

# Advances in Mass Spectrometry for Membrane Protein Pharmacology

*This manuscript ([permalink](#)) was automatically generated from [dschust-r/review\\_ms\\_mem\\_prot@6d5fabd](#) on May 21, 2025.*

## Authors

---

- **Dina Schuster** 

 [0000-0001-6611-8237](#) ·  [dschust-r](#)

Sarafan ChEM-H, Stanford University, Stanford, CA, 94305, USA

✉ — Correspondence possible via [GitHub Issues](#) or email to Dina Schuster <[dschust@stanford.edu](mailto:dschust@stanford.edu)>.

## Abstract

---

Membrane proteins are important targets for pharmacological research, due to their involvement in various cellular processes, ranging from signal transduction to transport, and cellular communication. While they make up roughly 30% of the human proteome and are the target of more than half of all approved drug products, their hydrophobicity and low abundance pose significant challenges for drug discovery and development. Mass spectrometry has emerged as a powerful tool for studying membrane protein structure, dynamics, regulation, as well as their interaction with proteins, small molecules, and lipids. In this review, we summarize recent findings and methodological advances that facilitate the study of cell surface organization, the discovery of druggable membrane proteins, and the identification of binding sites.

# 1. Novel mass spectrometric methods for the identification of drug targets and binding sites

---

[\[1,2,3,4,5,6,7,8,9\]](#)

## Accessibility approaches

[\[4,5,10,11,12,13,14\]](#)

## Thermal proteome profiling

[\[3,15\]](#)

## Proximity-based approaches and chemical cross-linking

[\[16,17,18,19,20,21,22,23\]](#)

## Native and intact mass spectrometry of membrane proteins

[\[24,25,26,27,28,29,30,31,32,33\]](#)

## 2. Selective probing of membrane proteins with chemoproteomics

---

[[34](#),[35](#),[36](#),[37](#),[38](#),[39](#)]

### 3. Mass spectrometry reveals the cell surface organization

---

[[2](#),[3](#),[18](#),[19](#),[24](#),[35](#),[40](#),[41](#)]

## 4. Insights into G protein-coupled receptors

---

[[3](#),[7](#),[24](#),[27](#),[29](#),[30](#),[32](#),[33](#),[42](#)]

## 5. Remaining challenges and outlook

---

[[8](#),[33](#),[43](#),[44](#),[45](#)]

# References

---

1. **Capture of the Mouse Organ Membrane Proteome Specificity in Peptidisc Libraries**  
Frank Antony, Zora Brough, Zhiyu Zhao, Franck Duong van Hoa  
*Journal of Proteome Research* (2024-01-17) <https://doi.org/g5w3hs>  
DOI: [10.1021/acs.jproteome.3c00825](https://doi.org/10.1021/acs.jproteome.3c00825) · PMID: [38232390](https://pubmed.ncbi.nlm.nih.gov/38232390/)
2. **A Peptidisc-Based Survey of the Plasma Membrane Proteome of a Mammalian Cell**  
Zhiyu Zhao, Arshdeep Khurana, Frank Antony, John W Young, Keeley G Hewton, Zora Brough, Tianshuang Zhong, Seth J Parker, Franck Duong van Hoa  
*Molecular & Cellular Proteomics* (2023-08) <https://doi.org/g9ks7s>  
DOI: [10.1016/j.mcpro.2023.100588](https://doi.org/10.1016/j.mcpro.2023.100588) · PMID: [37295717](https://pubmed.ncbi.nlm.nih.gov/37295717/) · PMCID: [PMC10416069](https://pubmed.ncbi.nlm.nih.gov/PMC10416069/)
3. **Cell surface thermal proteome profiling tracks perturbations and drug targets on the plasma membrane**  
Mathias Kalxdorf, Ina Günthner, Isabelle Becher, Nils Kurzawa, Sascha Knecht, Mikhail M Savitski, HChristian Eberl, Marcus Bantscheff  
*Nature Methods* (2021-01) <https://doi.org/ghswc8>  
DOI: [10.1038/s41592-020-01022-1](https://doi.org/10.1038/s41592-020-01022-1) · PMID: [33398190](https://pubmed.ncbi.nlm.nih.gov/33398190/)
4. **Target Deconvolution by Limited Proteolysis Coupled to Mass Spectrometry**  
Viviane Reber, Matthias Gstaiger  
*Methods in Molecular Biology* (2023) <https://doi.org/g9ks7q>  
DOI: [10.1007/978-1-0716-3397-7\\_13](https://doi.org/10.1007/978-1-0716-3397-7_13) · PMID: [37558949](https://pubmed.ncbi.nlm.nih.gov/37558949/)
5. **High-throughput peptide-centric local stability assay extends protein-ligand identification to membrane proteins, tissues, and bacteria**  
Kejia Li, Clement M Potel, Isabelle Becher, Nico Hüttmann, Martin Garrido-Rodriguez, Jennifer Schwarz, Mikhail M Savitski  
*Cold Spring Harbor Laboratory* (2025-04-29) <https://doi.org/g9ks7v>  
DOI: [10.1101/2025.04.28.650974](https://doi.org/10.1101/2025.04.28.650974)
6. **Effects of theophylline on ADCY5 activation—From cellular studies to improved therapeutic options for ADCY5-related dyskinesia patients**  
Dirk Tänzler, Marc Kipping, Marcell Lederer, Wiebke F Günther, Christian Arlt, Stefan Hüttelmaier, Andreas Merckenschlager, Andrea Sinz  
*PLOS ONE* (2023-03-03) <https://doi.org/grv9ht>  
DOI: [10.1371/journal.pone.0282593](https://doi.org/10.1371/journal.pone.0282593) · PMID: [36867608](https://pubmed.ncbi.nlm.nih.gov/36867608/) · PMCID: [PMC9983822](https://pubmed.ncbi.nlm.nih.gov/PMC9983822/)
7. **Phosphorylation Sites of the Gastric Inhibitory Polypeptide Receptor (GIPR) Revealed by Trapped-Ion-Mobility Spectrometry Coupled to Time-of-Flight Mass Spectrometry (TIMS-TOF MS)**  
Kyle A Brown, Rylie K Morris, Samantha J Eckhardt, Ying Ge, Samuel H Gellman  
*Journal of the American Chemical Society* (2023-12-13) <https://doi.org/g9ks7t>  
DOI: [10.1021/jacs.3c09078](https://doi.org/10.1021/jacs.3c09078) · PMID: [38091482](https://pubmed.ncbi.nlm.nih.gov/38091482/) · PMCID: [PMC10842860](https://pubmed.ncbi.nlm.nih.gov/PMC10842860/)
8. **Integrative structural modeling of macromolecular complexes using Assemblin**  
Vasileios Rantos, Kai Karius, Jan Kosinski  
*Nature Protocols* (2021-11-29) <https://doi.org/gg586q>  
DOI: [10.1038/s41596-021-00640-z](https://doi.org/10.1038/s41596-021-00640-z) · PMID: [34845384](https://pubmed.ncbi.nlm.nih.gov/34845384/)
9. **Simple But Efficacious Enrichment of Integral Membrane Proteins and Their Interactions for In-Depth Membrane Proteomics**



Pornparn Kongpracha, Pattama Wiriyasermkul, Noriyoshi Isozumi, Satomi Moriyama, Yoshikatsu Kanai, Shushi Nagamori

*Molecular & Cellular Proteomics* (2022-05) <https://doi.org/g9ks7r>

DOI: [10.1016/j.mcpro.2022.100206](https://doi.org/10.1016/j.mcpro.2022.100206) · PMID: [35085786](https://pubmed.ncbi.nlm.nih.gov/35085786/) · PMCID: [PMC9062332](https://pubmed.ncbi.nlm.nih.gov/PMC9062332/)

10. **Structure of *Mycobacterium tuberculosis* Cya, an evolutionary ancestor of the mammalian membrane adenylyl cyclases**

Ved Mehta, Basavraj Khanppnavar, Dina Schuster, Ilayda Kantarci, Irene Vercellino, Angela Kosturanova, Tarun Iype, Sasa Stefanic, Paola Picotti, Volodymyr M Korkhov

*eLife* (2022-08-18) <https://doi.org/gsx57q>

DOI: [10.7554/elife.77032](https://doi.org/10.7554/elife.77032) · PMID: [35980026](https://pubmed.ncbi.nlm.nih.gov/35980026/) · PMCID: [PMC9433096](https://pubmed.ncbi.nlm.nih.gov/PMC9433096/)

11. **Structural basis of calmodulin modulation of the rod cyclic nucleotide-gated channel**

Diane C A Barret, Dina Schuster, Matthew J Rodrigues, Alexander Leitner, Paola Picotti, Gebhard F X Schertler, U Benjamin Kaupp, Volodymyr M Korkhov, Jacopo Marino

*Proceedings of the National Academy of Sciences* (2023-04-03) <https://doi.org/gs27gg>

DOI: [10.1073/pnas.2300309120](https://doi.org/10.1073/pnas.2300309120) · PMID: [37011209](https://pubmed.ncbi.nlm.nih.gov/37011209/) · PMCID: [PMC10104587](https://pubmed.ncbi.nlm.nih.gov/PMC10104587/)

12. **Regulatory sites of CaM-sensitive adenylyl cyclase AC8 revealed by cryo-EM and structural proteomics**

Basavraj Khanppnavar, Dina Schuster, Pia Lavriha, Federico Uliana, Merve Özel, Ved Mehta, Alexander Leitner, Paola Picotti, Volodymyr M Korkhov

*EMBO Reports* (2024-02-13) <https://doi.org/g9kwfz>

DOI: [10.1038/s44319-024-00076-y](https://doi.org/10.1038/s44319-024-00076-y) · PMID: [38351373](https://pubmed.ncbi.nlm.nih.gov/38351373/) · PMCID: [PMC10933263](https://pubmed.ncbi.nlm.nih.gov/PMC10933263/)

13. **A peptide-centric local stability assay enables proteome-scale identification of the protein targets and binding regions of diverse ligands**

Kejia Li, Shijie Chen, Keyun Wang, Yan Wang, Lianji Xue, Yuying Ye, Zheng Fang, Jiawen Lyu, Haiyang Zhu, Yanan Li, ... Mingliang Ye

*Nature Methods* (2024-12-10) <https://doi.org/g84jvq>

DOI: [10.1038/s41592-024-02553-7](https://doi.org/10.1038/s41592-024-02553-7) · PMID: [39658593](https://pubmed.ncbi.nlm.nih.gov/39658593/)

14. **In-Cell Fast Photochemical Oxidation Interrogates the Native Structure of Integral Membrane Proteins**

Jie Sun, Mierxiati Saimi, Don Rempel, Qing Cao, Mengqi Chai, Weikai Li, Michael L Gross

*Angewandte Chemie International Edition* (2025-03-09) <https://doi.org/g9kwfm>

DOI: [10.1002/anie.202424779](https://doi.org/10.1002/anie.202424779) · PMID: [40033852](https://pubmed.ncbi.nlm.nih.gov/40033852/) · PMCID: [PMC12052488](https://pubmed.ncbi.nlm.nih.gov/PMC12052488/)

15. **Thermal proteome profiling identifies the membrane-bound purinergic receptor P2X4 as a target of the autophagy inhibitor indophagolin**

Marjorie A Carnero Corrales, Sarah Zinken, Georgios Konstantinidis, Muhammad Rafehi, Aliaa Abdelrahman, Yao-Wen Wu, Petra Janning, Christa E Müller, Luca Laraia, Herbert Waldmann

*Cell Chemical Biology* (2021-12) <https://doi.org/gmz72w>

DOI: [10.1016/j.chembiol.2021.02.017](https://doi.org/10.1016/j.chembiol.2021.02.017) · PMID: [33725479](https://pubmed.ncbi.nlm.nih.gov/33725479/)

16. **Cross-Linking Mass Spectrometry to Capture Protein Network Dynamics of Cell Membranome**

Lucia Santorelli, Michele Costanzo, Sara Petrosino, Michele Santoro, Marianna Caterino, Margherita Ruoppolo, Paolo Grumati

*Methods in Molecular Biology* (2024-12-24) <https://doi.org/g9kwfn>

DOI: [10.1007/978-1-0716-4298-6\\_16](https://doi.org/10.1007/978-1-0716-4298-6_16) · PMID: [39716008](https://pubmed.ncbi.nlm.nih.gov/39716008/)

17. **Cross-link assisted spatial proteomics to map sub-organelle proteomes and membrane protein topologies**

Ying Zhu, Kerem Can Akkaya, Julia Ruta, Nanako Yokoyama, Cong Wang, Max Ruwolt, Diogo Borges Lima, Martin Lehmann, Fan Liu

*Nature Communications* (2024-04-17) <https://doi.org/g9kwfv>

DOI: [10.1038/s41467-024-47569-x](https://doi.org/10.1038/s41467-024-47569-x) · PMID: [38632225](https://pubmed.ncbi.nlm.nih.gov/38632225/) · PMCID: [PMC11024108](https://pubmed.ncbi.nlm.nih.gov/PMC11024108/)

18. **Glycan–protein cross-linking mass spectrometry reveals sialic acid-mediated protein networks on cell surfaces**  
Yixuan Xie, Siyu Chen, Qiongyu Li, Ying Sheng, Michael Russelle Alvarez, Joeriggo Reyes, Gege Xu, Kemal Solakyildirim, Carlito B Lebrilla  
*Chemical Science* (2021) <https://doi.org/g9kwf3>  
DOI: [10.1039/d1sc00814e](https://doi.org/10.1039/d1sc00814e) · PMID: [34257876](https://pubmed.ncbi.nlm.nih.gov/34257876/) · PMCID: [PMC8246274](https://pubmed.ncbi.nlm.nih.gov/PMC8246274/)
19. **In situ cell-type-specific cell-surface proteomic profiling in mice**  
SAndrew Shuster, Jiefu Li, URee Chon, Miley C Sinantha-Hu, David J Luginbuhl, Namrata D Udeshi, Dominique Kiki Carey, Yukari H Takeo, Qijing Xie, Chuanyun Xu, ... Liqun Luo  
*Neuron* (2022-12) <https://doi.org/gg3hq5>  
DOI: [10.1016/j.neuron.2022.09.025](https://doi.org/10.1016/j.neuron.2022.09.025) · PMID: [36220098](https://pubmed.ncbi.nlm.nih.gov/36220098/) · PMCID: [PMC9742329](https://pubmed.ncbi.nlm.nih.gov/PMC9742329/)
20. **Profiling the proximal proteome of the activated  $\mu$ -opioid receptor**  
Benjamin J Polacco, Braden T Lobingier, Emily E Blythe, Nohely Abreu, Prachi Khare, Matthew K Howard, Alberto J Gonzalez-Hernandez, Jiewei Xu, Qiongyu Li, Brandon Novy, ... Ruth Hüttenhain  
*Nature Chemical Biology* (2024-03-25) <https://doi.org/gtqbbp>  
DOI: [10.1038/s41589-024-01588-3](https://doi.org/10.1038/s41589-024-01588-3) · PMID: [38528119](https://pubmed.ncbi.nlm.nih.gov/38528119/) · PMCID: [PMC11365811](https://pubmed.ncbi.nlm.nih.gov/PMC11365811/)
21. **Chromatographic Phospholipid Trapping for Automated H/D Exchange Mass Spectrometry of Membrane Protein–Lipid Assemblies**  
Dietmar Hammerschmid, Valeria Calvaresi, Chloe Bailey, Benjamin Russell Lewis, Argyris Politis, Michael Morris, Laetitia Denbigh, Malcolm Anderson, Eamonn Reading  
*Analytical Chemistry* (2023-01-27) <https://doi.org/g9kwms>  
DOI: [10.1021/acs.analchem.2c04876](https://doi.org/10.1021/acs.analchem.2c04876) · PMID: [36706021](https://pubmed.ncbi.nlm.nih.gov/36706021/) · PMCID: [PMC9909672](https://pubmed.ncbi.nlm.nih.gov/PMC9909672/)
22. **Molecular characterization of a complex of apoptosis-inducing factor 1 with cytochrome c oxidase of the mitochondrial respiratory chain**  
Johannes F Hevler, Riccardo Zenezeni Chiozzi, Alfredo Cabrera-Orefice, Ulrich Brandt, Susanne Arnold, Albert JR Heck  
*Proceedings of the National Academy of Sciences* (2021-09-21) <https://doi.org/g9kwf5>  
DOI: [10.1073/pnas.2106950118](https://doi.org/10.1073/pnas.2106950118) · PMID: [34548399](https://pubmed.ncbi.nlm.nih.gov/34548399/) · PMCID: [PMC8488679](https://pubmed.ncbi.nlm.nih.gov/PMC8488679/)
23. **A proximity proteomics pipeline with improved reproducibility and throughput**  
Xiaofang Zhong, Qiongyu Li, Benjamin J Polacco, Trupti Patil, Aaron Marley, Helene Foussard, Prachi Khare, Rasika Vartak, Jiewei Xu, Jeffrey F DiBerto, ... Ruth Hüttenhain  
*Molecular Systems Biology* (2024-07-01) <https://doi.org/g9kwf2>  
DOI: [10.1038/s44320-024-00049-2](https://doi.org/10.1038/s44320-024-00049-2) · PMID: [38951684](https://pubmed.ncbi.nlm.nih.gov/38951684/) · PMCID: [PMC11297269](https://pubmed.ncbi.nlm.nih.gov/PMC11297269/)
24. **Capturing a rhodopsin receptor signalling cascade across a native membrane**  
Siyun Chen, Tamar Getter, David Salom, Di Wu, Daniel Quetschlich, Dror S Chorev, Krzysztof Palczewski, Carol V Robinson  
*Nature* (2022-04-06) <https://doi.org/g9kwfw>  
DOI: [10.1038/s41586-022-04547-x](https://doi.org/10.1038/s41586-022-04547-x) · PMID: [35388214](https://pubmed.ncbi.nlm.nih.gov/35388214/) · PMCID: [PMC9007743](https://pubmed.ncbi.nlm.nih.gov/PMC9007743/)
25. **Native Mass Spectrometry of Membrane Protein–Lipid Interactions in Different Detergent Environments**  
Smriti Kumar, Lauren Stover, Lie Wang, Hanieh Bahramimoghaddam, Ming Zhou, David H Russell, Arthur Laganowsky

*Analytical Chemistry* (2024-10-12) <https://doi.org/g9kwfr>  
DOI: [10.1021/acs.analchem.4c03312](https://doi.org/10.1021/acs.analchem.4c03312) · PMID: [39394983](https://pubmed.ncbi.nlm.nih.gov/39394983/) · PMCID: [PMC11503522](https://pubmed.ncbi.nlm.nih.gov/PMC11503522/)

26. **Native mass spectrometry of proteoliposomes containing integral and peripheral membrane proteins**  
Yun Zhu, Sangho D Yun, Tianqi Zhang, Jing-Yuan Chang, Lauren Stover, Arthur Laganowsky  
*Chemical Science* (2023) <https://doi.org/g9kwf4>  
DOI: [10.1039/d3sc04938h](https://doi.org/10.1039/d3sc04938h) · PMID: [38098719](https://pubmed.ncbi.nlm.nih.gov/38098719/) · PMCID: [PMC10718073](https://pubmed.ncbi.nlm.nih.gov/PMC10718073/)
27. **Capillary Zone Electrophoresis-Mass Spectrometry of Intact G Protein-Coupled Receptors Enables Proteoform Profiling**  
Ashley N Ives, Kevin Jooß, Rafael D Melani, Ryan T Fellers, John Janetzko, Neil L Kelleher  
*Analytical Chemistry* (2025-03-27) <https://doi.org/g9kwfs>  
DOI: [10.1021/acs.analchem.4c06994](https://doi.org/10.1021/acs.analchem.4c06994) · PMID: [40146057](https://pubmed.ncbi.nlm.nih.gov/40146057/)
28. **Capillary Zone Electrophoresis-Tandem Mass Spectrometry for Top-Down Proteomics of Mouse Brain Integral Membrane Proteins**  
Qianjie Wang, Tian Xu, Fei Fang, Qianyi Wang, Peter Lundquist, Liangliang Sun  
*Analytical Chemistry* (2023-08-18) <https://doi.org/g9kwfq>  
DOI: [10.1021/acs.analchem.3c02346](https://doi.org/10.1021/acs.analchem.3c02346) · PMID: [37595263](https://pubmed.ncbi.nlm.nih.gov/37595263/) · PMCID: [PMC10540247](https://pubmed.ncbi.nlm.nih.gov/PMC10540247/)
29. **The Effects of Sodium Ions on Ligand Binding and Conformational States of G Protein-Coupled Receptors—Insights from Mass Spectrometry**  
Mark T Agasid, Lars Sørensen, Leonhard H Urner, Jun Yan, Carol V Robinson  
*Journal of the American Chemical Society* (2021-03-12) <https://doi.org/gjf7x5>  
DOI: [10.1021/jacs.0c11837](https://doi.org/10.1021/jacs.0c11837) · PMID: [33711230](https://pubmed.ncbi.nlm.nih.gov/33711230/) · PMCID: [PMC7995251](https://pubmed.ncbi.nlm.nih.gov/PMC7995251/)
30. **Evaluation of Drug Responses to Human  $\beta$ AR Using Native Mass Spectrometry**  
Michiko Tajiri, Shunsuke Imai, Tsuyoshi Konuma, Keiko Shimamoto, Ichio Shimada, Satoko Akashi  
*ACS Omega* (2023-06-28) <https://doi.org/g9kwft>  
DOI: [10.1021/acsomega.3c02737](https://doi.org/10.1021/acsomega.3c02737) · PMID: [37457453](https://pubmed.ncbi.nlm.nih.gov/37457453/) · PMCID: [PMC10339329](https://pubmed.ncbi.nlm.nih.gov/PMC10339329/)
31. **Native mass spectrometry and structural studies reveal modulation of MsbA-nucleotide interactions by lipids**  
Tianqi Zhang, Jixing Lyu, Bowei Yang, Sangho D Yun, Elena Scott, Minglei Zhao, Arthur Laganowsky  
*Nature Communications* (2024-07-15) <https://doi.org/gt4mfb>  
DOI: [10.1038/s41467-024-50350-9](https://doi.org/10.1038/s41467-024-50350-9) · PMID: [39009687](https://pubmed.ncbi.nlm.nih.gov/39009687/) · PMCID: [PMC11251056](https://pubmed.ncbi.nlm.nih.gov/PMC11251056/)
32. **Mass spectrometry captures biased signalling and allosteric modulation of a G-protein-coupled receptor**  
Hsin-Yung Yen, Idir Liko, Wanling Song, Parth Kapoor, Fernando Almeida, Joanna Toporowska, Karolina Gherbi, Jonathan TS Hopper, Steven J Charlton, Argyris Politis, ... Carol V Robinson  
*Nature Chemistry* (2022-11-10) <https://doi.org/jmm7>  
DOI: [10.1038/s41557-022-01041-9](https://doi.org/10.1038/s41557-022-01041-9) · PMID: [36357787](https://pubmed.ncbi.nlm.nih.gov/36357787/) · PMCID: [PMC9758051](https://pubmed.ncbi.nlm.nih.gov/PMC9758051/)
33. **Native mass spectrometry prescreening of G protein-coupled receptor complexes for cryo-EM structure determination**  
Donggyun Kim, Weijing Liu, Rosa Viner, Vadim Cherezov  
*Structure* (2024-12) <https://doi.org/g9kwfp>  
DOI: [10.1016/j.str.2024.10.004](https://doi.org/10.1016/j.str.2024.10.004) · PMID: [39471802](https://pubmed.ncbi.nlm.nih.gov/39471802/) · PMCID: [PMC11625002](https://pubmed.ncbi.nlm.nih.gov/PMC11625002/)

34. **Lipid- and protein-directed photosensitizer proximity labeling captures the cholesterol interactome**  
Andrew P Becker, Elijah Bilech, John Paul Kennelly, Ashley R Julio, Miranda Villaneuva, Rohith T Nagari, Daniel W Turner, Nikolas R Burton, Tomoyuki Fukuta, Liujuan Cui, ... Keriann M Backus  
*Cold Spring Harbor Laboratory* (2024-08-20) <https://doi.org/g9kwhm>  
DOI: [10.1101/2024.08.20.608660](https://doi.org/10.1101/2024.08.20.608660) · PMID: [39229057](https://pubmed.ncbi.nlm.nih.gov/39229057/) · PMCID: [PMC11370482](https://pubmed.ncbi.nlm.nih.gov/PMC11370482/)
35. **A chemical proteomics approach for global mapping of functional lysines on cell surface of living cell**  
Ting Wang, Shiyun Ma, Guanghui Ji, Guoli Wang, Yang Liu, Lei Zhang, Ying Zhang, Haojie Lu  
*Nature Communications* (2024-04-08) <https://doi.org/g9kwhj>  
DOI: [10.1038/s41467-024-47033-w](https://doi.org/10.1038/s41467-024-47033-w) · PMID: [38589397](https://pubmed.ncbi.nlm.nih.gov/38589397/) · PMCID: [PMC11001985](https://pubmed.ncbi.nlm.nih.gov/PMC11001985/)
36. **Probing Monotopic Phosphoglycosyl Transferases from Complex Cellular Milieu**  
Alyssa J Anderson, Leah M Seebald, Christine A Arbour, Barbara Imperiali  
*ACS Chemical Biology* (2022-11-08) <https://doi.org/g6g3mb>  
DOI: [10.1021/acscchembio.2c00648](https://doi.org/10.1021/acscchembio.2c00648) · PMID: [36346917](https://pubmed.ncbi.nlm.nih.gov/36346917/) · PMCID: [PMC9703085](https://pubmed.ncbi.nlm.nih.gov/PMC9703085/)
37. **Dual-Probe Activity-Based Protein Profiling Reveals Site-Specific Differences in Protein Binding of EGFR-Directed Drugs**  
Wouter van Bergen, Kristina Žuna, Jan Fiala, Elena E Pohl, Albert JR Heck, Marc P Baggelaar  
*ACS Chemical Biology* (2024-07-25) <https://doi.org/g9kwhh>  
DOI: [10.1021/acscchembio.3c00637](https://doi.org/10.1021/acscchembio.3c00637) · PMID: [39052621](https://pubmed.ncbi.nlm.nih.gov/39052621/) · PMCID: [PMC11334109](https://pubmed.ncbi.nlm.nih.gov/PMC11334109/)
38. **Defining the Cell Surface Cysteinome Using Two-Step Enrichment Proteomics**  
Tianyang Yan, Lisa M Boatner, Liujuan Cui, Peter J Tontonoz, Keriann M Backus  
*JACS Au* (2023-12-13) <https://doi.org/g5c55k>  
DOI: [10.1021/jacsau.3c00707](https://doi.org/10.1021/jacsau.3c00707) · PMID: [38155636](https://pubmed.ncbi.nlm.nih.gov/38155636/) · PMCID: [PMC10751780](https://pubmed.ncbi.nlm.nih.gov/PMC10751780/)
39. **A proteome-wide map of 20(S)-hydroxycholesterol interactors in cell membranes**  
Yu-Shiuan Cheng, Tianyi Zhang, Xiang Ma, Sarida Pratuangtham, Grace C Zhang, Alexander A Ondrus, Amirhossein Mafi, Brett Lomenick, Jeffrey J Jones, Alison E Ondrus  
*Nature Chemical Biology* (2021-11-19) <https://doi.org/g9kwhk>  
DOI: [10.1038/s41589-021-00907-2](https://doi.org/10.1038/s41589-021-00907-2) · PMID: [34799735](https://pubmed.ncbi.nlm.nih.gov/34799735/) · PMCID: [PMC8607797](https://pubmed.ncbi.nlm.nih.gov/PMC8607797/)
40. **Cell Surface Engineering Enables Surfaceome Profiling**  
Zak Vilen, Abigail E Reeves, Timothy R O'Leary, Eugene Joeh, Naomi Kamasawa, Mia L Huang  
*ACS Chemical Biology* (2022-04-20) <https://doi.org/g9kwmw>  
DOI: [10.1021/acscchembio.1c00865](https://doi.org/10.1021/acscchembio.1c00865) · PMID: [35443134](https://pubmed.ncbi.nlm.nih.gov/35443134/) · PMCID: [PMC9901301](https://pubmed.ncbi.nlm.nih.gov/PMC9901301/)
41. **Quantitative Glycan-Protein Cross-Linking Mass Spectrometry Using Enrichable Linkers Reveals Extensive Glycan-Mediated Protein Interaction Networks**  
Siyu Chen, Yixuan Xie, Michael Russelle Alvarez, Ying Sheng, Yasmine Bouchibti, Vincent Chang, Carlito B Lebrilla  
*Analytical Chemistry* (2025-01-13) <https://doi.org/g9kwmv>  
DOI: [10.1021/acs.analchem.4c04134](https://doi.org/10.1021/acs.analchem.4c04134) · PMID: [39805041](https://pubmed.ncbi.nlm.nih.gov/39805041/) · PMCID: [PMC11780575](https://pubmed.ncbi.nlm.nih.gov/PMC11780575/)
42. **Structural Mass Spectrometry Captures Residue-Resolved Comprehensive Conformational Rearrangements of a G Protein-Coupled Receptor**  
Hongyue Liu, Pengfei Yan, Zhaoyu Zhang, Hongbo Han, Qingtong Zhou, Jie Zheng, Jian Zhang, Fei Xu, Wenqing Shui  
*Journal of the American Chemical Society* (2024-07-13) <https://doi.org/g9kwmx>  
DOI: [10.1021/jacs.4c03922](https://doi.org/10.1021/jacs.4c03922) · PMID: [39001877](https://pubmed.ncbi.nlm.nih.gov/39001877/)

43. **Cryo-EM of soft-landed  $\beta$ -galactosidase: Gas-phase and native structures are remarkably similar**  
Tim K Esser, Jan Böhning, Alpcan Önür, Dinesh K Chinthapalli, Lukas Eriksson, Marko Grabarics, Paul Fremdling, Albert Konijnenberg, Alexander Makarov, Aurelien Botman, ... Stephan Rauschenbach  
*Science Advances* (2024-02-16) <https://doi.org/gth2cp>  
DOI: [10.1126/sciadv.adl4628](https://doi.org/10.1126/sciadv.adl4628) · PMID: [38354247](https://pubmed.ncbi.nlm.nih.gov/38354247/) · PMCID: [PMC10866560](https://pubmed.ncbi.nlm.nih.gov/PMC10866560/)
44. **Cryogenic Soft Landing Improves Structural Preservation of Protein Complexes**  
Michael S Westphall, Kenneth W Lee, Colin Hemme, Austin Z Salome, Keaton Mertz, Timothy Grant, Joshua J Coon  
*Analytical Chemistry* (2023-09-21) <https://doi.org/g9kwmt>  
DOI: [10.1021/acs.analchem.3c03228](https://doi.org/10.1021/acs.analchem.3c03228) · PMID: [37732836](https://pubmed.ncbi.nlm.nih.gov/37732836/) · PMCID: [PMC10568529](https://pubmed.ncbi.nlm.nih.gov/PMC10568529/)
45. **Generating cysteine-trypsin cleavage sites with 2-chloroacetamidine capping**  
Samuel Ofori, Heta S Desai, Flowreen Shikwana, Lisa M Boatner, Emil R Dominguez III, José O Castellón, Keriann M Backus  
*Chemical Communications* (2024) <https://doi.org/g9kwmz>  
DOI: [10.1039/d4cc01583e](https://doi.org/10.1039/d4cc01583e) · PMID: [39081146](https://pubmed.ncbi.nlm.nih.gov/39081146/)