BIOGRAPHICAL SKETCH

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NAME: Chakrapani, Sudha

eRA COMMONS USER NAME (credential, e.g., agency login): SUDHAC

POSITION TITLE: Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Madras, Chennai, India	B.S.	06/1995	Chemistry
University of Pune, India	M.S.	06/1997	Biochemistry
Indian Institute of Technology, India	M.Tech.	02/1999	Biomedical Engineering
University at Buffalo, Buffalo, NY	Ph.D.	05/2004	Physiology & Biophysics
University of Virginia, Charlottesville, VA	Postdoctoral	01/2006	Physiology & Biophysics
University of Chicago, Chicago, IL	Postdoctoral	07/2008	Physiology & Biophysics

A. Personal Statement

My long-standing scientific interest has been in developing a molecular-level understanding of the ion-transport phenomenon across cellular membranes that occurs under normal and pathophysiological conditions. My research over the last 25 years has focused on ion channels that mediate fast synaptic transmission at the neuronal and neuromuscular junction; namely, ligand- and voltage- gated ion channels. My scientific approach is a combination of cutting-edge multidisciplinary tools that includes Cryo-EM and X-ray crystallography for high-resolution structure determination, EPR spectroscopy for protein dynamic measurements, and electrophysiology for functional characterization of ion channels. We solved the first cryo-EM structure of the full-length 5-HT_{3A}R channel in its resting conformation and the structures of full-length glycine receptors in a lipid environment (*Nature Communications, 2018, 2020*). Our findings have revealed the intricate details of conformational changes underlying channel activation and allosteric modulation by endogenous ligands and drug molecules (Nature, 2018; *Nature Communications, 2019, 2022; eLIFE 2020)*. Using a range of diverse structural, dynamics, and functional approaches, we are continuing to address some of the fundamental questions in the membrane protein field that have remained elusive so far.

Administrative and leadership experience: In 2018, I took on the Directorship of the Cryo-Electron Microscopic Core (Cryo-EM Core) at the CWRU SOM and oversaw the establishment of the high-resolution imaging facility including building renovation, installation of the Titan Krios, recruitment of technical staff, and the development and administration of the Cryo-EM Pilot Grant Program. In 2020, I was appointed as the Director of the Cleveland Center for Membrane and Structural Biology (CCMSB). In this role, I am directly involved in many initiatives at CWRU SOM to strengthen the structural biology area including NIH-funded expansion of Cryo-EM instrumentation, development of a formal multi-institution training program in structural biology and molecular biophysics, and recruitment of tenured and tenure-track faculty in these areas.

Teaching and Mentoring: I have been extremely fortunate to work with and mentor extremely talented individuals who have helped build my research program and are an integral part of what we have achieved as a team. In the last 12 years, *I have trained 8 graduate students (past and current) of which 5 are female and two*

URiM. All my predoctoral trainees and postdoctoral trainees have remained in biomedical science professions. Among past trainees from the lab, two of the five predoctoral trainees hold leadership positions in pharmaceutical industries and two of the three postdoctoral trainees are independent PIs with faculty positions. In addition, I have participated in 33 graduate student thesis progress committees, of which I am Chair on 7 of them. Among the accolades won by my trainees, the notable ones include postdoctoral Fellowships from the American Heart Association by Dr. Basak, and Dr. Arvind Kumar; F32 NIH postdoctoral Fellowship to Dr. Gibbs, Biophysical Society Student Travel Award and the University of Chicago postdoctoral Fellowship by Dr. Nicholas Schmandt, and the *Recknagel Award* from the DPB by Ms. Yvonne Gicheru and Ms. Kayla Kindig. Over the last twelve years, my lab has hosted nine students from the DPB Summer Undergraduate Research Program and the Heart Lung Blood Summer Research Program. Two of these students, Ross Bonner and Lauren Talley (URM), are contributing authors on a paper in *Journal of General Physiology, 2015*. I am on the mentoring Committee of 6 Junior faculty members to provide them guidance on grants, tenure, promotion, and professional growth. Since 2012, I have served on the Graduate Education Committee at the Department of Physiology and Biophysics, and in 2019 was appointed to the MSTP Steering Committee. I am certified as a Trained Facilitator of the *Entering Mentoring* curricula published by CIMER and will be leading mentoring training for the Faculty at the CWRU SOM. Toward contributing to the Cleveland community, I participate in *True2U*, a volunteer mentoring program that helps Cleveland Metropolitan School District 8th graders prepare to make the most of high school and put them on a path to career readiness. The Cryo-EM Core and CWRU SOM are working with the Ohio Academic Resources Network (OARnet) on a proposal to develop statewide research and teaching DMZ and VPN network infrastructure for secure, high-quality access to the shared network-accessible resources. We hope to provide teaching tools and virtual sessions on Cryo-EM applications to nine smaller higher education institutions in the state. These efforts are geared toward improving the exposure of these students to various science and research-related career paths.

Ongoing and recently completed projects that I would like to highlight include:
NIH R35 GM134896
Chakrapani (PI)
01/01/20 – 12/31/24
Structure and Function of Pentameric Ligand-Gated Ion Channels

Completed Research Support
NIH R01 GM131216
Chakrapani (PI)
01/1/19 – 12/31/22
Structure, Function, and Modulation of Serotonin (3A) receptors"
(Rolled into R35 MIRA Award).

NIH R01 GM108921
Chakrapani (PI)
09/1/14 – 08/31/20
Molecular Mechanisms of Desensitization and Drug Modulation in Ligand-Gated Ion Channels.
(Renewal funded as R35 MIRA Award)

Citations:

1. Basak S, Gicheru Y, Rao S, Sansom MSP, **Chakrapani S***. (2018) Cryo-EM reveals two distinct serotonin-bound conformations of full-length 5-HT3A receptor. ***Nature***.;563(7730):270-4. doi: 10.1038/s41586-018-0660-7. PubMed PMID: 30401837; PMCID:PMC6237196 (*Article Recommended by Faculty 1000)*
2. Basak S, Kumar A, Ramsey S, Gibbs E, Kapoor A, Filizola M, Chakrapani S. High-resolution structures of multiple 5-HT3AR-setron complexes reveal a novel mechanism of competitive inhibition. **eLife**. 2020;9. Epub 2020/10/17. doi: 10.7554/eLife.57870. PubMed PMID: 33063666.
3. Kumar A, Kindig K, Rao S, Zaki AM, Basak S, Sansom MSP, Biggin PC, Chakrapani S. Structural basis for cannabinoid-induced potentiation of alpha1-glycine receptors in lipid nanodiscs. ***Nature Communications***. 2022;13(1):4862. Epub 2022/08/19. doi: 10.1038/s41467-022-32594-5. PubMed PMID: 35982060; PMCID: PMC9388682.

4. Gibbs E, Klemm E, Seiferth D, Kumar A, Ilca SL,. Biggin PC, and **Chakrapani S***. (2023) Conformational Dynamics of Heteromeric Glycine receptors during Gating and Allosteric Modulation. ***Nature Communications*** DOI 10.1038/s41467-023-37106-7

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointments

2022- Interim Chair, Department of Pharmacology, Case Western Reserve University, Cleveland, OH
2020- Director, Cleveland Center for Membrane and Structural Biology, Case Western Reserve University, Cleveland, OH
2020- Professor, Department of Physiology and Biophysics, Case Western Reserve University, Cleveland, OH
2018- Director, Cryo-Electron Microscopy Core, Case Western Reserve University, Cleveland, OH
2017-2020 Associate Professor (Tenured), Department of Physiology and Biophysics, Case Western Reserve University, Cleveland, OH
2010-2017 Assistant Professor (Tenure-track), Department of Physiology and Biophysics, Case Western Reserve University, Cleveland, OH
2008-2010 Research Assistant Professor, Department of Biochemistry and Molecular Biology, University of Chicago, Chicago, IL

Other Experience and Professional Memberships

2026 *Co-Chair*, Ion Channels Gordon Research Conference
2025 *Program Co-Chair*, 2025 Annual meeting of the Biophysical Society.
2022 *Mentor*, Junior Faculty Mentoring Cohort, *Journal of General Physiology*.
2019-2023 *Permanent Member*, Biochemistry and Biophysics of Membranes, NIH Study Section.
2022-2025 Associate Editor, Biophysical Journal
2018-2020 Reviewer, United States-Israel Binational Science Foundation
2018-present Editorial Advisory Board, Journal of General Physiology
2018 Reviewer, French National Research Agency (ANR), France
2018 Ad hoc Reviewer, NIH BPNS study Section (Feb cycle).
2017-2018 Reviewer, MCMB grant proposal, Medical Research Council (MRC) UK
2016-2019 Ad hoc Reviewer, NIH BBM study Section
2015-2018 Councilor (elected to office), Society for General Physiologists.
2015-2021 Committee for Professional Opportunities for Women Committee (CPOW), Biophysical Society
2015-2017 Reviewer, American Heart Association (Basic Cell, Proteins & Crystallography1 and Proteins & Crystallography 1 and 3)
2015-present Member, Society for General Physiology
2014 Reviewer, NIGMS Program Projects Grants (P01) special emphasis panel
2012-2013 Panelist, Early Career Development Committee, Biophysical Society
2010-present Member, American Heart Association
2003-present Member, Biophysical Society

Honors

2022 *Keynote Speaker*, Ion Channels GRC at Mt. Holyoke College MA
2019-present Joseph T. Wearn, MD, University Professorship in Medicine
2018 CWRU nominee for the Mallinckrodt Scholar Program.
2012-2016 Scientist Development Grant, American Heart Association.
2007-2008 Postdoctoral Fellowship (Competitive Renewal), American Heart Association
2005-2008 Postdoctoral Fellowship, American Heart Association
2004 University at Buffalo nominee for the CGS/UMI Distinguished Dissertation award.
2004 Dean's Award for Outstanding Dissertation, First Prize. University at Buffalo, SUNY.

2004	Herbert Schuel Award for outstanding research in the field of Cell and Developmental Biology, University at Buffalo, SUNY.
1999	Selected for the Cambridge Commonwealth Trust Scholarship and Overseas Research Scholar Award.
1997-1999	Biomedical Engineering Scholarship, Indian Institute of Technology, Bombay, India
1997	Selected for Junior Research Fellowship, Council for Scientific and Industrial Research, India
1995-1997	National Chemical Laboratory Scholarship, Pune, India

C. Contributions to Science

1. Structure-function relationships in nicotinic Acetylcholine receptors. One of the fundamental challenges in the ion channel field is to understand how spatially-separated structural motifs of the channel communicate in order to fine-tune its function. In my doctoral research, I addressed this question in nicotinic acetylcholine receptor-channels (nAChR) that belong to the neurotransmitter gated Cys-loop receptor family. These channels are responsible for mediating fast synaptic transmission in neuronal and neuronal muscular junctions. Through single-channel current measurements of over 100 mutations and extensive model-based kinetic analysis within the framework of linear free energy relationships, I found that signal transduction occurs as a sequential movement of rigid "blocks" or "micro-domain" originating at the extracellular ligand-binding domain and culminating at the gate within the transmembrane region. Such an organized and linked motion of rigid bodies may underlie fast dynamics of the allosteric conformational change in these channels. This system also proved ideal to probe the speed-limits of global protein motions in the membrane.

a. **Chakrapani, S**., T.D. Bailey, and A. Auerbach. (2003). The role of loop 5 in acetylcholine receptor channel gating. ***J Gen Physiol***. 122:521-539. PMCID:PMC2229574
b. **Chakrapani, S**., T.D. Bailey, and A. Auerbach. (2004). Gating Dynamics of the Acetylcholine Receptor Extracellular Domain. ***J Gen Physiol***. 123: 341-356. (Featured on the Cover). PMCID:PMC2217457
c. **Chakrapani, S**., and A. Auerbach. (2005). A speed limit for conformational change of an allosteric membrane protein*.* ***Proc Natl Acad Sci U S A***, 2005. 102(1): p. 87-92. PMCID:PMC544059

2. C-type inactivation and modal gating behavior in K^+ channels. Studying prokaryotic channels provides a unique advantage to draw direct information from structural, dynamics, and functional measurements. However, unlike eukaryotic channels most of the bacterial members were not well-characterized at the functional level, this was particularly the case for KcsA, a pH-activated K^+ channel. As a part of my postdoctoral training, I carried out extensive kinetic analysis both at the macroscopic and single-channel level to characterize C-type inactivation and fast gating events that underlie KcsA function. To obtain high resolution structure of KcsA in multiple conformational states, I crystallized the channel in various mutant forms and in the presence of several modulators. Equating functional states to structural snapshots from crystallography, have led to a better understanding of the structural basis for inactivation from pre-open states, interaction of ions with the channel, modal gating behavior, and transitions that lead to fast gating events.

a. **Chakrapani, S**., Cordero-Morales, J. F., and Perozo, E. (2007a). A quantitative description of KcsA gating I: macroscopic currents. ***J Gen Physiol*** *130*, 465-478. PMCID:PMC2151670
b. **Chakrapani, S**., Cordero-Morales, J. F., and Perozo, E. (2007b). A quantitative description of KcsA gating II: single-channel currents. ***J Gen Physiol*** *130*, 479-496. PMCID:PMC2151667
c. **Chakrapani, S[a].**, Cordero-Morales, J. F[a]., Jogini, V., Pan, A. C., Cortes, D. M., Roux, R., and Perozo, E. (2011) On the structural basis for modal gating in K^+ channels ***Nature Structure & Molecular Biology*** *18 (1),* PMCID:PMC3059741. *[a]equal contribution.*
d. Ostmeyer J, **Chakrapani S**, Pan AC, Perozo E, Roux B. (2013) Recovery from slow inactivation in K+ channels is controlled by water molecules. ***Nature***. 501(7465):121-4. PubMed PMID: 23892782; PMCID:PMC3799803

3. Voltage-sensing mechanism and slow-inactivation in ion channels. Voltage-gated channels play a critical role in cellular excitability and thereby form the basis for initiation and propagation of nerve impulses. The structure of the voltage-sensor and the mechanisms underlying gating-charge movement have been areas intensively studied. Both the structure and the protein motions in the sensor are critically governed by the local membrane environment. Also as a part of my postdoctoral training, I used site-directed spin labeling and electron paramagnetic resonance (EPR) spectroscopy to directly investigate the architecture of the sensor in a

reconstituted system. I studied the dynamics of the isolated voltage-sensors of prokaryotic K^+ (KvAP) and Na^+ (NaChBac) channels by EPR spectroscopy. These findings provided an in-depth view of the architecture of this domain on the membrane along with insights into the open-inactivated state of the channel. More recently, my lab characterized the molecular motions underlying slow-inactivation in voltage-gated Na+ channel (NavSp1) by pulsed-EPR spectroscopy.

a. **Chakrapani, S**., Cuello, L.G., Cortes, D.M., and Perozo, E. (2008). Structural dynamics of an isolated-voltage sensor domain in lipid bilayer. ***Structure*** *16, 398-409* PMCID:PMC2703488
b. **Chakrapani, S**., Sompornpisut, P., Intharathep, P., Roux, B. & Perozo, E. (2010). The activated state of a sodium channel voltage sensor in a membrane environment. ***Proc Natl Acad Sci U S A*** 107, 5435-40. PMCID:PMC2851821
c. **Chakrapani, S**. (2015) EPR studies of gating mechanisms in ion channels ***Methods in Enzymology*** 557:279-306 PMCID:PMC4503332
d. Chatterjee S, Vyas R, Chalamalasetti SV, Sahu ID, Clatot J, Wan X, Lorigan GA, Deschenes I, **Chakrapani S***. The voltage-gated sodium channel pore exhibits conformational flexibility during slow inactivation. ***J Gen Physiol***. 2018;150(9):1333-47. doi: 10.1085/jgp.201812118. PubMed PMID: 30082431; PMCID: PMC6122925.
*This article was featured in a commentary "Progress in Understanding Slow Inactivation Speeds up" Payandeh, J ***Journal of General Physiology*** (2018)

4. Gating mechanisms in pentameric ligand-gated ion channels. Since joining the faculty at Case Western Reserve University as an Assistant professor in 2010, a major research focus of my lab has been to understand allosteric mechanisms in pentameric ligand-gated ion channels (pLGIC). Using prokaryotic homologues GLIC and ELIC as model systems, we elucidated the ligand-induced pore opening mechanism by EPR spectroscopy. Patch-clamp measurements from reconstituted channels were used to show the salient features of desensitization in GLIC that bears resemblance to the mechanism observed in the eukaryotic counterpart. These methods have allowed us to directly measure the effect of membrane lipid constituents on channel function and to determine the underlying changes in protein dynamics under these conditions. In addition, we studied long-range allosteric communications by engineering functional chimeric channels that incorporates domains from different members of the family. By using X-ray crystallography and pulse-EPR measurement, we determined the crystal structure of the chimera and measured ligand-induced structural changes which reveal conformational coupling between domains. More recently, my lab is geared towards applying these approaches in combination with cryo-EM to complex eukaryotic pLGIC. We recently determined the structures of the full-length 5-HT_{3A}R in the apo, and serotonin-bound conformations by single-particle cryo-EM. The structure reveals salient features of the resting, state and the conformational changes underlying serotonin-mediated activation. I served as the principal investigator in all these studies.

a. Basak, S. [a], Schmandt, N. [a], Gicheru, Y [a]., and **Chakrapani, S*.** (2017) Crystal structure and dynamics of a lipid-induced potential desensitized state of a pentameric ligand-gated channel (***eLIFE,*** doi: 10.7554/eLife.23886). PMCID:PMC5378477
b. Basak S, Gicheru Y, Rao S, Sansom MSP, **Chakrapani S***. Cryo-EM reveals two distinct serotonin-bound conformations of full-length 5-HT3A receptor. ***Nature***. 2018;563(7730):270-4. doi: 10.1038/s41586-018-0660-7. PubMed PMID: 30401837. PMCID:PMC6237196 (*Article Recommended by Faculty 1000)*
c. Basak S[a], Gicheru Y[a], Kapoor A., Mayer ML., Filizola M, and **Chakrapani S***. (2019) Molecular mechanism of setron-mediated inhibition of full-length 5-HT3A receptors. ***Nature Communications*** 10, 3225, doi:10.1038/s41467-019-11142-8. PMCID:PMC6642186
d. Kumar A, Basak S, Rao S, Gicheru Y, Mayer ML, Sansom MSP, **Chakrapani S*.** (2020) Mechanisms of activation and desensitization of full length glycine receptors in lipid nanodisc. ***Nature Communications*** Jul 27;11(1):3752. doi: 10.1038/s41467-020-17364-5.PMID: 32719334

Complete List of Published Work in MyBibliography:
https://www.ncbi.nlm.nih.gov/sites/myncbi/sudha.chakrapani.1/bibliography/50561146/public/?sort=date&direction=ascending

BIOGRAPHICAL SKETCH

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NAME: Stauffer, Madeleine Marie

POSITION TITLE: PhD Candidate

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Start Date MM/YYYY	Completion Date MM/YYYY	FIELD OF STUDY
Allegheny College, Meadville, PA	B.S.	08/2016	05/2020	Neuroscience
Case Western Reserve University (CWRU), Cleveland, OH	Ph.D.	07/2020	12/2025	Physiology and Biophysics

A. Personal Statement

My passion for understanding the human nervous system started early in my academic career, beginning with an interest in human behavior and quickly narrowing down to the molecular mechanisms within neural signaling. In the second year of my undergraduate studies, I sought out research experience in the lab of Dr. Lauren French at Allegheny College, which provided me a unique opportunity to study ion channel behavior that aligned well with my growing interest in molecular neuroscience. I focused my attention on observing the behavior of both voltage-gated calcium ion channels and metabotropic serotonin channels through the use of the two-electrode voltage clamp (TEVC) technique. While identifying inhibitors of these receptors with TEVC helped me develop an enthusiasm for understanding disease mechanisms and drug design, I recognized that in order to take my understanding of these proteins further I would need to understand receptor structure. Upon graduation from Allegheny College, I entered the Biomedical Sciences Training Program at Case Western Reserve University (CWRU). I joined the lab of Dr. Sudha Chakrapani, where groundbreaking studies were already being conducted using cryogenic electron microscopy (cryo-EM), TEVC, and additional collaborative efforts to bring together both complex insight into pentameric ligand-gated ion channel (pLGIC) structures and their electrophysiological behavior. Shifting from neurophysiological research to structural studies immediately after obtaining my undergraduate degree provided both a challenge and an opportunity to refine my electrophysiological recording skills while gaining a skillset in cryo-EM. My current research continues to deepen my understanding of ion channel structure and function, as well as fueling my enthusiasm for improving therapeutic strategies targeting receptors linked to neurological diseases and disorders.

B. Positions, Scientific Appointments, and Honors

2023- Graduate Student Representative Seminar Planning Committee, CWRU, *Cleveland, OH*
2021 Physiology and Biophysics Academic Award, CWRU*, Cleveland, OH*
2020 – Ph.D. Candidate, CWRU, *Cleveland, OH*
2018 – 2020 Beta Beta Beta Member, Allegheny College, *Meadville, PA*
2019 Best Poster Presentation Biology III, Penn State Behrend – Sigma Xi, *Erie, PA*
2019 Neuroscience Junior Major Prize, Allegheny College, *Meadville, PA*
2019 Neuroscience Faculty Prize, Allegheny College, *Meadville, PA*
2019 Teaching Assistant Biology Department, Allegheny College, *Meadville, PA*
2017 – 2018 Teaching Assistant Chemistry Department, Allegheny College, *Meadville, PA*

C. Contributions to Science

During my *undergraduate research career*, I was able to work in Dr. Lauren French's lab at Allegheny College for three years. I started my research experience observing the behavior of the T-type calcium ion channel, Cav3.2, and its inhibition through the use of the two-electrode voltage clamp technique (TEVC). This ion channel has been linked to various Idiopathic Generalized Epilepsies (IGEs) and is identified as a possible drug target for future treatments of these diseases. My additional contributions were optimizing and setting up protocols for future publications within the lab, focusing on optimizing expression of various ionotropic and metabotropic receptors in *Xenopus laevis* oocytes. These protocols and experiences have left me with a broadened understanding of protein expression in oocytes for TEVC studies. I additionally became heavily involved in mentoring and teaching fellow scientists interested in pursuing biology, resulting in a paper exploring pedagogical strategies for teaching undergraduate students neurophysiological concepts.

1. French, L. B., **Stauffer, M.**, and Requena, M. S. (2024). Sherlock Holmes and the Neurophysiologists: Unraveling the "Mystery" of Active Learning Success. *Journal of undergraduate neuroscience education : JUNE : a publication of FUN, Faculty for Undergraduate Neuroscience*, *22*(3), A160–A166. https://doi.org/10.59390/EHEK8915

During my *graduate research career*, I have joined Dr. Sudha Chakrapani's lab and focus on the 5-hydroxytryptamine type 3 receptor (5-HT_3R). The 5-HT_3 receptor is the only ionotropic receptor in the serotonin receptor family and has important roles in gut modulation and gut-brain communication. These receptors are made up of five subunits, which together form an extracellular domain (ECD), transmembrane domain (TMD), and intracellular domain (ICD). 5-HT_3 receptors can be found in homomers composed of five A subunits, or heteromers composed of the A subunit and four other possible subunits: B, C, D, or E. While this receptor with its many subunits has links to diseases such as irritable bowel syndrome (IBS), obsessive compulsive disorder (OCD), and schizophrenia, current treatments for these diseases target the more ubiquitously expressed A subunit of this pentameric channel. Setrons, a class of drug known for being antagonists of the 5-HT_3R, are currently used for treatment of chemotherapy-induced nausea and emesis. However, their full inhibition of 5-HT_3Rs can lead to detrimental secondary effects. This has directed drug design toward partial agonists of this receptor, with the hope that the reduction of 5-HT_3R activity and not the full elimination of it will allow for more efficient treatment. My projects within the Chakrapani Lab has focused on the human 5-HT_3R and modulation of the murine 5-HT_3R, which is the most explored structure to date. My contributions to projects in the lab include providing electrophysiological recordings for studies exploring partial agonism and allosteric modulation of the 5-HT_3R, as well as optimizing purification and EM grid preparation protocols for cryo-EM data collections.

1. Felt, K., **Stauffer, M**., Salas-Estrada, L., Guzzo, P. R., Xie, D., Huang, J., Filizola, M., & Chakrapani, S. (2024). Structural basis for partial agonism in 5-HT_{3A} receptors. *Nature structural & molecular biology*, *31*(4), 598–609. https://doi.org/10.1038/s41594-023-01140-2.