Rice, A. S., Woolf, C. J., Currie, G. L., Dworkin, R. H., Eisenach, J. C., Evans, S., Gewandter, J. S., Gover, et al

2016; 157 (4): 901-909

- **Knock-In Mice with NOP-eGFP Receptors Identify Receptor Cellular and Regional Localization** *JOURNAL OF NEUROSCIENCE*
Ozawa, A., Brunori, G., Mercatelli, D., Wu, J., Cippitelli, A., Zou, B., Xie, X. (., Williams, M., Zaveri, N. T., Low, S., Scherrer, G., Kieffer, B. L., Toll, et al
2015; 35 (33): 11682-11693
- **A mu-delta opioid receptor brain atlas reveals neuronal co-occurrence in subcortical networks** *BRAIN STRUCTURE & FUNCTION*
Erbs, E., Faget, L., Scherrer, G., Matifas, A., Filliol, D., Vonesch, J., Koch, M., Kessler, P., Hentsch, D., Birling, M., Koutsourakis, M., Vasseur, L., Veinante, et al
2015; 220 (2): 677-702
- **A novel anxiogenic role for the delta opioid receptor expressed in GABAergic forebrain neurons.** *Biological psychiatry*
Chu Sin Chung, P., Keyworth, H. L., Martin-Garcia, E., Charbogne, P., Darcq, E., Bailey, A., Filliol, D., Matifas, A., Scherrer, G., Ouagazzal, A., Gaveriaux-Ruff, C., Befort, K., Maldonado, et al
2015; 77 (4): 404-415
- **A novel anxiogenic role for the delta opioid receptor expressed in GABAergic forebrain neurons.** *Biological psychiatry*
Chu Sin Chung, P., Keyworth, H. L., Martin-Garcia, E., Charbogne, P., Darcq, E., Bailey, A., Filliol, D., Matifas, A., Scherrer, G., Ouagazzal, A., Gaveriaux-Ruff, C., Befort, K., Maldonado, et al
2015; 77 (4): 404-415
- **Delta opioid receptors expressed in forebrain GABAergic neurons are responsible for SNC80-induced seizures** *BEHAVIOURAL BRAIN RESEARCH*
Chung, P. C., Boehrer, A., Stephan, A., Matifas, A., Scherrer, G., Darcq, E., Befort, K., Kieffer, B. L.
2015; 278: 429-434
- **Input- and Cell-Type-Specific Endocannabinoid-Dependent LTD in the Striatum.** *Cell reports*
Wu, Y., Kim, J., Tawfik, V. L., Lalchandani, R. R., Scherrer, G., Ding, J. B.
2015; 10 (1): 75-87
- **In vivo techniques to investigate the internalization profile of opioid receptors.** *Methods in molecular biology (Clifton, N.J.)*
Pradhan, A. A., Tawfik, V. L., Tipton, A. F., Scherrer, G.
2015; 1230: 87-104
- **Sensory biology: it takes Piezo2 to tango.** *Current biology*
Vásquez, V., Scherrer, G., Goodman, M. B.
2014; 24 (12): R566-9
- **The Netrin-1 receptor DCC is a regulator of maladaptive responses to chronic morphine administration** *BMC GENOMICS*
Liang, D., Zheng, M., Sun, Y., Sahbaie, P., Low, S. A., Peltz, G., Scherrer, G., Flores, C., Clark, J. D.
2014; 15
- **Delta opioid receptors expressed in forebrain GABAergic neurons are responsible for SNC80-induced seizures.** *Behavioural brain research*
Chu Sin Chung, P., Boehrer, A., Stephan, A., Matifas, A., Scherrer, G., Darcq, E., Befort, K., Kieffer, B. L.
2014; 278C: 429-34
- **Impaired Hippocampus-Dependent and Facilitated Striatum-Dependent Behaviors in Mice Lacking the Delta Opioid Receptor** *NEUROPSYCHOPHARMACOLOGY*
Le Merrer, J., Rezai, X., Scherrer, G., Becker, J. A., Kieffer, B. L.
2013; 38 (6): 1050-1059
- **Pre- and postsynaptic inhibitory control in the spinal cord dorsal horn** *Conference on Cellular and Network Functions in the Spinal Cord*
Bardoni, R., Takazawa, T., Tong, C., Choudhury, P., Scherrer, G., MacDermott, A. B.
BLACKWELL SCIENCE PUBL.2013: 90-96
- **DISTRIBUTION OF DELTA OPIOID RECEPTOR-EXPRESSING NEURONS IN THE MOUSE HIPPOCAMPUS** *NEUROSCIENCE*
Erbs, E., Faget, L., Scherrer, G., Kessler, P., Hentsch, D., Vonesch, J., Matifas, A., Kieffer, B. L., Massotte, D.
2012; 221: 203-213
- **In Vivo Visualization of Delta Opioid Receptors upon Physiological Activation Uncovers a Distinct Internalization Profile** *JOURNAL OF NEUROSCIENCE*
Faget, L., Erbs, E., Le Merrer, J., Scherrer, G., Matifas, A., Benturquia, N., Noble, F., Decossas, M., Koch, M., Kessler, P., Vonesch, J., Schwab, Y., Kieffer, et al
2012; 32 (21): 7301-7310

- **Localization and Regulation of Fluorescently Labeled Delta Opioid Receptor, Expressed in Enteric Neurons of Mice** *GASTROENTEROLOGY*
Poole, D. P., Pelayo, J., Scherrer, G., Evans, C. J., Kieffer, B. L., Bunnett, N. W.
2011; 141 (3): 982-U695

- **Behavioral indices of ongoing pain are largely unchanged in male mice with tissue or nerve injury-induced mechanical hypersensitivity** *PAIN*
Urban, R., Scherrer, G., Goulding, E. H., Tecott, L. H., Basbaum, A. I.
2011; 152 (5): 990-1000

- **VGLUT2 expression in primary afferent neurons is essential for normal acute pain and injury-induced heat hypersensitivity** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
Scherrer, G., Low, S. A., Wang, X., Zhang, J., Yamanaka, H., Urban, R., Solorzano, C., Harper, B., Hnasko, T. S., Edwards, R. H., Basbaum, A. I.
2010; 107 (51): 22296-22301

- **In Vivo Delta Opioid Receptor Internalization Controls Behavioral Effects of Agonists** *PLOS ONE*
Pradhan, A. A., Becker, J. A., Scherrer, G., Tryoen-Toth, P., Filliol, D., Matifas, A., Massotte, D., Gaveriaux-Ruff, C., Kieffer, B. L.
2009; 4 (5)

- **Dense transient receptor potential cation channel, vanilloid family, type 2 (TRPV2) immunoreactivity defines a subset of motoneurons in the dorsal lateral nucleus of the spinal cord, the nucleus ambiguus and the trigeminal motor nucleus in rat** *NEUROSCIENCE*
Lewinter, R. D., Scherrer, G., Basbaum, A. I.
2008; 151 (1): 164-173

- **Knockin mice expressing fluorescent delta-opioid receptors uncover G protein-coupled receptor dynamics in vivo** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
Scherrer, G., Tryoen-Toth, P., Filliol, D., Matifas, A., Laustriat, D., Cao, Y. Q., Basbaum, A. I., Dierich, A., Vonesh, J., Gaveriaux-Ruff, C., Kieffer, B. L.
2006; 103 (25): 9691-9696

- **The delta agonists DPDPE and deltorphin II recruit predominantly mu receptors to produce thermal analgesia: a parallel study of mu, delta and combinatorial opioid receptor knockout mice** *EUROPEAN JOURNAL OF NEUROSCIENCE*
Scherrer, G., Befort, K., Contet, C., Becker, J., Matifas, A., Kieffer, B. L.
2004; 19 (8): 2239-2248