FY 2025 Annual Report

Unit Name

Membrane Cooperativity Unit

Professor Akihiro Kusumi

Collaborations

Koichiro M. Hirosawa, Institute for Glyco-core Research (iGCORE), Gifu University, Japan, Single-molecule methods for characterizing receptor dimers reveal metastable opioid receptor homodimers that induce functional modulation

Ziya Kalay, Institute for Integrated Cell-Material Sciences (WPI-iCeMS), Kyoto University, Japan, Single-molecule methods for characterizing receptor dimers reveal metastable opioid receptor homodimers that induce functional modulation

Masataka Yanagawa, Graduate School of Pharmaceutical Sciences, Kyoto University, Japan, Single-molecule methods for characterizing receptor dimers reveal metastable opioid receptor homodimers that induce functional modulation

Asuka Inoue, Graduate School of Pharmaceutical Sciences, Kyoto University, Japan, Single-molecule methods for characterizing receptor dimers reveal metastable opioid receptor homodimers that induce functional modulation

Ryoji Kise, Graduate School of Pharmaceutical Sciences, Kyoto University, Japan, Single-molecule methods for characterizing receptor dimers reveal metastable opioid receptor homodimers that induce functional modulation

Hiroshi Ueda, (1) Laboratory for the Study of Pain, Research Institute for Production Development (2) Department of Pharmacology, National Defense Medical Center, (1) Japan (2) Taiwan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Takahiro K. Fujiwara, Institute for Integrated Cell-Material Sciences (WPI-iCeMS), Kyoto University, Japan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Masayuki Sakamoto, Graduate School of Biostudies, Kyoto University, Japan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Tatsushi Yokoyama, Graduate School of Biostudies, Kyoto University, Japan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Hiroyuki Neyama, Center for Cancer Immunotherapy and Immunobiology, Kyoto University Graduate School of Medicine, Japan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Simone Pigolotti, Biological Complexity Unit, Okinawa Institute of Science and Technology Graduate University, Japan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Wakako Fujita, (1) Department of Medical Pharmacology, Nagasaki University Graduate School of Biomedical Sciences (2) Laboratory of Pharmacotherapeutics, Faculty of Pharmacy, Juntendo University, (1) Japan (2) Japan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Rinshi S. Kasai, (1) Division of Advanced Bioimaging, National Cancer Center Research Institute (2) Institute for Glyco-core Research (iGCORE), Gifu University (3) Institute for Life and Medical Sciences, Kyoto University, (1)

Japan (2) Japan (3) Japan, Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance

Dragomir Milovanovic, German Center for Neurodegenerative Diseases (DZNE) , Germany, Revealing the cellular signaling platforms formed by regulated liquid-liquid phase separation (LLPS)

Kyoto University (KUIAS), Japan, Revealing super-transient signaling molecular complexes by single-molecule imaging

Geert van den Bogaart, Department of Molecular Immunology, Groningen Biomolecular Sciences and Biotechnology Institute, University of Groningen, The Netherlands, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Yusuke Hirabayashi, Department of Chemistry and Biotechnology, School of Engineering, The University of Tokyo, Japan, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Christian Hoffmann, (1) Institute of Biochemistry, Charité-Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität Berlin, and Berlin Institute of Health (2) Laboratory of Molecular Neuroscience, German Center for Neurodegenerative Diseases (DZNE), (1) Germany (2) Germany, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Johannes Vincent Tromm, (1) Institute of Biochemistry, Charité-Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität Berlin, and Berlin Institute of Health (2) Laboratory of Molecular Neuroscience, German Center for Neurodegenerative Diseases (DZNE), (1) Germany (2) Germany, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Koki Nakamura, Department of Chemistry and Biotechnology, School of Engineering, The University of Tokyo, Japan, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Takahiro Nagao, Department of Chemistry and Biotechnology, School of Engineering, The University of Tokyo, Japan, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Han Wang, Institute of Biochemistry, Charité-Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität Berlin, and Berlin Institute of Health, Germany, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Frans Bianchi, Department of Molecular Immunology, Groningen Biomolecular Sciences and Biotechnology Institute, University of Groningen, The Netherlands, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Dragomir Milovanovic, (1) Institute of Biochemistry, Charité-Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität Berlin, and Berlin Institute of Health (2) Laboratory of Molecular Neuroscience, German Center for Neurodegenerative Diseases (DZNE), (1) Germany (2) Germany, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Chinyere Logan, (1) Institute of Biochemistry, Charité-Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität Berlin, and Berlin Institute of Health (2) Laboratory of Molecular Neuroscience, German Center for Neurodegenerative Diseases (DZNE), (1) Germany (2) Germany, Membrane-protein-mediated phase separation orchestrates organelle contact sites

Michisuke Yuzaki, Keio University, Japan, Elucidation of nano-scale localization of synaptic proteins in living mouse neurons in culture

Research Personnel

Taka-aki Tsunoyama, Staff Scientist

Maoji Wang, Postdoctoral Scholar

Bo Tang, Postdoctoral Scholar

Amine Betuel Nuriseria Aladag, Postdoctoral Scholar

Saahil Acharya, Postdoctoral Scholar

Juma Sayson, Research Assistant

Jun-Seok Lee, Research Unit Technician

Ryuto Shinozaki, Research Unit Technician

Irina Meshcheryakova, Research Unit Technician

Yasuyuki Shiroma, Research Assistant

Subhransu Sekhar Sahoo, Research Intern

Iliyas Marat, Research Intern

Roksolana Demchynska, Research Intern

Scholarly Contributions and Creative Productions (by Faculty)

Journal Article

1. Zhou, P.; Kasai, R. S.; Fujita, W.; Tsunoyama, T. A.; Neyama, H.; Ueda, H.; Yokoyama, T.; Sakamoto, M.; Pigolotti, S.; Fujiwara, T. K.; Kusumi, A.

   Single-molecule Characterization of Opioid Receptor Heterodimers Reveals Soluble μ-δ Dimer Blocker Peptide Alleviates Morphine Tolerance. Nature Communications 2025, 16.

   https://www.nature.com/articles/s41467-025-64695-2
2. Zhou, P.; Tsunoyama, T. A.; Kasai, R. S.; Hirosawa, K. M.; Kalay, Z.; Aladag, A.; Fujiwara, T. K.; Yokoyama, T.; Sakamoto, M.; Kise, R.; Yanagawa, M.; Inoue, A.; Pigolotti, S.; Kusumi, A.

   Single-molecule Methods for Characterizing Receptor Dimers Reveal Metastable Opioid Receptor Homodimers That Induce Functional Modulation. Nature Communications 2025, 16.

   https://www.nature.com/articles/s41467-025-64694-3

Presentation at Conference

1. Kusumi, A.

   Metastable Nano-Liquid Signal Integration Hub on the Plasma Membrane, iTRVZ, Which Enhances Cancer Development Symposium 1SHA “Mesoscale Cooperative Formation and Function of Cellular Membranes and Cytoskeleton Revealed by Advanced Microscopy” (Co-Organizer with Assoc. Prof. Sawako Yamashiro of Kyoto University)
   . The 63rd Annual Meeting of the Biophysical Society of Japan. 2025.
2. Kusumi, A.

   Nano-Liquid Signal Integration Hubs Promoting Cell Survival and Growth. CellBio2025. 2025.
3. Kusumi, A.

   Metastable Nano-Liquid Signal Integration Hub on the Plasma Membrane, iTRVZ, Involved in Cancer Development. Pacifichem 2025. 2025.

Seminars

1. Kusumi, A.

   Ultrafast Single MoleculeImaging and Discovery of Metastable Nano-liquid Signaling Hub. Graduate School of Medicine and Dentistry. Tokyo Science University. 2025
2. Kusumi, A.

   Nano-Liquid Signaling Platform on the Plasma Membrane as Unveiled by Advanced Single-Molecule Imaging. Max-Planck Institute for Biochemistry, Martinsried, Germany. 2025.
3. Kusumi, A.

   Ultrafast Single Molecule Imaging and Discovery of Metastable Nano-Liquid Signaling Hub. LMU CeNS Colloquium, Center for NanoScience, Ludwig-Maximilians-Universität München, Munich, Germany. 2025.
4. Kusumi, A.

Signal Integration Platforms on the Plasma Membrane as Revealed by Advanced Single-Molecule Imaging. Department of Zoology and Neurobiology at the Ruhr University Bochum, Bochum, Germany. 2025.

5. Kusumi, A.

   Nano-Liquid Signal Integration Hubs Promoting Cell Survival and Growth as Revealed by Advanced Single-Molecule Imaging. Department of Biology/Chemistry, Osnabrück University, Osnabrück, Germany. 2025.

Scholarly Contributions (by Unit Members)

Name of Unit Member	Type	Title	Outlet	Publisher	Year Pub
Taka-aki Tsunoyama	Journal Article	Single-molecule characterization of opioid receptor heterodimers reveals soluble μ-δ dimer blocker peptide alleviates morphine tolerance	Nature communications	Springer Nature	2025-11-7
Maoji Wang	Journal Article	Infrared nanosensors of piconewton to micronewton forces	Nature	Nature	2025-1/1
Taka-aki Tsunoyama	Journal Article	Membrane-protein-mediated phase separation orchestrates organelle contact sites	Molecular Cell	Cell press	2026-1/8
Taka-aki Tsunoyama	Journal Article	Single-molecule methods for characterizing receptor dimers reveal metastable opioid receptor homodimers that induce functional modulation	Nature comminitations	Springer Nature	2025-11-7
Saahil Acharya	Journal Article	SynGAP forms biocondensates at sub-micromolar concentrations and recruits PSD95 and receptor oligomers, functioning as a key initiator of PSD formation	BioRxiv	CSHL	2025-4/23
Amine Betuel Nuriseria Aladag	Journal Article	Single-molecule methods for characterizing receptor dimers reveal metastable opioid receptor homodimers that induce functional modulation	Nature Communications	Nature	2025-11-7
Taka-aki Tsunoyama	Poster Presentation at Conference	Initiators for inhibitory synapse formation: actin polymerization induced by co-condensation of gephyrin and Ena-VASP family proteins	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Saahil Acharya	Poster Presentation at Conference	Bio-condensates of SynGAP at sub-micromolar concentrations recruit key scaffold proteins and receptors at the post-synapse	The 63rd Annual Meeting of the Biophysical Society of Japan	Biophysical society of Japan	2025-9/24
Maoji Wang	Poster Presentation at Conference	Integrin Nanocluster Dynamics and Interaction with Paxillin Nanoclusters	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Maoji Wang	Poster Presentation at Conference	Initiators for inhibitory synapse formation: actin polymerization induced by co-condensation of	The 63rd Annual Meeting of the		2025-9/24

Name of Unit Member	Type	Title	Outlet	Publisher	Year Pub
		gephyrin and Ena-VASP family proteins	Biophysical Society of Japan		
Taka-aki Tsunoyama	Poster Presentation at Conference	SuperPAINT visualization of dynamic nanoscale heterogeneity of the entire plasma membrane	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Saahil Acharya	Presentation at Conference	Bio-condensates of SynGAP at sub-micromolar concentrations recruit key scaffold proteins and receptors at the post-synapse	First Neuro Winter Summit	National Institute for Physiological Sciences	2026-3/24
Amine Betuel Nuriseria Aladag	Presentation at Conference	SuperPAINT Library: Systematically designed pairs of tag proteins and fluorescent ligands for single-molecule super-resolution imaging	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Taka-aki Tsunoyama	Presentation at Conference	Nano-liquid signaling platform responsible for both cancer cell growth and immune evasion	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Taka-aki Tsunoyama	Presentation at Conference	SuperPAINT Library: Systematically designed pairs of tag proteins and fluorescent ligands for single-molecule super-resolution imaging	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Taka-aki Tsunoyama	Presentation at Conference	Metastable nano-liquid signal integration hub on the plasma membrane, iTRVZ, which enhances cancer development	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Taka-aki Tsunoyama	Presentation at Conference	Initiation of excitatory synapse formation: SynGAP LLPS at nanomolar concentrations induces PSD95 and receptor oligomer recruitment	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Amine Betuel Nuriseria Aladag	Presentation at Conference	Initiators for inhibitory Synapse formation: actin polymerization induced by co-condensation of gephyrin and ENA-VASP family proteins	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24
Maoji Wang	Presentation at Conference	SuperPAINT Library: Systematically designed pairs of tag proteins and fluorescent ligands for single-molecule super-resolution imaging	The 63rd Annual Meeting of the Biophysical Society of Japan		2025-9/24

Honors, Awards & Fellowships

Term 2 2020 - Ongoing	Avanti Award in Lipids, 2020, Biophysical Society (U.S.A.)

Outreach Activities [For Unit Members Only]

Term 2 2025	Taka-aki Tsunoyama, Staff Scientist [Fiscal Year: 2024]

Workshops and Seminars [Organized and Hosted by Faculty/Units]

Speaker Name(s)	Title	Location	Co-Organizers	Date
Akihiro Kusumi +25 scientists	Symposium BIO027: Uncovering Membrane Receptors Function from the Interplay Between Molecular Structure and Intermolecular Interactions.	Honolulu, Hawaii, U.S.A.	Valerica Raicu, Kalina Hristova, Matt Call, Akihiro Kusumi, Claudiu Gradinaru	2025-12-17
Michael M. Kozlov	Model for tension propagation in crumpled compartmentalised cell membranes	OIST (Lab4 E01)		2025-11-06
Sawako Yamashiro, Gregory Giannone, Reinhard Fässler, Bo Tang, Akihiro Kusumi	Symposium 1SHA: Mesoscale cooperative formation and function of cellular membranes and cytoskeleton revealed by advanced microscopy	Nara, Japan	Sawako Yamashiro, Akihiro Kusumi	2025-09-24
Grégory Giannone	Deciphering the spatiotemporal and mechanical regulation of integrin and actin cytoskeleton at the nanoscale	OIST (Lab4 E48)		2025-09-19
Reinhard Fässler	Integrin transmembrane domains serve as an allosteric activator for ectodomain folding in the endoplasmic reticulum	OSIT (Lab4 E48)		2025-09-19