

JANUARY 2023, ISSUE 7



ARC Industrial Transformation Training Centre for Cryo-electron Microscopy of Membrane Proteins

Quarterly newsletter

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Australian Government
Australian Research Council



MONASH
University



MOLECULAR
HORIZONS



UNIVERSITY
OF WOLLONGONG
AUSTRALIA



CCeMMP acknowledges the peoples of the Kulin, Dharawal, Yuin and Wadi Wadi Nations on whose land the Centre and its Nodes operate. We pay our respects to their Elders, past, present and emerging.

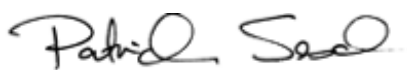
Image credit - Dr Sarah Piper
(@SarahJ_Piper, @PiperProteins)

Welcome

Professor Patrick Sexton

Centre Director

Welcome to the 7th instalment of the ARC CCeMMP quarterly newsletter, and the first newsletter of 2023. This quarter saw the launch of the new Centre website, we welcomed a new ICHDR student to the WEHI node, and celebrated major funding awards from the ARC, NHMRC, MRFF and commercial partners to members across all the Nodes. The Centre also contributed to multiple workshops on cryo-EM organised across different campuses.



Professor Patrick Sexton
Centre Director



Did you know?



The Protein Data Bank (PDB) is 52 years old! Structural biologists worldwide have used, and continue to use, the comprehensive PDB database to access atomic coordinates and gain insights from protein and gain insights from protein structures – since 1971 (before many centre members were born...). The PDB, co-founded by Brookhaven National Laboratory (USA) and the Crystallographic Data Centre Cambridge (UK) as a repository for crystallography data, initially only contained seven structures.

On the 12th of January this year, the PDB reached a new milestone of over 200,000 (experimentally determined) structures being deposited. The majority of these structures were obtained using X-ray diffraction, but electron microscopy (EM)-derived structures are on the rise. In 2015, less than 1,000 EM structures were available, but owing to the 'resolution revolution', over 13,000 EM structures are currently deposited in the PDB.

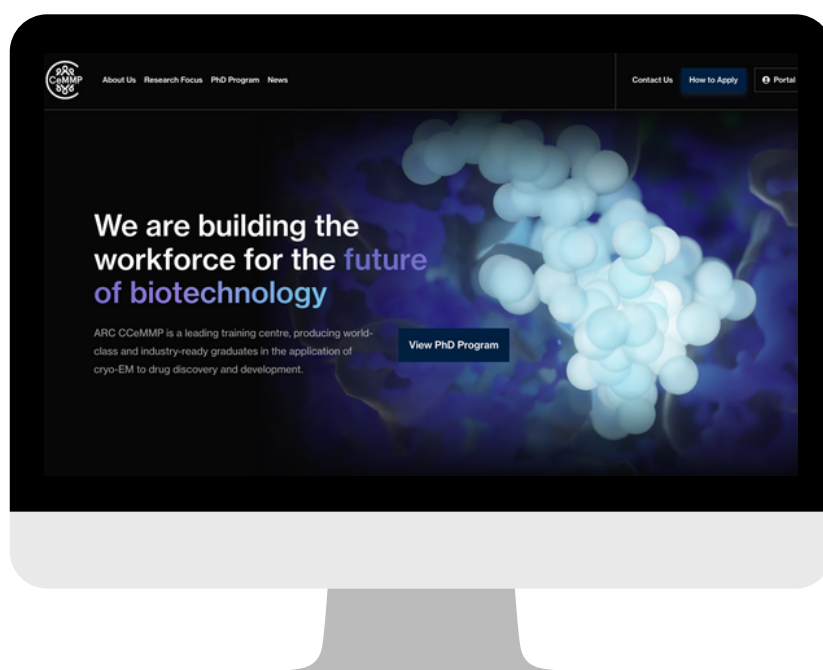
More recently the RCSB PDB website also started to include Computed Structure Models (CSM) from prediction software such as AlphaFold, and now includes more than a million entries of these CSMs. Dive into the diverse world of protein structures through the RCSB PDB under <https://www.rcsb.org/>. (*Info and data obtained from the RCSB PDB website*).

On the cover: from Debnath Ghosal at Bio21 node, an extracellular filament structure (~3Å) where each of the monomers are membrane proteins and processed before incorporation into the filament. This manuscript is now accepted for publication (below). Kreida S, Narita A, Johnson MD, Tocheva EI, Das A, Ghosal, D, Jensen GJ. Cryo-EM structure of the *Agrobacterium tumefaciens* type IV secretion system-associated T-pilus reveals stoichiometric protein-phospholipid assembly. *bioRxiv*. doi: <https://doi.org/10.1101/2022.09.25.509369>

Centre updates

Centre website 2.0

The Centre has undertaken a revamp of its website through the services of ViVO Digital. The new website allows better assimilation of graphics, easier management of updates of the most recent Centre activities and media/social media and better integration with mobile platforms, such as smart phones and iPads. We are currently working through the best organisation of the many facets of the Centre's function, but the new interface is up and running – same address (<https://ccemmp.org/>), brand new look. Take a tour!



ARC, NHMRC and MRFF grant success

Congratulations to centre members from all of our Nodes on their recently announced ARC, NHMRC and MRFF grant funding: Matt Belousoff (Monash U.), James Bouwer (U. Wollongong), Peter Czabotar (WEHI), Debnath Ghosal (U. Melbourne), Mike Griffin (U. Melbourne), Eric Hanssen (U. Melbourne), Tracy Josephs (Monash U.), Chris Langmead (Monash U.), Isabelle Lucet (WEHI), Lezanne Ooi (U. Wollongong), Michael Parker (U. Melbourne), Darren Riddy (Monash U.), Isabelle Rouiller (U. Melbourne), Patrick Sexton (Monash U.), Greg Stewart (Monash U.), Paul Stuppel (Monash U.), Antoine van Oijen (U. Wollongong), Denise Wootten (Monash U.). It was fantastic to see so many Centre researchers successful in these extremely competitive national funding schemes.

More details can be found under the respective Node reports.

It was also exciting and rewarding to see all our Nodes connected by an ARC LIEF grant with lead CI Eric Hanssen (U. Melbourne). This grant will fund a state-of-the-art instrument to support next generation workflows for integrated light and electron microscopy. It provides Australian researchers access to the latest tools in the rapidly developing field of cryo-electron tomography and in situ visualisation of protein structures within cells.

Hanssen E, Ghosal D, McFadden G, Rouiller I, Parker M, Ivanova E, Wootten D, Belousoff M, Lucet I, Czabotar P, Bouwer J. A cryo correlative focused ion beam, a new frontier in structural biology. *ARC Linkage Infrastructure, Equipment and Facility 2023* (LE 230100099). ARC award \$685,000 (total funds \$1.15 M).



**BUILDING
A HEALTHY
AUSTRALIA**



**Australian Government
Australian Research Council**



**Australian Government
National Health and Medical Research Council**



High Performance Computing

The Centre has partnered with Monash Massive M3 to purchase new HPC dedicated to Centre researchers. The new infrastructure comprising 6 NVIDIA A10 equipped GPU compute nodes was delivered the Monash in January 2023 and is expected to be operational for use for Centre students and Centre projects in February 2023. The Centre is also partnering with Monash Massive for a second procurement in 2023 that is focused on large scale data storage; more on this to come in later Newsletters.

ICHDR update



We welcomed Xiaomin Wang, the latest ICHDR recruit to the WEHI Node (more about Xiaomin and her project in the WEHI Node update).

Our semester 1 2022 cohort of students have completed their technical training rotations in biochemistry, imaging and data analysis. They look forward to applying their new skills to their thesis research projects over the remaining years of their candidature.

Node Updates

Monash Node

Professor Denise Wootten
Node Leader, Monash University

Dr. Laurence Miller from the Mayo Clinic, Arizona visits MIPS

The Monash Node welcomed Dr. Laurence Miller from the Mayo Clinic in Scottsdale (Arizona, USA), an international leader in study of gastrointestinal GPCRs, including cholecystokinin and secretin receptors. Dr. Miller spent a week in December at the Monash Node, discussing collaborative research with Centre scientists as well as spending time with Centre students and postdoctoral fellows.



Clarivate Analytics Highly Cited Researchers, 2022



Prof Patrick Sexton and Prof Arthur Christopoulos have been included in the list of the world's most influential researchers as 2022 Clarivate analytics Highly Cited Researchers in the categories of both 'Pharmacology & Toxicology' and 'Biology & Biochemistry'



New Funding

National Grants

ARC Discovery Project 2023 (DP230102776) Denise Wootten (CIA), Matt Belousoff (CIB), Tracy Josephs (CIC). *Structure and dynamics of class B1 G protein coupled receptors* (\$776,880)

ARC Discovery Project 2023 (DP230102777) Denise Wootten (CIA). *The physiological importance of GLP-1R and GIPR dimerisation* (\$585,929)

NHMRC Development Grant – (2022585) Chris Langmead (CIA), Greg Stewart (CIC), Denise Wootten (CIE). *Development of novel GPR52 agonists for the treatment of schizophrenia* (\$780,000)

NHMRC Ideas Grant (2021675) Jesse Mobbs (CID): *Harnessing endogenous opioids to treat gut motility disorders and pain* (\$1,260,809)

National Drug Discovery Centre (NDDC) high-throughput screening grant–90% subsidy on HTS campaigns [~\$300,000]

- Chris Langmead (CIA), Greg Stewart (CIB). *New medicines for mental health disorders.*
- Darren Riddy (CIA), Patrick Sexton (CIC), Denise Wootten (CID), Paul Stuppelle (CIE). *New medicines for metabolic disease.*

Monash Research Impact Fund (MRIF) – Chris Langmead. *GPR52 modulators for the treatment of cognitive impairments associated with schizophrenia* (\$72,000)

New Funding (cont.)

Institutional Grants

DDB Theme support for EMCR professional development

- Natalie Diepenhorst \$2500 to be used for the Monash Management Essentials Course. This course is designed to provide the necessary framework, skills and knowledge to transition to the role of Manager.
- Sarah Piper \$150 to attend a workshop on media training. *Channelling your voice: Impact and engagement for thought leaders.*

Commercial funding

Patrick Sexton, Denise Wootten. (2022-2023) GPCR drug discovery. Septerna Inc. (USA).

University of Melbourne (Bio21) Node

A/Professor Isabelle Rouiller

Node Leader and Deputy Director, University of Melbourne

Single Particle Cryo-EM Workshop

Dr Sepideh Valimehr organised a single particle cryo-EM workshop at Bio21, Ian Holmes Imaging Centre, complete with hands-on microscope training. Instructors included Centre ICPDs, Dr Sepideh Valimehr, Dr Matt Belousoff, and Centre members, Dr Josh Hardy, Dr Eric Hansen and Dr Hamish Brown. Eight Centre members participated in this *in-person* workshop. The workshop was sponsored by our Partner Organisation, Thermo Fisher Scientific.



New Funding

National Grants

ARC Discovery Project 2023 (DP230102422) Mike Griffin (CIA), Eric Hanssen (CIB). *How do cytokine receptors transmit signals?* (\$531,445)

ARC Discovery Project 2023 (DP230100769) Debnath Ghosal (CIC). *Asgard archaea: the first eukaryotic cells?* (\$604,482)

ARC Discovery Project 2023 (DP230101148) Michael Parker (CIA). *All in the family: understanding a new class of bacterial toxins* (\$673,293)

NHMRC Ideas Grant (2023-2026) (2020780) Eric Hanssen (CIC). *Does finite slowing of feeding cause artemisinin resistance in malaria?* (\$859,736)

Australian Dental Research Foundation (ADRF) Grant 2022 Debnath Ghosal (CID). *Characterisation of the structure and dynamics of oral polymicrobial biofilms using confocal microscopy and cryo-electron tomography* (\$25,000)

University of Wollongong Node

Dr. Gökhan Tolun

Node Leader, University of Wollongong

Dr. Lianne Spinklink Promoted to Level B1

Lianne is a Research Fellow at the University of Wollongong. She works with Distinguished Professor Antoine van Oijen on the development and use of single-molecule techniques to study the dynamic behaviour of proteins in complex biological systems, with a focus on DNA replication. In 2021, she received a Prioritising Emerging Research Leaders (PERL) Fellowship and the Dame Bridget Ogilvie Award (career advancement award) as recognition for her contribution to health and medical research in Wollongong. In 2022, she was awarded an NHMRC emerging leadership grant to develop a novel single-molecule directed-evolution method.



New Funding

National Grants

ARC Centre of Excellence in Quantum Biotechnology (2023-2029)

The University of Wollongong is one of the academic organisations involved in the newly formed ARC Centre of Excellence in Quantum Biotechnology. Two CCEMMP members will be involved in this Centre of Excellence, Distinguished Prof Antoine van Oijen and Prof Lezanne Ooi. There are four Themes in the Centre including Single-protein Dynamics and Control (represented by Prof Antoine van Oijen), and Neural Imaging, with Prof. Lezanne Ooi as Theme Leader. The Neural Imaging theme aims to use quantum technologies to measure neuronal function, with an important focus on neuronal ion channel, receptors and other membrane proteins. The Single-protein Dynamics and Control theme is heavily focused on structure-function relationships in proteins and experimentally aims to increase the temporal resolution of single-molecule measurements of protein dynamics (using quantum-based tools). Cryo-EM methods will be used in combination with these ultrafast measurements to provide a structural framework for data interpretation. Target systems will include enzymes, protein-protein interactions as well as ion channels and other membrane proteins. Prof Antoine van Oijen, will also assume the role of Deputy Director of the Centre with Mentoring, Training and Equity as his portfolio. The Centre will receive \$35 million over 7 years.

New Funding (cont.)

National Grants

ARC Discovery Project (2023-2025) (DP230101981) Lezanne Ooi (CIB) *Phenotyping hippocampal DCX+ cells to unravel human adult neurogenesis* (\$634,931)

NHMRC Ideas Grant (2019934) James Bouwer (AI) *Novel determinants of male fertility carried by seminal fluid extracellular vesicles*, 4 years (\$899,842.25)

Travel Grants

- Jodi Brewster, **University of Wollongong EMCR Enabling Grant**, \$3,000 to support international conference travel. Jodi will use this grant to attend the American Society of Biochemistry and Molecular Biology Conference (Discover BMB) in Seattle, Washington 25-28th March, 2023.
- Lucy Fitschen, **AMMS bursary** to attend the 27th Australian Conference on Microscopy and Microanalysis, \$500 plus conference registration.
- Aidan Grosas, **Travel Award from the National Foundation for Eye Research**, International Conference on the Lens, Kona, Hawaii, USA, \$2,400 USD,

WEHI Node

A/Professor Isabelle Lucet

Node Leader, WEHI

Advancing Application of the Cost-Effective Plunge Freezer for Cryo-EM Sample Preparation

Last year, engineering students recruited through the Monash Industry Team Initiative (MITI) program built a cost-effective cryo plunger with a plunging time of up to 10 ms. This year, MITI students Mihin Perera and Ziling Tang, are making significant improvements to this plunger. Some of the salient features are 1) modelling the behaviour of the fluid on the grid as it is sprayed, 2) more robust and faster solenoid movement as it drops the grid into the liquid ethane and 3) tracking of grid preparation and vitreous ice formation using high-speed camera/lens system. This project is funded through WEHI's NMAT funds.

Introducing ICHDR Xiaomin Wang

Welcome to Xiaomin! Xiaomin is a PhD candidate in Shabih Shakeel's laboratory based at the WEHI node. Her PhD will investigate the structural basis for neuropilin-1 interaction with SARS-CoV-2 using advanced technology such as cryo-EM. Xiaomin grew up in Lanzhou, China and completed her MSc at The King Mongkut's University of Technology Thonburi (KMUTT) in Thailand. As a big fan of movies, Xiaomin can't help imagining 3D Cryo-EM movies to visualize the dynamics of structures at near-atomic resolution under native physiological conditions. Meanwhile, she loves to go everywhere and explore the world.

Supervisor: Dr. Shabih Shakeel



Upcoming events

ARC CCEMMP Seminar series

The seminar series for the year resumes Feb 14, 2023. We look forward to a year of scientifically stimulating seminars starting with Prof. Eva Nogales (University of California, Berkeley) who will be speaking on Structural insights into the regulation of the gene silencer PRC2.

Eva Nogales is a Distinguished Professor of Molecular and Cell Biology. She has been a Howard Hughes Medical Institute Investigator since 2000 and she is also a Senior Faculty Scientist at Lawrence Berkeley National Laboratory (LBNL). Eva has received the Burton medal of the Microscopy Society of America, the Grimwade medal from the University of Melbourne, the Biophysical Lectureship from the Biophysical Society, the Dorothy Crowfoot Hodgkin Award from the Protein Society, the Mildred Cohn Award from the American Society of Biochemistry and Molecular Biology, the Keith R Porter Lecture Award from the American Society for Cell Biology (ASCB), and the LBNL Director's Award for Exceptional Science Achievement. She is a Fellow of ASCB and the Biophysical Society, a member of the National Academy of Sciences of the USA and the American Academy of Arts & Sciences, and foreign associate member of EMBO and the Real Academia de Ciencias de España. The work in Eva's lab is dedicated to the mechanistic understanding of large macromolecular assemblies through the visualization, using cryo-electron microscopy, of their structure, dynamics and regulatory interactions.



Our March speaker will be Dr. Evan O'Brien from Prof Brian Kobilka's lab at Stanford speaking on using Cryo-EM as a tool to characterize and exploit allostery in GPCRs. Full bio and seminar details can be found on the new website.

Lorne Proteins CCEMMP Embedded Satellite Meeting Feb 7, 2023: 'Cryo-EM of Membrane Proteins'



ARC CCEMMP will be hosting an embedded Satellite Meeting at Lorne Proteins 2023 on Tuesday 7th February. This satellite meeting will bring together experts in cryo-EM of membrane proteins to discuss recent progress within this rapidly advancing field.

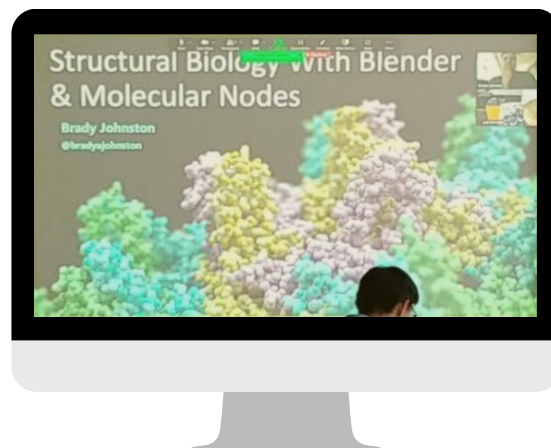
Invited speakers include: Prof Radu Aricescu (University of Cambridge), Assistant Prof Gira Bhabha (New York University), Prof Filippo Mancini (Columbia University), Prof Melani Ohi (University of Michigan), Prof Denise

Wootten (Monash Institute of Pharmaceutical Sciences), Dr Matt Doyle (University of Sydney) and Dr Yan Jiang (University of Sydney). We look forward to hearing about this in the next Newsletter.

Organising Committee: Dr. Josh Hardy (Chair, WEHI), Prof Renae Ryan (USyd), Dr. Shabih Shakeel (WEHI), Dr. Nazanin Mohebali (Monash), Dr. Sepideh Valimehr (Bio21/UoM), Prof Patrick Sexton (Monash).

Blender3D Workshop

A small group of Centre members will attend a 'science visualisation in Blender3D' workshop led by Brady Johnston on 2nd-3rd of Feb at MIPS. Brady is in Melbourne for the Lorne meeting and has agreed to run a 'test' Blender3D workshop to a small group of centre members, before we launch a larger workshop **available for all centre members** later in the year. Next newsletter we will be able to see some of their creations.



Recent Centre Activities and Achievements

Industry Engagement

- Patrick Sexton – briefing with Novo Holdings (Denmark) on Cryo-EM and GPCR drug discovery, November 1st 2022.
- Patrick Sexton and Denise Wootten extend their sponsored research collaboration with Septerna Inc for an additional 12 months (San Francisco, USA)
- Researchers within the Nodes continue active collaborations with industry partners with monthly project meetings Centre Partner Organisations; Astex Pharmaceuticals, AstraZeneca, Boehringer Ingelheim, Novo Nordisk, Pfizer, Servier and Thermo Fisher Scientific.

Centre Members Transitioning to Industry

- Dr. Rachel Johnson recruited to OMass Therapeutics (Oxford, UK)
- Dr. Thomas Coudrat recruited to CSIRO (Melbourne, Aus)

Conference Presentations

International

Karen Gregory: JPS-ASCEPT lecturer. *Fine-tuning glutamate receptor activity with allosteric modulators for psychiatric and neurodegenerative disorders*. Presented at 96th Annual Meeting of the Japanese Pharmacological Society 2022, Nov 30-Dec 3, Yokohama, Japan.

Aidan Grosas: Abstract selected for oral presentation. *Structural, functional, and mechanistic basis for the oligomerisation of the major eye lens protein β B2-crystallin*. Presented at the International Conference on the Lens 2022, Dec 4-9, Kona, Hawaii, USA.

Lezanne Ooi: Invited talk. *Reversing early phenotypes of neurodegeneration in Alzheimer's disease iPSC-derived neurons*. Presented at 3rd Annual Asia Pacific Association for Neural Transplantation and Repair (APANTR) meeting 2022, October 14, Hobart, Australia.

Patrick Sexton: Invited talk. *Harnessing cryo-EM to probe G protein-coupled receptor structure and function*. Presented at 11th Conference of the International Chemical Biology Society 2022, December 4-7, Brisbane, Australia.

National

James Bouwer: Abstract selected for oral presentation. *Managing big-data and processing in cryogenic cryo-electron microscopy*. Presented at eResearch Conference 2022, Oct 20-22, Brisbane.

Lucy Fitschen: Abstract selected for oral presentation. *Towards the cryo-EM structure of Phage λ EATR complex*. Presented at Bugs by the Beach 2022, Dec 9, Wollongong.

National (cont.)

Lucy Fitschen: Poster presentation. *Towards the cryo-EM structure of the bacteriophage lambda EATR complex*. Presented at the 27th Australian Conference on Microscopy and Microanalysis 2023, Jan 29-Feb 2, Perth.

Karen Gregory: Abstract selected for oral presentation. *Fine-tuning glutamate receptor activity with allosteric inhibitors for neurodegenerative and psychiatric disorders*. Presented at ASCEPT-APSA 2022, Nov 29-Dec 2, Perth.

Aidan Grosas: Abstract selected for an oral presentation. *Structural, functional, and mechanistic basis for the oligomerisation of the major eye lens protein β B2-crystallin*. Presented at the 4th Proteostasis and Disease Symposium 2022, Nov 22, Wollongong.

Aidan Grosas: Invited talk. *Using native ion-mobility mass spectrometry coupled to SEC to elucidate the oligomerisation pathway of the eye lens protein betaB2-crystallin*. Presented at the 13th ACT Mass Spectrometry Symposium 2022, Nov 24, Canberra.

Jesse Mobbs: Invited talk. *Cryo-EM structure of the human P2X1 purinoceptor for use in male contraception*. Presented at ASCEPT-APSA 2022, Nov 29 - Dec 2, Perth.

Jordan Nicholls: Abstract selected for oral presentation. *Structural Characterisation of BALF2 Annealase by cryo-EM*. Presented at Bugs by the Beach 2022, Dec 9, Wollongong.

Jordan Nicholls: Poster presentation. *A ball with BALF2: Characterisation of an essential Epstein-Barr virus annealase*. Presented at the 27th Australian Conference on Microscopy & Microanalysis 2023, Jan 29-Feb 2, Perth.

Lezanne Ooi: invited talk. *Disease mechanisms and drug discovery in ALS stem cell models: past, present and future*. Presented at the 40th annual scientific meeting, Australian Neuroscience Society 2022, Dec 5, Melbourne.

Lisanne Spenkelink: Invited talk. *E. coli DNA replication does not require ATP*. Bugs by the Beach 2022, Dec 9, Wollongong.

Lisanne Spenkelink: Abstract selected for oral presentation. *Single-molecule genotyping of thousands of variants*. Australian Society for Biophysics meeting 2022, Dec 22, Hobart.

Presentations to Academia

International

Lezanne Ooi: Invited talk. *Lipid alterations and an increased susceptibility to ferroptosis in Alzheimer's disease neurons*. Presented to Japan Society for the Promotion of Science, online 24 November 2022.

Patrick Sexton: Seminar. *Understanding structure and activation of amylin and calcitonin receptors*. Presented to Tianjin University, China, online, January 17 2023.

National

Aidan Grosas: Seminar. *More than meets the eye – the oligomerisation of lens crystallin proteins*. Presented to School of Science, Western Sydney University October 21, 2022

Patrick Sexton: Seminar. *Using cryo-EM to interrogate peptide hormone GPCR structure and dynamics*. Presented to Department of Chemistry, Monash University, November 7, 2022.

Sarah Piper: Seminar. *Dynamic drug targets: Using Cryo-EM data and MD simulations to create realistic 3D animations of GPCR complexes*. Presented at Making Futures (Australian Biochemistry Lunch seminar), online, November 14, 2022.

Outreach activities

SVI Health Matters Webinar

Michael Parker: SVI Health Matters Webinar Series, November 2022: "Alzheimer's disease". Lay talk to potential donors



Social Media - the last 3 months

20.8 K	1.8%	133	41	159	3
impressions	engagement rate	link clicks	retweets	likes	new followers (Jan)

Publications

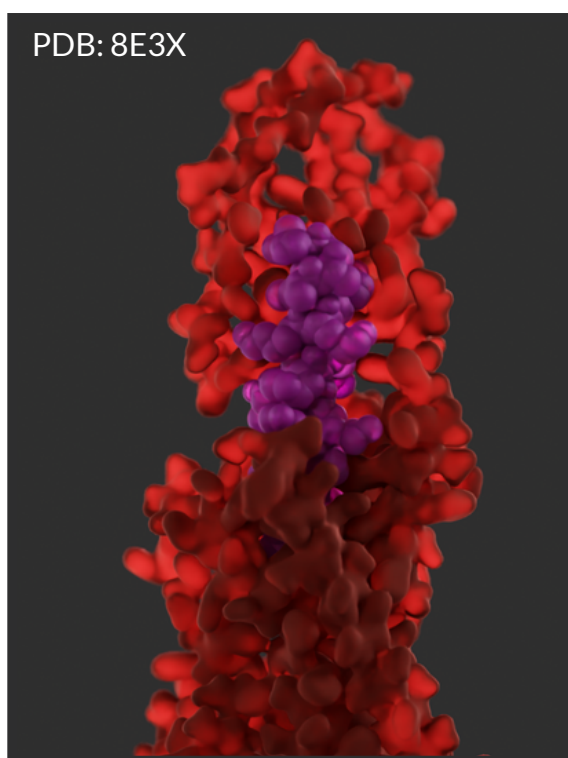
1. **Johnstone BA, Joseph R, Christie MP, Morton CJ, McGuinness C, Walsh JC, Böcking T, Tweten RK & Parker MW** . Cholesterol-dependent cytolysins: The outstanding questions. *IUBMB Life* 74, 1169-1179, 2022.. <https://doi.org/10.1002/iub.2661>
2. **Piper SJ, Deganutti G, Lu J, Zhao P, Liang YL, Lu Y, Fletcher MM, Hossain MA, Christopoulos A, Reynolds CA, Danev R, Sexton PM & Wootten D**. Understanding VPAC receptor family peptide binding and selectivity. *Nat Commun* 13, 7013, 2022. <https://doi.org/10.1038/s41467-022-34629-3>
3. **Cary BP, Zhang X, Cao J, Johnson RM, Piper SJ, Gerrard EJ, Wootten D & Sexton PM**. New Insights into the Structure and Function of Class B1 GPCRs. *Endocrine Reviews*, 2022, <https://doi.org/10.1210/endrev/bnac033>
4. **Jiang Y, Yeasmin M, Gondin AB, Christopoulos A, Valant C, Burger WAC, Thal DM**. Importance of receptor expression in the classification of novel ligands at the M2 muscarinic acetylcholine receptor. *Br J Pharmacol*. First published 22 Dec 2022 . <https://doi.org/10.1111/bph.16021>
5. Kreida S, Narita A, Johnson MD, Tocheva EI, Das A, **Ghosal D** & Jensen GJ. Cryo-EM structure of the *Agrobacterium tumefaciens* type IV secretion system-associated T-pilus reveals stoichiometric protein-phospholipid assembly. (accepted in Structure) *bioRxiv* 2022.09.25.509369; doi: <https://doi.org/10.1101/2022.09.25.509369>
6. Kaplan M, Shepherd DC, Vankadari N, Kim KW, Larson CL, Dutka P, Beare PA, Krzymowski E, Heinzen RA, Jensen GJ, & **Ghosal D**. Structural remodeling of *Coxiella burnetii* during its biphasic developmental cycle revealed by cryo-electron tomography. (in revision) *bioRxiv* 2022.08.23.505044; doi: <https://doi.org/10.1101/2022.08.23.505044>

Published Structures

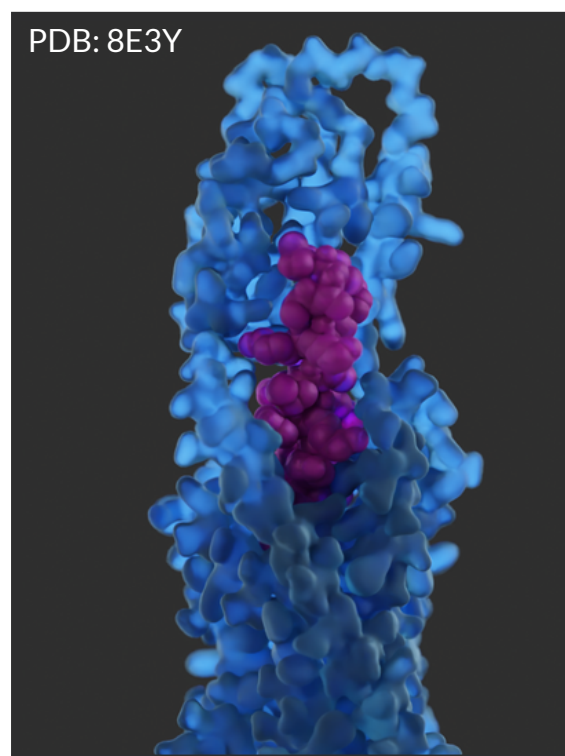
Sarah Piper, Patrick Sexton, Denise Wootten, Radostin Danev PDB 8E3X, PDB 8E3Y, PDB 8E3Z (DOI: 10.1038/s41467-022-34629-3)

Sarah Piper, Patrick Sexton, Denise Wootten, Radostin Danev EMDB-27872, EMDB-27873, EMDB-27874 (DOI: 10.1038/s41467-022-34629-3)

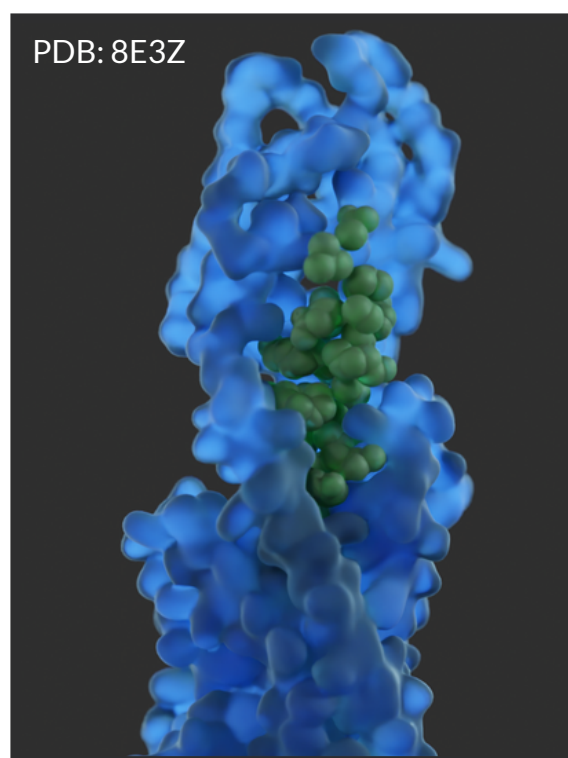
CCeMMP cryo-EM structure image gallery



PAC₁R-PACAP₂₇



VPAC₁R-PACAP₂₇



VPAC₁R-VIP

Image credit: Sarah Piper
(@SarahJ_Piper, @PiperProteins)