



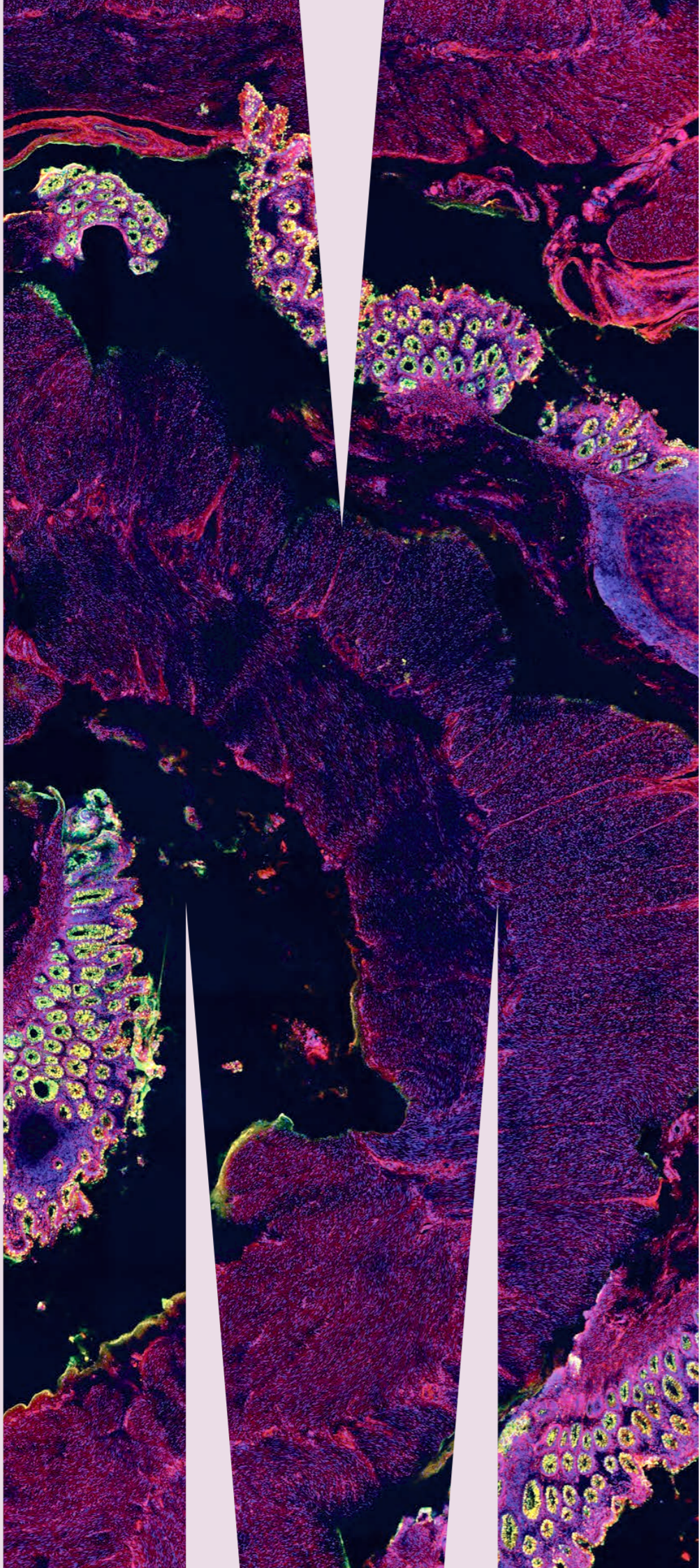
**MONASH**  
University

**MONASH  
INSTITUTE OF  
PHARMACEUTICAL  
SCIENCES**

BETTER  
MEDICINES  
BY DESIGN

2023  
ANNUAL REPORT





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Cover image: Swiss roll preparation of human colon tissue captured on a Leica SP8 confocal microscope using a 20x magnification objective. Image is labelled for DAPI (blue), TFF3 (Green), CLCA1 (Yellow) and WGA (Red).

Credit: Matthew Rowe, PhD student in the DDB Theme.

# MIPS 2023 – BY THE NUMBERS

## RANKING

**#2**

Worldwide, in Pharmacy & Pharmacology  
(QS Ranking by Subject, 2023)

## PEOPLE

**284** Staff  
**255** Research students

## RESEARCH OUTPUTS

**293** Research articles  
**53%** International co-authorship

## RESEARCH GRANTS AND CONTRACTS

**96** Research grants awarded

**\$66.4M** Research income awarded

**\$46M** In Australian Competitive Grant funding

**64** Research contracts

**\$19.6M** in research contracts and international grants

## COMMERCIALISATION

**8** Invention disclosures

**4** Spin-out and start-up companies

**15** Patent families under active management

**7** Licences including options and assignments

## MIPS AT A GLANCE



## RESEARCH THEMES

Drug Discovery Biology

Medicinal Chemistry

Centre for Drug Candidate Optimisation

Drug Delivery, Disposition & Dynamics

Centre for Medicine Use and Safety

## THERAPEUTIC PROGRAM AREAS

Cardiovascular and Metabolic Health

Neuroscience and Mental Health

Global Health

## RESEARCH PLATFORMS

# ABOUT MIPS

The Monash Institute of Pharmaceutical Sciences (MIPS) can trace its roots to 1881 when the Victorian College of Pharmacy opened. Monash University was established in 1958 and in 1992 the College of Pharmacy was merged with the University. In 2008 the College became the Faculty of Pharmacy and Pharmaceutical Sciences and the Monash Institute of Pharmaceutical Sciences was established.

Today, MIPS is a dynamic, innovative and ambitious centre of research and learning, with a growing emphasis on cutting edge projects to deliver societal impact.

As the home of the majority of research activity within the Monash Faculty of Pharmacy and Pharmaceutical Sciences, MIPS brings together more than 500 of the world's best scientists to research drug discovery, design, delivery and use. Our therapeutic strengths lie in neuroscience and mental health, cardiovascular and metabolic health, and global health.

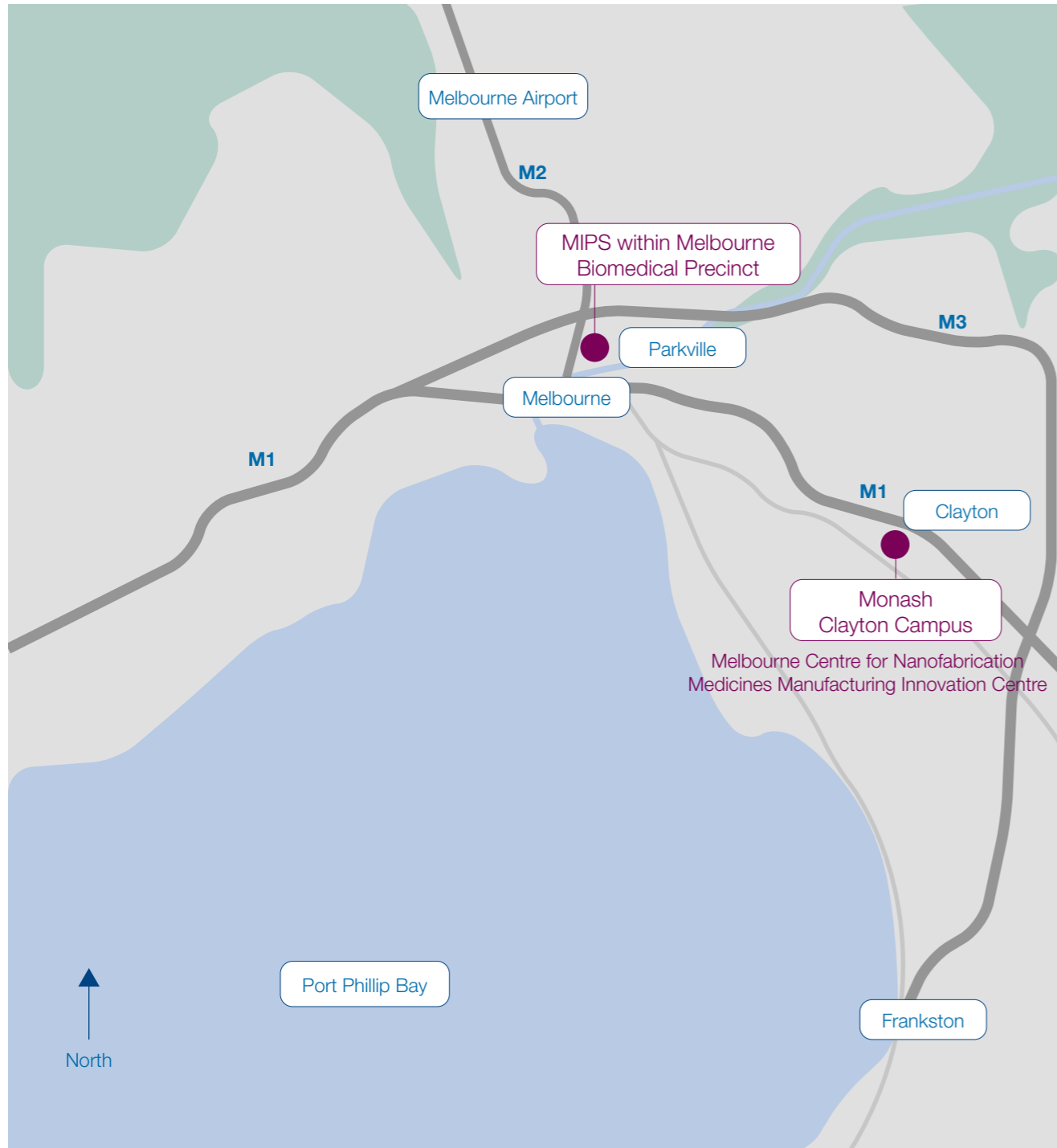
We are committed to research translation and have made major contributions to collaborative drug discovery programs that have progressed more than 35 novel drug candidates into clinical development.

## OUR VALUES

- Innovation and impact**  
 We take excellence as a given. Instead we strive for excellence that is innovative and leads to internationally recognised impact making a difference to the lives of people all over the world.
- Collaboration**  
 We achieve so much more by working with others. We actively seek collaborations within MIPS and Monash more broadly but, vitally, with national and international partners. Our research is better for it.
- Diversity and inclusion**  
 We know that diversity in our people brings better scientific and health outcomes. By fostering an inclusive environment we are developing a culture where all of our staff and students know that they are valued.
- Integrity**  
 Public trust in health research is vital. We earn the trust of our collaborators, as well as health consumers, by upholding the highest standards of integrity and honesty.

## LOCATION

MIPS is housed at the Monash University Parkville campus, the university's most research intensive campus. Close to Melbourne's CBD and part of Australia's top health and biomedical precinct, our neighbours include major hospitals, the University of Melbourne, WEHI, the Florey, the Doherty Institute and CSL Limited. We have a secondary research presence in Clayton at the Melbourne Centre for Nanofabrication and the Medicines Manufacturing Innovation Centre has a node at the nearby Australian Synchrotron.



## MIPS WITHIN THE MELBOURNE BIOMEDICAL PRECINCT PARKVILLE



# DIRECTOR'S MESSAGE

Welcome to the MIPS annual report for 2023. It is a great pleasure to share the highlights of the year and to celebrate the achievements of the remarkable scientists and professional staff at MIPS.

A significant focus for the year was planning for the future and initiation of the planning cycle for the quinquennial review of MIPS activities in 2024. These activities included discussion within the MIPS Themes of the emerging trends in Pharmaceutical Science research over the next several years and culminated in a 2-day off-site planning session in December to crystallise the basis of the MIPS strategic plan. In parallel, we were very excited to announce (mid-year) the purchase by Monash University of 343 Royal Parade, a building many would recognise as previously occupied by CSIRO. This acquisition will provide MIPS with much needed expansion space, and refurbishment plans for the site are being drawn up to support and complement the strategic plan.

You will see in the subsequent pages of this annual report many excellent examples of impactful science, with some key translational highlights including:

- The successful completion of Phase 1 clinical trials for MIPS therapeutic innovations, including an inhaled form of oxytocin and a novel mRNA COVID 19 vaccine.
- Successful completion of a Phase 2a clinical trial for the 'Glyph' lymph targeted prodrug technology, initially developed at MIPS and licenced to PureTech Health.
- Start-up of Pacalis, a new company involved in the optimisation and development of next-generation medicines for mental health disorders.
- Support via the Curator program for xCystence Bio, a Monash spin-out in collaboration with the Smyth group at the Monash Biomedicine Discovery Institute.
- Continued success for Septerna, a US-based start-up focussed on GPCR-targeting drug discovery, which was co-founded by Arthur Christopoulos and Patrick Sexton and which secured \$150M (USD) in a Series B fund raising in 2023.

In addition to the translational and clinical work described above, we continue to focus efforts in the potentially revolutionary area of mRNA therapeutics. In 2023 we started work in earnest on the Victorian mRNA Innovation Hub (VMIH), a collaboration with the University of Melbourne that is funded by mRNA Victoria and seeks to identify novel mRNA and mRNA delivery technologies. We also launched mRNA Core, a Medical Research Future Fund (MRFF) initiative to support the supply of formulated mRNA therapeutics to collaborators across the country. Finally, we were delighted in August to welcome Victoria's Minister for Industry and Innovation, the Hon. Ben Carroll MP, to MIPS to launch the Monash-Moderna Quantitative Pharmacology Accelerator, a five-year collaborative program with Moderna that aims to develop novel quantitative pharmacology approaches to drive advancements in mRNA medicines, including therapeutics and vaccines.

In the broader area of medicinal chemistry, we were also delighted to welcome the Federal Assistant Minister for Health and Aged Care, the Hon. Ged Kearney MP, to MIPS in November to launch MedChem Australia (MCA). This is a first-of-its-kind national initiative, headquartered at MIPS, that connects three of the nation's top medicinal chemistry groups – ourselves, the Walter and Eliza Hall Institute and the University of Sydney. MCA will accelerate promising early-stage drug discovery projects towards clinical trials with the ultimate goal of creating new medicines for a broad range of diseases. MCA is a significant (5-year, \$15M) investment and we are very grateful to the funders (MRFF, Therapeutic Innovation Australia (TIA) and the three academic partners).

Success in the MRFF National Critical Research Infrastructure Scheme in 2023 also allowed a major investment in new infrastructure to support our Drug Target Identification Platform (DTIP). DTIP is based on state-of-the-art 'omics' technologies and supports the Australian drug discovery community to provide efficient and unbiased avenues to the identification of drug targets and biomarkers. Investment in a new Orbitrap 'Astral' Mass Spectrometer, which is only the second in Australia, will dramatically expand the scale and scope of the experiments that the platform can provide.

We also continue to focus on expanding the diversity of the MIPS workforce, and I'd like to take this opportunity to thank the Her Research Matters (HRM) team that was formed at MIPS in 2019. HRM was formed to promote and foster an inclusive and equitable leadership environment for women in academia and has played a key role in encouraging and supporting women to progress into leadership positions across MIPS and the broader Faculty of Pharmacy and Pharmaceutical Sciences. Notably, while we still have work to do, the efforts of HRM and others have led to an increase in the proportion of women Associate Professors and Professors in the Faculty from 23 per cent in 2019, to 36 per cent in 2023.

Finally, we were pleased to see Monash again recognised by the QS World University Rankings by Subjects as a leading institution in Pharmacy and Pharmacology (#2 worldwide in 2023) and to see three MIPS scientists named in the 2023 Clarivate Highly Cited Researcher list. There are also many individual award winners listed in the report. My sincere congratulations to all and great thanks to everyone for their efforts through 2023.

**Professor Christopher J.H. Porter**  
Director



# 2023 HIGHLIGHTS & STAFF ACHIEVEMENTS

## MONASH RANKED #2 IN THE WORLD IN PHARMACY AND PHARMACOLOGY

Monash has retained its position as one of the top universities in the world for Pharmacy and Pharmacology in the 2023 QS World University Rankings by Subject, with a global ranking of #2. The announcement in March of the #2 ranking is the sixth year in a row that Monash has featured in the top three universities in this subject area. Although this ranking reflects the performance of researchers across the whole of the university, with a majority of Monash's pharmacy and pharmacology researchers based in MIPS we can proudly attribute this ranking to the research achievements of our staff and students.

The QS subject rankings are determined by five metrics: citations per publication, H-index, international research network index, academic reputation, and employer reputation. It is the academic reputation score, achieved through surveys of academics across the world, that we are most proud of. This is the sixth year in a row where Monash achieved the top score globally for academic reputation, when rated by our academic colleagues. We acknowledge and greatly appreciate this recognition by our peers.

Thank-you to QS and our international colleagues, and more importantly our researchers for another year of outstanding ranking performance.

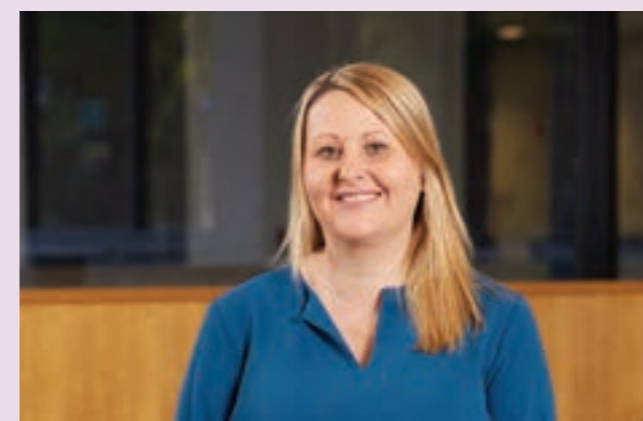


## MIPS RESEARCHER AWARDED A PRESTIGIOUS ARC LAUREATE FELLOWSHIP



2023 saw the commencement of the Professor Nico Voelcker's ARC Laureate Fellowship. The fellowship, one of the most prestigious in Australia, was officially awarded at the end of 2022 and recognises Nico's significant expertise in nanostructured silicon-based wearable and implantable biosensors. Nico was awarded almost \$3.3M and over the next five years his project will design advanced sensors that allow monitoring of more detailed biological signals than current wearable sensors like fitness trackers. People will be able to wear these sensors for long periods of time, either implanted in the body or as a patch on the skin. Nico's aim is to measure changes in the skin to help people make decisions about their health or performance.

## NHMRC RESEARCH EXCELLENCE AWARDS



Professor Patrick Sexton and Professor Denise Wootten were recipients of prestigious Research Excellence Awards from the National Health and Medical Research Council (NHMRC), awarded annually to the highest-ranked researchers following peer review. Patrick was awarded the 2023 NHMRC Peter Doherty Investigator Grant Award (Leadership) for the project 'Structure, function and modulation of peptide hormone G protein-coupled receptors (GPCRs)'. Denise was awarded the 2023 NHMRC Elizabeth Blackburn Investigator Grant Award (Leadership in Basic Science) for the project 'Mechanistic understanding of biased agonism and dimerisation for co-targeting incretin receptors for metabolic diseases'.

## MULTIPLE FELLOWSHIPS AWARDED TO MIPS ECR



One of MIPS' leading young researchers, Dr Arisbel Batista Gondin, was awarded two fellowships this year. In August Arisbel was awarded an Australian Research Council (ARC) Discovery Early Career Researcher Award (DECRA), valued at \$453,237, to study *Molecular insights into the allosteric regulation of opioid receptors*. Then in December, she was awarded a National Health and Medical Research Council (NHMRC) Emerging Leadership Level 1 Investigator fellowship, *Developing safer therapeutic approaches for the treatment of pain via allosteric regulation of opioid receptors*, valued at \$587,040.

Through these related fellowships Arisbel will undertake fundamental scientific research into the foundation of allosteric regulation of opioid receptors before using the outcomes of these studies to develop therapies for the treatment of pain. Arisbel will be commencing these fellowships when she has completed her current Bridge Researcher Exchange and Development within Industry (REDI) Fellowship. The Bridge REDI Fellowship program was funded by the Medical Research Future Fund and equipped researchers and entrepreneurs with the knowledge, skills and networks needed to commercialise new pharmaceuticals. In 2023 Arisbel began her Bridge REDI Fellowship in the Antibody Discovery and Protein Engineering group at CSL Research and upon completion will apply the skills and knowledge she has developed to her ARC DECRA and NHMRC Investigator fellowships.

We are proud of all of our developing researchers and Arisbel exemplifies the excellence of this group within MIPS.

## MONASH GRADUATE ASSOCIATION SUPERVISOR OF THE YEAR AWARD



Dr Cornelia Landersdorfer and her students. L-R: Han (Mary) Le, Jess Tait, Dr Connie Landersdorfer, Bonnie Breen, Dominika Fuhs. Not pictured: Alice Terrill.

The Monash Graduate Association (MGA) is the representative body for all graduate research and coursework students enrolled at Monash University. The MGA is an independent, not-for-profit association governed by graduate students, for graduate students.

Each year the MGA seeks nominations from students for the Supervisor of the Year Award and in 2023 the overall winner, from all supervisors across the University was Associate Professor Cornelia Landersdorfer from the Drug Delivery, Disposition and Dynamics Theme. Her students said of her, 'Connie possesses every trait you can imagine when you think of what a great supervisor could be. She is an incredible role model, especially for young female researchers. Connie has an empowering approach to research; always reminding us that among the mistakes and rejection, it is important to get back up and keep moving forward. Her mentorship has helped us develop our skills both professionally and personally, making us better versions of ourselves every day.'

## VICTORIAN PHARMACIST OF THE YEAR



The Pharmaceutical Society of Australia (PSA) has named CMUS Director Professor Simon Bell as Victorian Pharmacist of the Year. This award is made annually to a pharmacist who has made impressive contributions to the profession and the health of their communities.

Simon led the development of Australia's new Clinical Practice Guidelines for the Appropriate Use of Psychotropic Medications in People Living with Dementia and in Residential Aged Care. He has led a series of large NHMRC and Medical Research Future Fund projects investigating new pharmacist services to improve the quality use of medicines for people living with dementia. Simon has a strong commitment to research capacity building, having mentored 16 successful PhD candidates, many of whom have gone on to accept senior clinical and academic roles. He is also a strong advocate for consumer engagement in research.

The PSA is the only Australian Government-recognised peak national professional pharmacy organisation representing all of Australia's 36,000 pharmacists working in all sectors and across all locations.



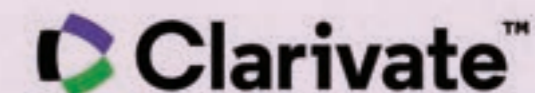
## CLARIVATE™ HIGHLY CITED RESEARCHERS



The annual Clarivate™ Highly Cited Researchers list is a compilation of the most influential scientists in their field, worldwide. In 2023 three MIPS staff were ranked in the top 1% in the field of pharmacology and toxicology - Professor Arthur Christopoulos, Dean of the Faculty of Pharmacy and Pharmaceutical Sciences, Professor Patrick Sexton, and Associate Professor Natalie Trevaskis. For Professors Christopoulos and Sexton this is the third year in a row that they have been named a highly cited researcher, and for Associate Professor Trevaskis her second year in a row.



The annual list uses quantitative and qualitative analysis to identify individuals from across the globe who have demonstrated significant and broad influence in their field of research. Specifically, the Highly Cited Researchers' names are drawn from the publications that rank in the top 1% by citations for field and publication year in the Web of Science citation index over the last decade. Once the author list of highly cited papers is compiled, it is further refined using qualitative analysis and expert judgement.



## MEDCHEM AUSTRALIA



*The Hon. Ged Kearney MP, Assistant Minister for Health and Aged Care, launching MedChem Australia at MIPS in November.*

2023 saw the announcement and launch of MedChem Australia, an initiative backed by \$15 million in funding from the Australian Government and other partners, to accelerate early-stage drug discovery projects, helping translate research into new medicines for various diseases. MedChem Australia is headquartered at MIPS and brings together other medicinal chemistry leaders in Australia - WEHI and the University of Sydney. Along with strategic collaborative partner Therapeutic Innovation Australia, MedChem Australia will support the discovery of new medicines through creativity and collaboration.

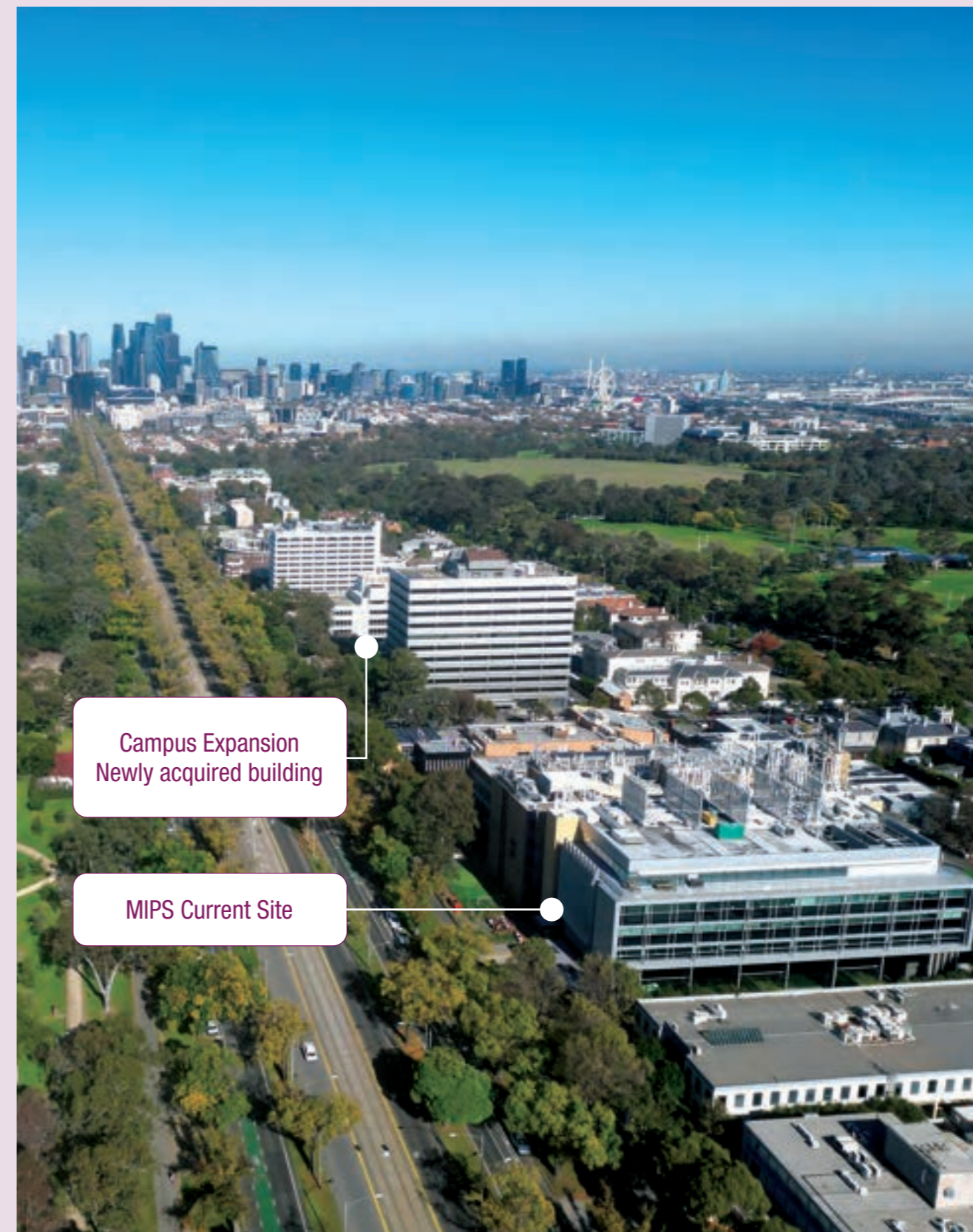
Read more about MedChem Australia and other national collaborations that MIPS leads on page 57.



## MIPS PARKVILLE CAMPUS EXPANSION

In 2023 Monash University acquired a site on Royal Parade in Parkville previously occupied by the CSIRO. The site (343 Royal Parade) is just 150m from MIPS and will increase the size of the Monash Parkville campus by more than 25%. The existing property will be refurbished to support the expansion of MIPS' activities in medicinal chemistry, drug candidate optimisation and neuromedicine discovery. The site will be the new home of MIPS' translational activities, supporting the development of biological advances into preclinical and clinical drug candidates suitable for commercial progression.

The scale of the refurbishment means that it will take a number of years to get the site to the world-class level required for the discovery and development of new medicines. In the meantime, our researchers are excited about the opportunities that the new site will allow for development and expansion of our recent areas of focus, next generation neuromedicines, and novel mechanisms of drug screening and structure-based drug design.



# FACULTY RESEARCH AWARDS

The annual Faculty Research Awards recognise the sustained excellence in research and graduate research of MIPS staff. Staff are nominated by their peers and winners are determined by a sub-committee of Faculty Executive, chaired by the Associate Dean Research. The members of the sub-committee for the 2023 awards were Professor Peter Scammells (Associate Dean Research, Chair), Professor Chris Porter (MIPS Director), Professor Rebecca Ritchie (DDB Theme Leader), Professor Michelle McIntosh (D4 Theme Leader), Associate Professor Ben Capuano (Med Chem Theme Leader), Dr Jenni Ilomäki (CMUS), Dr Amandeep Kaur (Med Chem).

## FACULTY RESEARCH AWARD



Awarded in recognition of a sustained and outstanding contribution to the Faculty's research.

2023 winner - **Professor Colin Pouton**, Drug Delivery, Disposition and Dynamics Theme

Since joining Monash in 2001 Colin has been active in three primary areas: oral delivery systems for poorly water-soluble drugs; nucleic acid delivery systems for therapeutic use; and applications of stem cell technology. In the most recent 5 years Colin's focus has been in mRNA technology for vaccination and therapeutics. He has over 180 publications, with more than 44,000 citations. Over the past three years he has led research grants that have been awarded over \$20M.

## FACULTY AWARD FOR RESEARCH ENTERPRISE



*The Glyph Team. L-R: Associate Professor Natalie Trevaskis, Dr Dan Zhen, Dr Nathania Leong, Viena Ferreira, Dr Garima Sharma, Dr Enyuan Cao, Xiaotong Zhou and Professor Chris Porter. Not pictured: Dr Mitchell McInerney, Dr Luojuan Hu and Dr Sifei Han are not pictured.*

Awarded in recognition of excellence in innovation and collaboration, and successful partnership with industry, government or other external organisation.

2023 winners - PureTech Prodrug Team: **Professor Chris Porter, Associate Professor Natalie Trevaskis, Dr Sifei Han, Dr Enyuan Cao, Dr Dan Zheng, Dr Nathania Leong, Dr Garima Sharma, Dr Mitchell McInerney and Dr Xiaotong Zhou**, all from D4.

The outstanding work of the PureTech Prodrug team was also recognised in the University research awards where the team won the 2023 award in the same category. Congratulations to the whole team!

The team worked to optimise a technology that targets drugs to the lymphatic system by forming prodrugs that mimic the structure of dietary lipids. These prodrugs can dramatically enhance the oral bioavailability of drugs and target critical immune tissues in the gut. The IP developed was licensed to PureTech Health in 2017 and the technology has since been validated through clinical trials, focusing on the treatment of anxiety and post-partum depression.

## EARLY CAREER RESEARCH AWARD



Awarded in recognition of excellence by an early career researcher (less than 10 years post-PhD) who has achieved outstanding research excellence and impact.

2023 winner - **Dr Daniel Priebbenow**, Med Chem

Dan's research employs advanced synthetic technologies including photocatalysis and transition-metal catalysis to explore novel modes of chemical reactivity and develop more efficient and sustainable strategies to access existing therapeutics and new methods to access unique molecular scaffolds in the pursuit of novel therapeutics. Dan's research excellence and innovation has been widely recognised by the scientific community through a series of fellowships and awards amounting to more than \$700,000 in funding.

## EMERGING EARLY CAREER RESEARCH AWARD



Awarded in recognition of excellence by an early career researcher (less than 5 years post-PhD) who has achieved research excellence.

2023 winner - **Dr Amanda Cross**, CMUS

Amanda's research focus is to improve knowledge translation of evidence and guidelines into practice to reduce medication-related harm for people living with dementia and in residential aged care. A key part of this research program involves exploring novel roles for pharmacists to act as 'knowledge brokers' to facilitate knowledge translation. She has a strong publication track record, having authored 30 publications, including 16 as first author and one as senior author. Her work is published in top-quartile journals. Amanda has secured over \$4.7M in research funding as a chief investigator.

## EARLY CAREER RESEARCHER PUBLICATION AWARD



Awarded for in recognition of publication excellence by researchers up to 5 years post-PhD.

2023 winner - **Dr Jianjun (Jason) Cao**, DDB

Amongst Jason's achievements is a first author publication in the prestigious journal *Science* during his PhD. The publication *A structural basis for amylin receptor phenotype* (DOI:10.1126/science.abm9609) details the work to advance the development of potential treatment for obesity by targeting amylin receptors. As the first author, Jason Cao conducted a majority of the laboratory experiments involving protein generation, analysed the cryo-EM data, and drafted and edited the manuscript.

## FACULTY AWARD FOR EXCELLENCE IN POSTGRADUATE SUPERVISION



Awarded to staff who have demonstrated exceptional supervision, mentoring and training practices to benefit and enrich the experiences of their graduate research students. Nominations for this award must be submitted by a graduate research student

2023 winner - **Associate Professor Natalie Trevaskis**, D4

In 5 years, Natalie has supervised 16 PhD, 1 Masters and 7 Honours students, with 8 PhD completions to date. Her students come from a diverse range of cultural, linguistic, religious and educational backgrounds. Twelve of 16 PhD students are women. Natalie has fostered a strong sense of community within her group and she motivates her PhD students to complete on time and all have passed with minor revisions. Her students have benefited from the novel projects, ideas and translational training opportunities that her research program has generated and have published exceptional papers. Natalie's PhD graduates have leading roles in industry and academia.

## FACULTY PROFESSIONAL RESEARCH AWARD



Awarded to professional staff members who have made outstanding contributions to the success of Monash research.

2023 winner - **Dr Leanne Hawkey**, Med Chem.

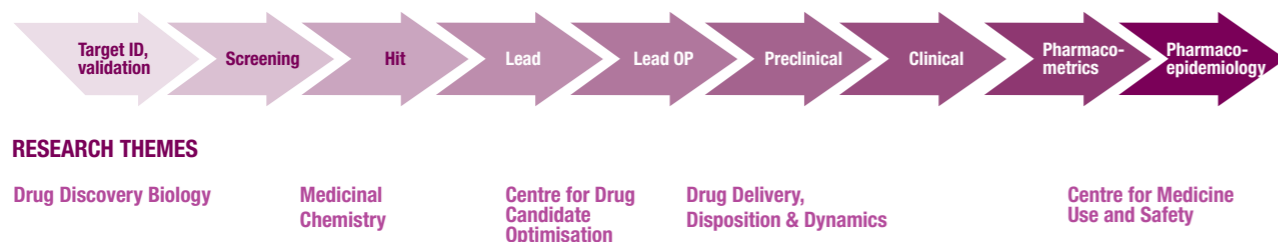
Not only was Leanne the winner of the Faculty award, but she was also the overall winner in the University research awards recognising the vital contribution she makes to research. Congratulations Leanne!

Leanne has actively supported Monash's research efforts in several professional capacities since 2011, and from early 2020 has focused her energies towards advancement of early-stage drug development programs within the Australian Translational Medicinal Chemistry Facility (ATMCF). Through Leanne's leadership and guidance, the ATMCF has grown, supporting more than 20 collaborative medicinal chemistry/drug discovery projects per year across a range of clinical areas, encompassing cross-faculty and multi-institutional project teams. Leanne also supports the creation and submission of many grant applications, resulting in the award of several major opportunities including the MRFF funded MedChem Australia initiative.



# RESEARCH THEMES

The MIPS Themes are the homes of our research expertise. Each Theme contributes to the drug discovery, development, and use activities of the Institute.



**DRUG DISCOVERY BIOLOGY (DDB)**

**MEDICINAL CHEMISTRY (MED CHEM)**

**CENTRE FOR DRUG CANDIDATE OPTIMISATION (CDCO)**

**DRUG DELIVERY, DISPOSITION AND DYNAMICS (D4)**

**CENTRE FOR MEDICINE USE AND SAFETY (CMUS)**



## DRUG DISCOVERY BIOLOGY



Grants awarded

**19**

Staff

**91**

Total research income

**\$17,735,610**

Publications

**70**

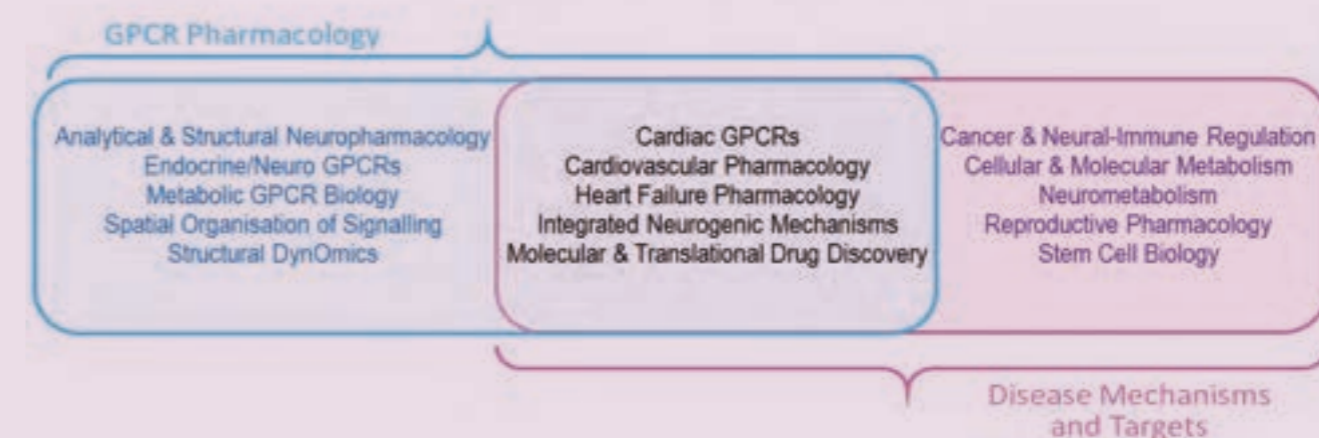
Theme Leader: **Professor Rebecca Ritchie**

The Drug Discovery Biology Theme (DDB) comprises over 90 research staff and 40 research students. Research undertaken within the 15 DDB laboratories falls broadly into two overarching areas, GPCR Pharmacology and Disease Mechanisms and Targets, with international leaders in each of these. Several research groups bridge both major areas—drug discovery is the common focus. DDB research is supported by major research grant and fellowship support, including from the Australian Research Council, the National Health and Medical Research Council, the Medical Research Future Fund, Diabetes Australia, and the Heart Foundation of Australia.

DDB incorporates the headquarters of the Neuromedicine Discovery Centre (NDC). The NDC is a national collaboration to discover and translate a new generation of trusted, evidence-based medicines and therapies for those experiencing mental health conditions.

The activities of the NDC in 2023 is detailed on page 54.

## Drug Discovery Biology



DDB researchers undertake significant outreach activities across media engagement, consumer and community engagement, and participation and fundraising in major charity events, for example the Mother's Day Classic, Tour de Cure, Melbourne Marathon, and The Bloody Long Walk.



DDB research has a sustained impact on the understanding and treatment of major global health burdens, with principal therapeutic focus areas comprising neurological disease, cardiovascular disease and metabolic disease. Pain, inflammatory disease and cancer represent additional areas of research attention. DDB's major multidisciplinary and complementary areas of expertise, held in high international regard, include:

- Pharmacology
- Structural biology
- Target identification and
- Translational science.



One of the standout areas for which DDB has been well-recognised is the Theme's specialist expertise with respect to the structure and function of G protein-coupled receptors, including novel aspects of receptor signaling such as the role of allostery and bias. Further, DDB's multidisciplinary expertise as applied particularly to neuroscience, metabolic and cardiovascular disease continues to make major inroads identifying key genes, proteins and pathways important in metabolic disease, as well as the development of new treatments for heart failure resulting from interruptions in coronary blood supply (such as in heart attack) or as a result of diabetes, obesity or hypertension.

DDB serves as the headquarters of the ARC Industrial Transformation Training Centre for Cryo-Electron Microscopy of Membrane Proteins for Drug Discovery, a national training centre with collaborators from the University of Melbourne, WEHI and the University of Wollongong and research partners including AstraZeneca, Servier and Thermo Fisher Scientific.

## MAJOR SCIENCE OF 2023

The major scientific achievements of DDB each year are celebrated by two major annual one-day events, the student-led DDB Scientific Student Symposium as well as the Theme-wide DDB Symposium. The 2023 DDB Symposium had 110 attendees, with outstanding presentations from 45 HDR students. DDB Student Symposium award winners included Chantel Mastos (Best HDR Oral presentation), Monica Suehiro (Best HDR Poster presentation) and Chloe Landy (Best HDR 3-Minute Thesis presentation). The DDB Symposium is inspired by and is designed to complement the highly successful annual DDB Scientific Student Symposium, and featured exemplary research presentations from 13 DDB academic researchers, including ECRs Dr Samantha McNeill, Dr Anh Nguyen, Dr Sheng Yu Ang, Dr Anida Velagic; MCRs Dr Elva Zhao, Dr Sarah Turpin-Nolan, Dr Matthew Belousoff, Dr Simona Carbone; and senior scientists Dr Sab Ventura, Dr Celine Valant, Dr John Scott, Dr Helena Qin and Dr David Thal. In addition to these events, the major science emerging from DDB is showcased by the impressive array of publications, a select group of which are highlighted on pages 22-24.



## MAJOR AWARDS AND OTHER ACHIEVEMENTS OF 2023

Several DDB researchers were recipients of major awards in 2023. Key highlights include:

- Prof Patrick Sexton: NHMRC Peter Doherty Investigator Grant Award (top-ranked Leadership Investigator Award); Clarivate™ Analytics Highly Cited Researcher, Pharmacology & Toxicology; American Chemical Society Gordon Hammes Lectureship
- Prof Denise Wootten: NHMRC Elizabeth Blackburn Investigator Grant Award (top-ranked Leadership Investigator Award - Basic Science)
- Prof Arthur Christopoulos: Clarivate Analytics Highly Cited Researcher, Pharmacology & Toxicology
- Prof Rebecca Ritchie: NHMRC Ideas grant
- A/Prof Michelle Halls: ARC Discovery Project, British Pharmacological Society Geoffrey Burnstock Prize
- Dr Chengxue (Helena) Qin: Diabetes Australia Millenium Type 2 Award
- Dr Arisbel Batista Gondin: ARC Discovery Early Career Researcher Award, NHMRC Emerging Investigator Award
- Dr Wessel Burger: Mollie Holman Award for Best Doctoral Thesis in the Faculty
- Felix Bennetts: World Congress of Pharmacology ECR Oral Prize



## SELECTED PUBLICATION HIGHLIGHTS

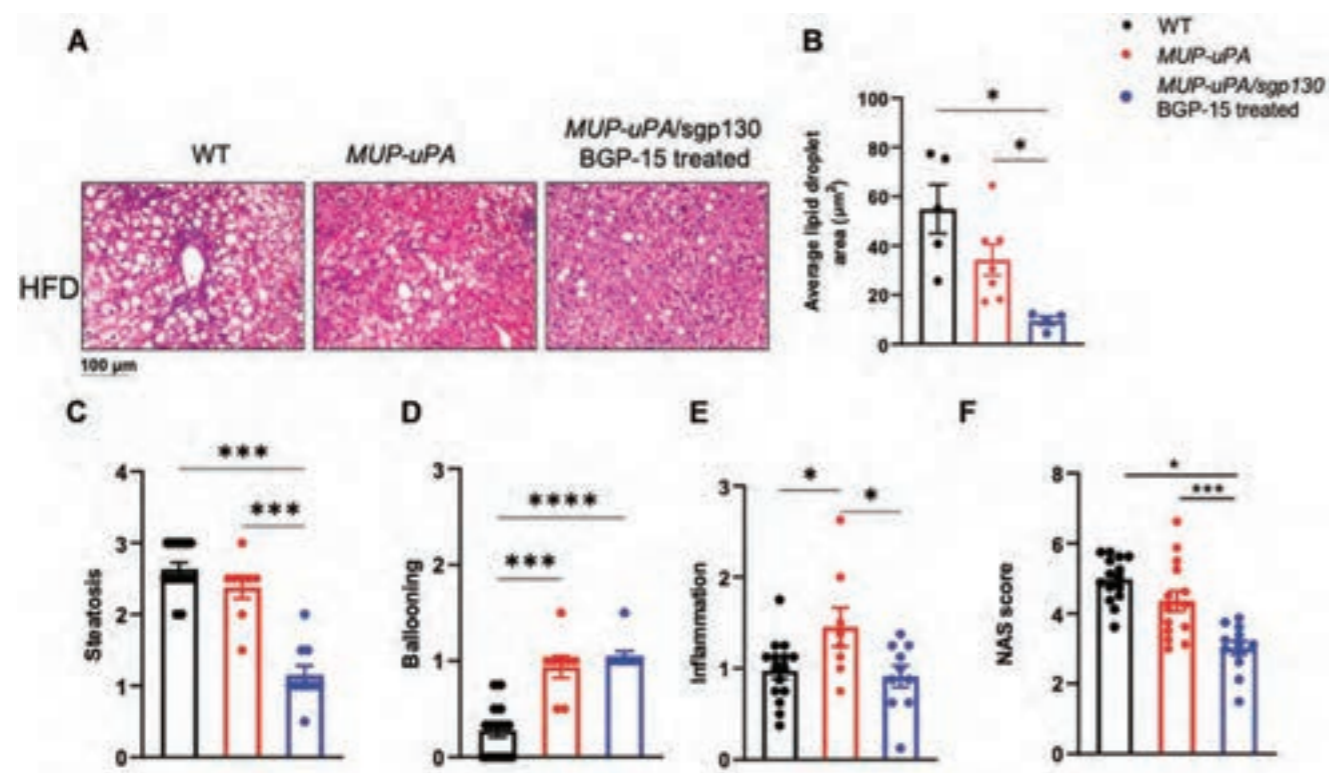
These original research works, published in prestigious leading journals, showcase a small selection of DDB's multidisciplinary areas of expertise and key achievements for 2023. They represent only a fraction of the more than 60 publications from the Theme.

### THERAPEUTIC BLOCKADE OF ER STRESS AND INFLAMMATION PREVENTS NASH AND PROGRESSION TO HCC



Boslem E, Reibe S, Carlessi R, Smeuninx B, Tegegne S, Egan CL, McLennan E, Terry LV, Nobis M, Mu A, Nowell C, Horadagoda N, Henstridge DC, Mellett NA, Timpson P, Jones M, Denisenko E, Forrest ARR, Tirnitz-Parker JEE, Meikle PJ, Rose-John S, Karin M, Febbraio MA. Science Advances. 2023 Sep 15;9(37):eadh0831. doi: 10.1126/sciadv.adh0831

The incidence of hepatocellular carcinoma (HCC) is rapidly rising largely because of increased obesity leading to nonalcoholic steatohepatitis (NASH). In this study a mouse model was used that mimics human NASH-driven HCC. DDB researchers and their colleagues observed activation of endoplasmic reticulum (ER) stress and inflammation in a subset of hepatocytes that was enriched in mice that progress to HCC. They next treated mice with the ER stress inhibitor BGP-15 and soluble gp130Fc, a drug that blocks inflammation by preventing interleukin-6 trans-signaling. They showed that this combined therapy reversed NASH and reduced NASH-driven HCC.

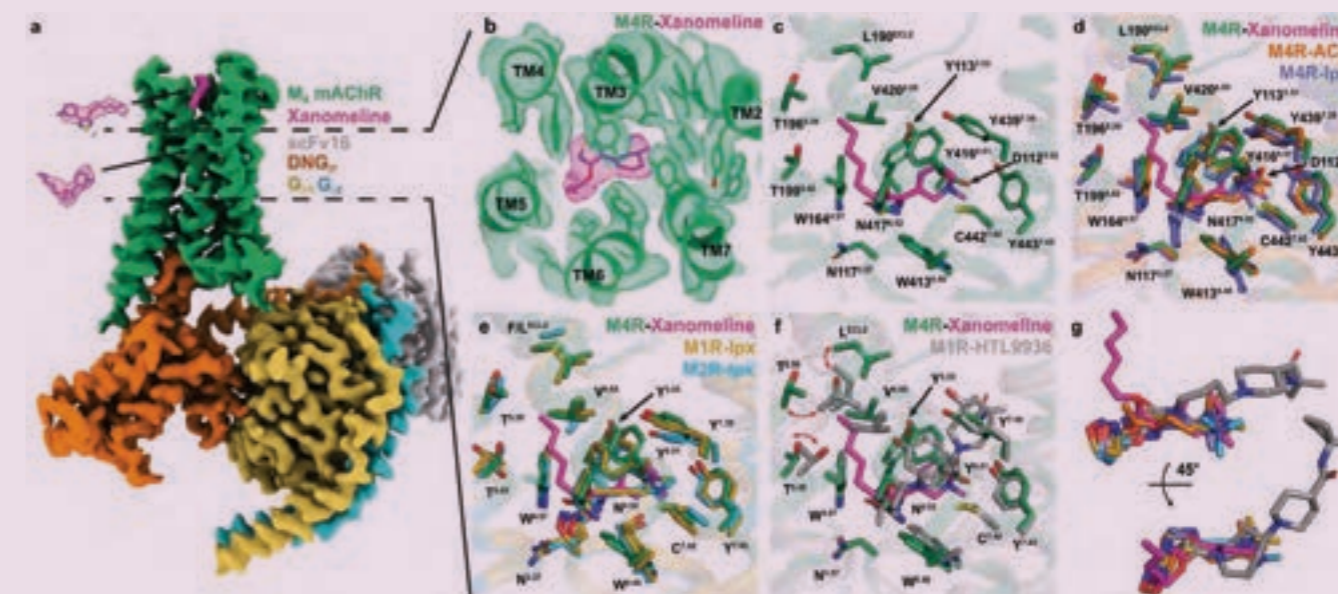


### XANOMELINE DISPLAYS CONCOMITANT ORTHOSTERIC AND ALLOSTERIC BINDING MODES AT THE M4 MACHR



Burger WAC, Pham V, Vuckovic Z, Powers AS, Mobbs JI, Laloudakis Y, Glukhova A, Wootten D, Tobin AB, Sexton PM, Paul SM, Felder CC, Danev R, Dror RO, Christopoulos A, Valant C, Thal DM. Nature Communications. 2023 Sep 6;14(1):5440. doi: 10.1038/s41467-023-41199-5

The M4 muscarinic acetylcholine receptor (M4 mAChR) is expressed in regions of the brain involved in the regulation of psychosis, cognition, and addiction. The mAChR agonist, xanomeline, has provided significant improvement in a Phase II clinical trial for the treatment of patients suffering from schizophrenia. DDB researchers determined the active state cryo-EM structure of xanomeline bound to the human M4 mAChR in complex with the heterotrimeric Gi1 transducer protein. Unexpectedly, two molecules of xanomeline were found to concomitantly bind to the monomeric M4 mAChR, with one molecule bound in the orthosteric (acetylcholine-binding) site and a second molecule in an extracellular vestibular allosteric site. Molecular dynamic simulations supports the structural findings, and pharmacological validation confirmed that xanomeline acts as a dual orthosteric and allosteric ligand at the human M4 mAChR.

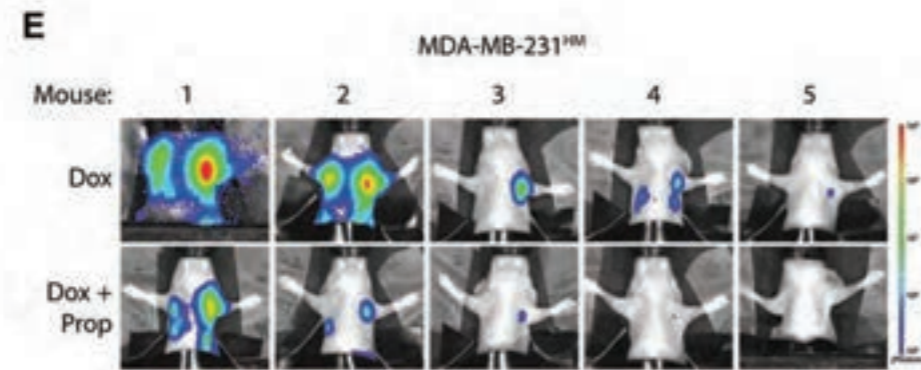
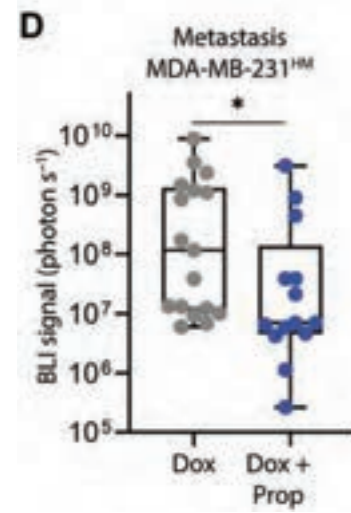


BETABLOCKADE ENHANCES ANTHRACYCLINE CONTROL OF METASTASIS IN TRIPLE-NEGATIVE BREAST CANCER



Chang A, Botteri E, Gillis RD, Löfling L, Le CP, Ziegler AI, Chung NC, Rowe MC, Fabb SA, Hartley BJ, Nowell CJ, Kurozumi S, Gandini S, Munzone E, Montagna E, Eikelis N, Phillips SE, Honda C, Masuda K, Katayama A, Oyama T, Cole SW, Lambert GW, Walker AK, Sloan EK. Science Translational Medicine. 2023 Apr 26;15(693):eadf1147. doi: 10.1126/scitranslmed.adf1147 Epub 2023 Apr 26. PMID: 37099632.

Triple-negative breast cancer (TNBC) is an aggressive subtype of breast cancer. TNBCs are innervated and often express  $\beta$ 2-adrenoceptor ( $\beta$ 2AR); however, beta-blockers have yet to be explored in conjunction with current standard therapy, anthracycline chemotherapy, for TNBC. DDB researchers evaluated this combination therapy saw that beta blockade enhanced efficacy of anthracycline chemotherapy for TNBC by reducing metastasis and represents a potential therapeutic strategy.



## MEDICINAL CHEMISTRY



Theme Leader: **Associate Professor Ben Capuano**

The major areas of research focus for the Medicinal Chemistry Theme (Med Chem) are in synthetic medicinal chemistry, structure-based drug design, fragment screening and academic drug discovery. Our research strengths also include peptide science, chemical-biology and computational chemistry.

As well as the significant number of academic groups conducting cutting edge basic and translational research, the Medicinal Chemistry Theme is home to two of Monash University's Research Platforms. The Monash Fragment Platform conducts early stage hit-identification and uses a range of different biophysical methods to characterise binding interactions. The Australian Translational Medicinal Chemistry Facility supports hit optimisation and hit-to-lead programs. The theme also headquarters the MRFF-funded initiative MedChem Australia, which, in partnership with WEHI and the University of Sydney, is a national medicinal chemistry capability to support drug discovery.

Research in Med Chem has led to the spin out of several start-up companies including Cincera, Ankere and Inosi Therapeutics, to develop novel agents to treat metabolic disease and fibrosis.

Grants awarded

**14**

Staff

**48**

Awarded research income

**\$14,274,551**

Publications

**42**



## MAJOR SCIENCE OF 2023

The science achievements in the Medicinal Chemistry Theme in 2023 are best captured in the following three papers. The papers showcase the expertise and capabilities within the Theme as well as the range of diseases where this expertise can be applied, specifically cancer, malaria and drug discovery in general.

**HIGHLIGHT PAPER:** RAPID ELABORATION OF FRAGMENTS INTO LEADS APPLIED TO BROMODOMAIN-3 EXTRA-TERMINAL DOMAIN



Adams, LA, Wilkinson-White, LE, Gunzburg, MJ, Headey, SJ, Mohanty, B, Scanlon, MJ, Capuano, B, Mackay, JP & Doak, BC 2023. Journal of Medicinal Chemistry. <https://doi.org/10.1021/acs.jmedchem.3c00137>

Fragment-based drug discovery has proven to be a successful strategy, with a growing number of approved drugs originating from fragment-based projects. The development of low-affinity fragment hits into higher-affinity leads is a major hurdle in fragment-based drug design. Researchers in the Monash Fragment Platform have developed a strategy to address this hurdle, termed Rapid Elaboration of Fragments into Leads (REFIL). REFIL employs a systematic workflow to elaborate fragment hits and generate higher-affinity binding molecules. The approach is target-agnostic and can be applied even in the absence of structural information. The workflow involves the selection of commercial analogues of fragment hits to generate preliminary structure-activity relationships. This is followed by parallel microscale chemistry using chemoinformatically designed reagent libraries to rapidly explore chemical diversity. This workflow was applied to identify ligands for the extra-terminal domain of bromodomain-3 (BRD3-ET). This enabled the identification of a series of ligands that bind to BRD3-ET. Using this approach, an improvement of >30-fold in binding affinity was achieved in a single round of library synthesis.

**HIGHLIGHT PAPER:** RATIONALLY DESIGNED CHIMERIC PI3K-BET BROMODOMAIN INHIBITORS ELICIT CURATIVE RESPONSES IN MYC-DRIVEN LYMPHOMA



D.H. Oh, X. Ma, S.J. Hogg, J. He, C. Kearney, D. Brasacchio, O. Susanto, B. Maher, I.G. Jennings, A. Newbold, P. Fraser, E. Gruber, L.M. Kats, G.P. Gregory, R. W. Johnstone, P.E. Thompson, J. Shortt, 2023. Proceedings of the National Academy of Science, USA. <https://doi.org/10.1073/pnas.2306414120>

Combination treatments in cancer are important for increasing effectiveness and overcoming resistance. Working with collaborators at Monash University's School of Clinical Sciences at Monash Health and the Peter MacCallum Cancer Centre, Med Chem researchers identified a truly synergistic drug combination, then generated a hybrid compound that provided this dual activity in a single molecule. The effect is much greater than would be predicted by the usual approach of combining two different drugs and minimal side effects were observed. This means we can more effectively kill cancer cells while minimising toxicity to normal cells. The project has focussed on blood cancers such as leukaemia, lymphoma and multiple myeloma. Further experiments will encompass other cancer types such as breast and colon and progression through pre-clinical development. The design and development of such dual-target molecules is a technically demanding challenge encompassing multiple disciplines around medicinal chemistry.

**HIGHLIGHT PAPER: STRUCTURE-BASED DEVELOPMENT OF POTENT PLASMODIUM FALCIPARUM M1 AND M17 AMINOPEPTIDASE SELECTIVE AND DUAL INHIBITORS VIA S1' - REGION OPTIMISATION**



Calic, PPS, Vinh, NB, Webb, CT, Malcolm, TR, Ngo, A, Lowes, K, Drinkwater, N, McGowan, S & Scammells, PJ 2023, 'Structure-based development of potent Plasmodium falciparum M1 and M17 aminopeptidase selective and dual inhibitors via S1' - region optimisation', *European Journal of Medicinal Chemistry*, vol. 248, 115051. <https://doi.org/10.1016/j.ejmech.2022.115051>

Malaria is a mosquito-borne disease caused by a parasite and remains a global health threat. The growing resistance to artemisinin-based therapies urgently calls for therapeutic agents with novel mechanisms of action. The plasmodium metalloaminopeptidases (PfA-M1 and PfA-M17) have been identified as attractive new antimalarial drug targets as inhibition of these enzymes results in antiplasmodial activity. This study has sought to improve the enzymatic inhibitory properties and the drug-likeness of a previously identified novel hydroxamic acid containing scaffold by introducing designed polar moieties into the S1' region of the enzyme active site. Structure-based compound design led to the identification of a variety of novel hydroxamic acids that show improved inhibitory activity against PfA-M1 and PfA-M17, in addition to displaying antiplasmodial activity. Bioisosteric replacement of the biaryl ring system with a bromophenyl moiety resulted in increased potency compared to the reference compound. Further modifications resulted in potent selective PfA-M1 inhibitors. These findings establish the importance of the previously under-utilised S1' domain and will aid the design of future PfA-M1 and PfA-M17 inhibitors.

**HIGHLIGHTS FROM SPINOUTS CINCERA & ANKERE**

- Cincera: completed drug candidate mechanism of action studies in July 2023 and initiated preclinical development activities in the second half of 2023. Cincera has raised Series B investment of between \$20-30M. This has been facilitated by the successful attainment of a \$500,000 CUREator grant in April 2023. This program of work has been shortlisted for a CUREator+ grant of \$5M to bring a small molecule to clinical trials.
- Ankere: Completed proof-of-concept studies in pulmonary arterial hypertension models (AK012) by September 2023, generated an advanced lead series and secured Tranche 2 funding from investors (IPG and Brandon Capital). This program received \$400,000 extension funding to facilitate proof-of-concept studies in 2023.



Professor Bernie Flynn and the Ankere team.

**MAJOR AWARDS AND OTHER ACHIEVEMENTS OF 2023**

- Australia and New Zealand Society for Magnetic Resonance Medal 2022 awarded to Professor Martin Scanlon: The medal is designed to recognise outstanding contributions to magnetic resonance in Australia or NZ.
- The Medical Research Future Fund backs new national venture, MedChem Australia, to strengthen homegrown medicine outcomes - Professors Stuppel, Monahan (both Med Chem) & Charman (CDCO)
- Drug discovery platform receives funding, providing a new approach for infectious and chronic disease treatments (CUREator) - Professors Flynn, Scanlon (both Med Chem) & Pouton (D4)
- Australian Research Council Discovery Project successes:
  - > Dr Dan Priebbenow (Med Chem)
  - > Associate Professor Michelle Halls (DDB) and Professor Martin Scanlon (Med Chem)
- Early career researcher awarded nearly \$1M in funding by the ARC - Dr Chris Smedley
- Faculty Early Career Researcher Award - Dr Dan Priebbenow.



**HIGHLIGHT PAPERS**

The Theme recognises the importance of fostering the next generation of researchers and highlights three papers in 2023 led by Med Chem early and mid-career researchers.

Jörg, M, van der Westhuizen, ET, Lu, Y, Christopher Choy, KH, Shackelford, DM, Khajehali, E, Tobin, AB, Thal, DM, Capuano, B, Christopoulos, A, Valant, C & Scammells, PJ 2023, 'Design, synthesis and evaluation of novel 2-phenyl-3-(1H-pyrazol-4-yl)pyridine positive allosteric modulators for the M4 mAChR', *European Journal of Medicinal Chemistry*, vol. 258, 115588. <https://doi.org/10.1016/j.ejmech.2023.115588>

Atkin, L & Priebbenow, DL 2023, 'The Indenyl Effect: Accelerated C-H Amidation of Arenes via Ind<sup>3+</sup>Rh(III) Nitrene Transfer Catalysis', *Angewandte Chemie - International Edition*, vol. 62, no. 23, e202302175. <https://doi.org/10.1002/anie.202302175>

Adams, LA, Wilkinson-White, LE, Gunzburg, MJ, Headey, SJ, Mohanty, B, Scanlon, MJ, Capuano, B, Mackay, JP & Doak, BC 2023, 'Rapid Elaboration of Fragments into Leads Applied to Bromodomain-3 Extra-Terminal Domain', *Journal of Medicinal Chemistry*, vol. 66, no. 8, pp. 5859-5872. <https://doi.org/10.1021/acs.jmedchem.3c00137>



## CENTRE FOR DRUG CANDIDATE OPTIMISATION



Theme Leader: **Professor Sue Charman**

The Centre for Drug Candidate Optimisation (CDCO) fosters drug discovery innovation through multidisciplinary collaboration with commercial partners, not-for-profit organisations and academic research institutes. The CDCO specialises in characterising physicochemical, biopharmaceutical and pharmacokinetic properties of candidate molecules to guide and inform medicinal chemistry and biology and translate promising molecules into drug candidates suitable for clinical development.

The CDCO utilises industry-standard approaches and protocols for in vitro ADME and in vivo pharmacokinetic platforms to fulfil candidate selection and progression criteria. These include in vitro chemical screens to assess solubility, partitioning, ionisation, and stability; in vitro assays to assess drug metabolism, enzyme inhibition, permeability, and protein binding, and in vivo assessment of drug absorption, disposition, clearance and bioavailability.

The CDCO contributes to the discovery and optimisation of drug candidates to treat infectious diseases, cancer, CNS disorders, cardiovascular and metabolic disease. In 2023, the CDCO celebrated 20 years of successful collaboration with national and international drug discovery teams. Over this time CDCO has contributed to the advancement of 42 compounds into clinical development and the registration of two new drugs.

Grants awarded

6



New contracts awarded

17



Total research income

\$3,493,126



Publications

9



Staff

23

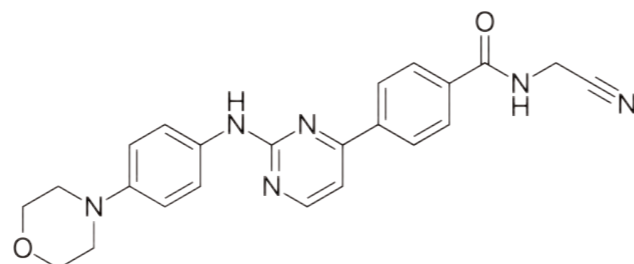


## MAJOR SCIENCE OF 2023

### MOMELOTINIB

A drug discovered by Australian researchers for the treatment of bone marrow cancer was approved by the US Food and Drug Administration (FDA). The program that delivered Momelotinib began in the late 1990s when Prof Andrew Wilks and Dr Chris Burns launched the Australian biotech, Cytopia. Monash researchers became involved in the project with the launch of the CDCO in 2003.

According to Prof Wilks, 'In the early 2000s, when the CDCO was first established, the timing was right for us to collaborate with Prof Charman and her team to help progress the compound series that ultimately led to Momelotinib; these were the necessary first steps in its voyage to becoming a treatment for patients living with myelofibrosis - a rare and poorly understood disease. Our work with the CDCO was an early catalyst propelling the discovery programme towards its stellar clinical success.'



### CTx-648

An international team of researchers, led by Pfizer in collaboration with Monash University and the Australian-based Cancer Therapeutics Cooperative Research Centre, have discovered a pre-clinical drug candidate demonstrating anti-tumour activity in Estrogen Receptor (ER) positive breast cancer models. The study, published in *Cell Chemical Biology*, describes the identification of a highly potent, selective and orally bioavailable 'KAT6A/B' inhibitor called 'CTx-648' which led to promising tumour growth inhibition in ER-positive breast cancer models in mice. The team from the CDCO led by Prof Susan Charman played a critical role profiling the physicochemical, metabolic and pharmacokinetic properties of candidate compounds to inform medicinal chemistry design strategies for compound optimisation.



### DNDI-6174:



An international study, co-led by Monash University CDCO researchers, has reported the discovery and preclinical development of a potential drug candidate to target leishmaniasis, a complex vector-borne disease in which *Leishmania* parasites are transmitted through the bite of female phlebotomine sandflies.

Leishmaniasis affects some of the world's poorest people and comes in three forms, including visceral leishmaniasis which, if left untreated, is nearly always fatal. New drugs for visceral leishmaniasis that are safe, low cost and adapted to the field are urgently required.

The study published in *Science Translational Medicine* describes how the team identified DNDI-6174 - an inhibitor of *Leishmania* - along with data to support its selection as a potential drug candidate for visceral leishmaniasis.

## MAJOR AWARDS AND OTHER ACHIEVEMENTS OF 2023

### MEDCHEM AUSTRALIA:

A Medical Research Future Fund (MRFF) National Critical Research Infrastructure grant of \$9.75 million was awarded to establish MedChem Australia, a new national medicinal chemistry initiative that will be headquartered at MIPS and will bring together leading medical chemistry groups from MIPS, WEHI and the University of Sydney along with the CDCO. Co-funding from Therapeutic Innovation Australia (TIA) and the three partner institutes brings the total seed funding to ~ \$15 million over five years. MedChem Australia will help to fill a significant capacity gap in the drug discovery pipeline between drug discovery biology programs and the generation of defined and optimised drug candidates that have the potential (and value) to attract the commercial partnerships necessary for clinical development.

### AUSTRALIAN CENTRE FOR TARGETED THERAPEUTICS:

Monash and the CDCO are partnering with WEHI and the Children's Cancer Institute through a new frontier technology centre that is set to revolutionise drug development for metastatic prostate cancer and childhood neuroblastoma. In 2023 the Australian Centre for Targeted Therapeutics was awarded \$15 million from the MRFF Frontier Health and Medical Research initiative to develop targeted protein degrader medicines and technology, a powerful new tool for destroying disease-causing proteins that cannot be targeted by conventional drugs.



## DRUG DISCOVERY, DISPOSITION AND DYNAMICS



Theme Leader: **Professor Michelle McIntosh**

The Drug Delivery, Disposition and Dynamics (D4) Theme is focused on designing and developing drug delivery systems that efficiently target drugs to the right place at the right time, be that via oral administration, inhalation or injection.

D4 are leaders in drug delivery and nanomedicine and have particular strengths in lipid based drug delivery and lymphatic transport.

D4 major programs address the challenges of:

- delivering drugs that have very low solubility
- switching the need to administer drug by injection to using other routes such as inhalation
- better understanding the subcellular trafficking of drug molecules
- targeting anticancer medicines to tumours
- understanding drug transport into the brain
- profiling the relationship between delivery system structure and function using field-leading analytical capabilities such as the Australian Synchrotron
- targeting drugs to the lymphatic system to better treat immune and metabolic disease.

Grants awarded

**40**

Staff

**84**

Total research income

**\$24,488,197**

Publications

**68**



## MAJOR SCIENCE OF 2023

- The Trevaskis research team was involved in two clinical papers - one exploring the efficacy of topical corticosteroids to treat hand osteoarthritis with rheumatologist Prof Flavia Cicutini at Alfred Hospital (Osteoarthritis and Cartilage Open 5 (3), 100382) and the other evaluating whether the COX-2 inhibitor celecoxib protects against diabetes progression with Dr Jenni Ilomäki and Shao Tan from CMUS (Diabetes Research and Clinical Practice 207, 111082).
- The Nicolazzo laboratory demonstrated the cognitive-enhancing effects of a blood-brain barrier penetrating scorpion-derived peptide in a mouse model of sporadic Alzheimer's disease. These findings pave the way to progress this peptide to the next stage of development for this neurodegenerative disease and were published in *Neurotherapeutics*. The laboratory also demonstrated a critical role of fatty acid binding protein 4 in mediating microglial mediated neuroinflammation, suggesting a potentially novel target for exploitation in neurodegenerative diseases in which neuroinflammation is a significant contributor.
- A collaboration between the Creek and Landersdorfer groups combined global metabolomics with mathematical modelling to identify new biomarkers of antibiotic resistance (Tait et al, *Antimicrob Agents Chemother* 2024), while another collaboration between the Creek, Rudd and Voelcker groups used lipidomics to identify lipid biomarkers that can detect the different stages of colorectal cancer (Krishnan et al, *Metabolomics* 2023).
- Lipid prodrug technology that was developed by Chris Porter and Natalie Trevaskis and licenced to PureTech Health in Boston, passed a significant milestone when a successful Phase 2a clinical trial was completed. In this case the technology was used to orally deliver allopregnanolone, a drug that is only currently available intravenously, and to examine its use in a model of anxiety. The showed that the oral prodrug of allopregnanolone was able to significantly reduce the cortisol (stress) response in a model of social anxiety.
- We also continue to work with Starpharma to develop a next generation targeted dendrimer based drug delivery systems and were delighted in 2023 to be awarded an ARC linkage grant to continue these investigations. Finally work continues with Halozyme, a San Diego based biotechnology company to explore the impact of their Enhance technology on the absorption and disposition of biologic-based medicines.
- There have been three initiatives established in D4 in 2023: the Quality of Medicines Initiative (funded through philanthropy); the mRNA Core (funded through MRFF); and a Drug Target Identification Platform (funded through MRFF).
- Overall there have been three clinical trials conducted based on D4 research: orally delivered allopregnanolone; inhaled oxytocin; and intranasal heparin.



## MAJOR AWARDS AND OTHER ACHIEVEMENTS OF 2023

- Natalie Trevaskis was recognised by the Faculty for her excellence in postgraduate supervision
- The Porter/Trevaskis prodrug team received the Vice Chancellor's award for excellence in enterprising research
- Joseph Nicolazzo was also elected as a Fellow of the International Pharmaceutical Federation, a federation which represents 4 million pharmacists and pharmaceutical scientists globally
- Ben Boyd was named a Fellow of the American Association of Pharmaceutical Scientists



Associate Professor Joe Nicolazzo at the International Pharmaceutical Federation (FIP) World Congress being awarded the FIP Fellowship by the first Australian FIP President, Paul Sinclair.



Professor Ben Boyd, who holds a joint appointment between MIPS and the University of Copenhagen.



## A HIGHLIGHT PAPER

Hoang Thu A., Cao Enyuan, Gracia Gracia, Nicolazzo Joseph A., Trevaskis Natalie L. *Development and application of a novel cervical lymph collection method to assess lymphatic transport in rats*. *Frontiers in Pharmacology* (2023) 14

DOI: 10.3389/fphar.2023.1111617

Up until the early 21st century, the brain was considered an organ devoid of lymphatic vessels. This concept was turned on its head when in 2015 lymphatic vessels were identified within the meninges that line the surface of the brain. Subsequently fluids, molecules and immune cells have been found to drain from the brain and surrounding structures to cervical lymphatics in the neck via the meningeal lymphatics as well as lymphatics at the back of the nose and alongside cranial nerves. The function of these lymphatics is impaired with age and impacts several neurological diseases. Prior studies relied on imaging technologies and did not allow analysis of the components within the lymph fluid draining the brain or quantification of their transport. In this paper our team developed a method to collect and analyse the cervical lymph fluid draining from the brain (in rodents) for the first time. We describe the protein, lipid and immune cell composition of the lymph. This valuable tool will enable more detailed quantitative analysis of changes to cervical lymph composition and transport in health and disease, and can be a valuable resource for discovery of diagnostic biomarkers or therapeutic targets in future studies.



## CENTRE FOR MEDICINE USE AND SAFETY



Theme Leader: **Professor Simon Bell**

The Centre for Medicine Use and Safety (CMUS) is focused on innovative research to promote safe and effective medicine use. CMUS runs major national and international collaborative and multidisciplinary projects. These projects address Australia's National Health Priority Area of Quality Use of Medicines and Medicine Safety.

CMUS has research strengths in pharmacoepidemiology, health economics, pharmacometrics and health services research. Key program areas include ageing and aged care, deprescribing, cardiovascular disease, diabetes and respiratory disease.

CMUS co-leads the Neurological and Mental Health Global Epidemiology Network (NeuroGEN) and Optimising Geriatric Pharmacotherapy through Pharmacoepidemiology Network (OPPEN). CMUS staff are recognised national and international leaders in deprescribing research, including through the Australian Deprescribing Network. CMUS staff address the evidence-practice gap through investigating novel strategies to translate evidence into practice. This includes developing new NHMRC-approved Australian clinical practice guidelines and innovative roles for pharmacists.

CMUS is committed to building research capacity. CMUS is home to 30 Australian and international PhD candidates and an expanding team of post-doctoral researchers focused on ensuring that patients achieve optimal health and medication outcomes.

Grants awarded

**8**

Staff

**15**

Total research income

**\$8,890,612**

Publications

**81**

### MAJOR RESEARCH OF 2023

#### MEGA-MAC

The Maximising Embedded Pharmacists in AGed CAre Medication Advisory Committees (MEGA-MAC) is evaluating using knowledge brokers to implement Australia's new Guiding Principles for Medication Management in Residential Aged Care Facilities. This three-year CMUS-led project is being conducted with the University of Sydney, Flinders University, New South Wales Therapeutic Advisory Group (NSW TAG) and three aged care provider organisations in Victoria, NSW and Western Australia. MEGA-MAC project achievements to date include a study of 120 MACs across Australia. The project has also developed quality indicators to measure concordance with the Guiding Principles.

#### EMBRACE

The Evidence-Based Medication knowledge Brokers in Residential Aged Care (EMBRACE) project is evaluating the effectiveness and cost-effectiveness of using embedded on-site pharmacists as knowledge brokers to implement Australia's new Clinical Practice Guidelines for the Appropriate Use of Psychotropic Medications in People Living with Dementia and in Residential Aged Care into practice. The EMBRACE project involves collaboration between Monash University, University of Queensland, Flinders University, New South Wales Therapeutic Advisory Group and five aged care provider organisations across Queensland, New South Wales, Victoria and Western Australia.

The trial involves 7 knowledge broker pharmacists working across 19 RACFs from four partner aged care organisations: Anglicare Southern Queensland (Qld), Lifeview (VIC), Montefiore (NSW) and Brightwater Care Group (WA). The trial is due to be completed in October 2024.

#### DEVELOPMENT OF NEW AUSTRALIAN CLINICAL PRACTICE GUIDELINES

CMUS led the development of new Australian Clinical Practice Guidelines for the Appropriate Use of Psychotropic Medications in People Living with Dementia and in Residential Aged Care. The Guidelines were developed by an 18-member multidisciplinary Guideline Development Group and approved by the National Health and Medical Research Council (NHMRC) in April 2023. The Guidelines contain 15 conditional recommendations and 49 good practice statements related to antipsychotics, benzodiazepines and antidepressants. The Guideline Companion Guide has been translated into Mandarin, Greek, Italian and Vietnamese. CMUS is currently leading two Medical Research Future Fund (MRFF) projects in partnership with aged care provider organisations across Australia to translate the Guidelines and related principles. Building on the success of the new psychotropic guidelines, CMUS and the Neuromedicines Discovery Centre are currently leading new Australian Clinical Practice Guidelines on the Appropriate Use of Psychedelics for Mental Health Conditions.



#### HAPPI MIND

HAPPI MIND (Holistic Approach in Primary care for Preventing Memory Impairment aNd Dementia) is a NHMRC-funded cluster randomised controlled trial across Victoria and New South Wales. Patients of participating practices aged 45-65 years with  $\geq 2$  potential dementia risk factors ( $n = 404$ ) have been identified and are followed up. HAPPI MIND participants receive six individualised dementia risk reduction sessions with a nurse trained in motivational interviewing and principles of behaviour change, a personalised risk reduction action plan and access to the purpose-built HAPPI MIND smartphone app for risk factor self-management. HAPPI MIND is a partnership involving Monash University, University of Newcastle, University of Melbourne, University of New South Wales, Deakin University, Flinders University, North West Melbourne Primary Health Network, and CSIRO.

#### TERRACOTTA

'Treatable traits' refer to individually assessing patients for a specified set of treatable problems, followed by the development and implementation of an individualised treatment program. TERRACOTTA is a cluster randomised trial, the first of its kind in Australian primary care, offering a tailored intervention, which includes a multidimensional assessment by a practice nurse to characterise treatable traits in patients with COPD followed by a personalised medicine approach targeting pulmonary, extrapulmonary and behavioural traits. TERRACOTTA is a partnership involving Monash University, University of Newcastle, University of Melbourne, Bond University, Austin Health, Lung Foundation Australia, Australian Practice Nurses Association, North West Melbourne Primary Health Network, and CSIRO. TERRACOTTA will inform clinical practice and facilitate continuous quality improvement in the care of patients with COPD.

## NeuroGEN

NeuroGEN (Neurological and Mental Health Global Epidemiology Network) is a big-data platform for research into neurodegenerative diseases and mental health conditions. NeuroGEN comprises 15 prescription databases that cover 320 million individuals from Australia, Finland, Hong Kong, Korea, the Netherlands, New Zealand, Scotland, Taiwan, United Kingdom and United States. NeuroGEN facilitates multinational research by providing a platform of collaborations, joint workshops and symposia, data harmonisation support, collaborative grant applications, and student and staff exchange. In 2023, the NeuroGEN platform was used to conduct the Global Hip Fracture Study and research into Long COVID.

## MONASH-MODERNA QUANTITATIVE PHARMACOLOGY ACCELERATOR

The Monash-Moderna Quantitative Pharmacology Accelerator (MMQPA) is a five-year program to advance the development of new mRNA therapeutics. The MMQPA will involve using mathematical modelling to accelerate the development of safe and effective mRNA therapeutics for a range of diseases by applying quantitative systems pharmacology, therefore improving the efficiency of mRNA development. This initiative is significant as it represents the first R&D Accelerator initiative to be established by the Melbourne-based Moderna Research Centre for Respiratory Medicines and Tropical Diseases



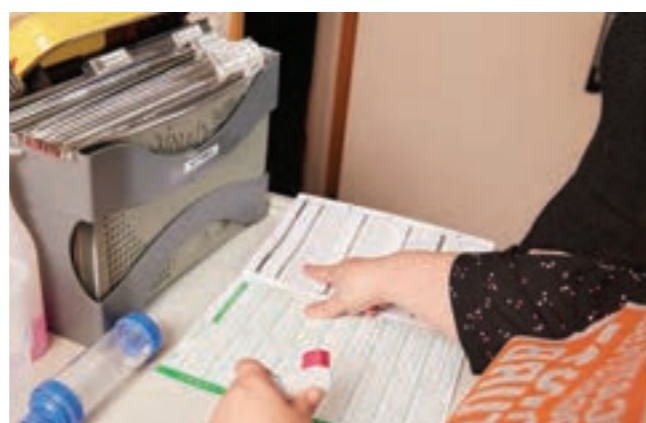
Chris Bral, Senior Vice President Non-Clinical Sciences, Moderna & Doron Ben-Meir, Monash Deputy Vice-Chancellor (Enterprise and Engagement) and Senior Vice-President, signing the MMQPA agreement

## NOVEL MODELLING TO PREDICT THE HEALTH ECONOMIC IMPACT OF NEW THERAPIES

Not appropriately capturing all cost and value outcomes of new interventions risks significant misallocation of resources. This NHMRC Ideas grant project is establishing the role of Mendelian randomisation to fill evidence gaps when a randomised clinical trial is not possible nor practical. Mendelian randomisation introduces a randomisation structure into observational studies and uses genetic variants to assess whether the observed association between an exposure and an outcome is likely to be causal. This project is facilitating better quantification of long-term health effects and costs, leading to more efficient use of cardiovascular therapeutics and improved value care for patients.

## THE AUSTRALIAN EPILEPSY PROJECT

Health Economics and Policy Evaluation Research group within CMUS is leading the health economic components of the government funded Australian Epilepsy Project. The project involves building a novel decision model to measure changes in management through neuroimaging, genomics, treatment, costs, and quality of life over a lifetime. The project involves developing, validating and applying a decision-analytic state-transition model that simulates the consequences of disease. The project involves AI-based treatment predictions of long-term functional outcome prognosis. This methodological innovation represents a paradigm shift in how the future burden of epilepsy is assessed. This project involves close collaboration with clinicians and researchers across Australia and worldwide. The approach may also be suitable for application to other health conditions



## MAJOR AWARDS AND OTHER ACHIEVEMENTS OF 2023

The CMUS team of staff and students grew considerably over 2023 to include more than 18 full time equivalent staff and 30 PhD candidates. This reflected a considerable growth in annual research income to more than \$8 million. In 2023, CMUS staff secured four Medical Research Future Fund projects, an Australian Research Council Discovery Project Grant and an NHMRC Investigator Grant. In addition, research funding was negotiated through the newly established Monash-Moderna Quantitative Pharmacology Accelerator program. Other funding partners included the Australian Association of Gerontology and Australian Rotary Health.

CMUS research was widely featured in the professional and mainstream media, including in newspapers, radio and TV. CMUS research was the subject of 24 Faculty and University-wide press releases. CMUS staff led workshops at major national and international conferences and events.

To enhance community engagement, CMUS established a new Consumer, Carer and Community Panel to better understand and integrate different stakeholder perspectives. It will help to better engage a broad range of stakeholders in the design and development of major research programs. This Panel will ensure that issues important to consumers, carers and community members are identified and prioritised. The Panel will also advise on strategies to aid the translation of research into clinical practice and policy.



## A HIGHLIGHT PAPER

CMUS researchers have found an increase in the dispensing of psychotropic medications to Australian children during the COVID pandemic, compared with dispensing levels in the years prior. With the uncertain balance between benefits and harms of these medications to young people, further investigation is warranted.

Stephen J Wood, Jenni Ilomäki, Jacqueline Gould, George SQ Tan, Melissa Raven, Jon N Jureidini, Luke E Grzeskowiak. *Dispensing of psychotropic medications to Australian children and adolescents before and during the COVID-19 pandemic, 2013-2021: a retrospective cohort study.* Medical Journal of Australia 2023;219(1):18-25. DOI 10.5694/mja2.51948



# THERAPEUTIC PROGRAM AREAS

Much of our collaborative work in drug discovery and development, and medicine use is disease agnostic, however, we have an internal focus in three main therapeutic areas:

- Cardiovascular and Metabolic Health,
- Global Health, and
- Neuroscience and Mental Health

In 2020 MIPS established Therapeutic Program Areas (TPAs) to focus on these topics. By bringing together our collective expertise in these areas we are better able to develop medicines to address health needs, and respond to targeted grant opportunities.

Within the TPAs we have major programs in neuropsychiatric disorders, metabolic disease, heart failure, fibrosis, chronic pain, addiction and malaria.

The TPAs, which are led by mid-career researchers in the Faculty, run a range of programs to build a community with shared research interests to discuss relevant scientific developments and opportunities. They have both internal and external facing roles, generating a critical mass to address a particular therapeutic need and to connect MIPS with the broader ecosystem. These broader networks include the Australian Global Health Alliance, the Monash Neuroscience Committee, and the Victorian Cardiovascular Research Network.

Since their establishment in 2020 the TPAs have grown their communities through 'Tea and Talk' sessions where topics of common interest are presented by MIPS researchers, holding seminars and symposia, providing support to researchers through grant review and development and co-funding.

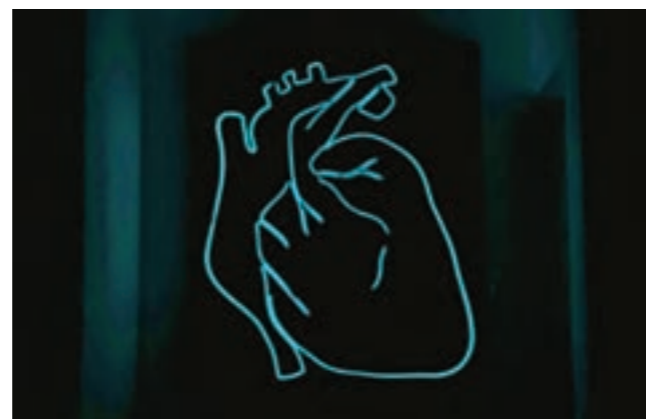
## CARDIOVASCULAR AND METABOLIC HEALTH

Co-leads: Associate Professor Lauren May & Associate Professor Natalie Trevaskis

The expertise from MIPS in the Cardiovascular and Metabolic Health TPA encompasses medicinal chemistry, structural biology, analytical pharmacology, drug disposition, drug delivery, translational models of disease and medicines use and safety.

We focus on understanding how excess nutrient consumption and nonfunctioning metabolic organs contribute to obesity, diabetes and metabolic associated cancers, thus enabling the development of improved treatments for metabolic associated diseases.

We have broad expertise in delineating the underpinning mechanisms of cardiovascular disease and in developing new treatments for heart failure resulting from interruptions in coronary blood supply (such as in heart attack), diabetic cardiomyopathy and cardiopulmonary disease.



## MAJOR ACTIVITIES OF 2023

### EVENTS

- MIPS Cardiovascular and Metabolic Health Symposium, Nov 2023. Approximately 70 attendees from MIPS, Uni Melb, Victorian Heart Institute, Baker Institute
- 2nd A.I.M. cardiovascular EMCR symposium, October 2023. This national event was co-hosted by ASCEPT Cardiovascular Special Interest Group, International Society for Heart Research, and MIPS Cardiovascular Health TPA

### COMMUNITY BUILDING ACTIVITIES

- Tea & Talks (5 labs: Rebecca Ritchie, Jenni Ilomäki, Amandeep Kaur, Dan Priebbenow, Ben Boyd; June 2023 – Jan 2024)
- Consumer Engagement Event, in collaboration with EMCR committee & HRM (25 & 27 October 2023)
- Sarah Turpin-Nolan awarded a REDI Fellowship which she undertook at CSL. In this role Sarah has built on the relationship between MIPS and CSL.
- Ongoing networking opportunities at ASHRA (Australian Stroke and Heart Research Accelerator) and Victorian Heart Institute events, including seminars series and education and training workshops.

## MAJOR AWARDS AND OTHER ACHIEVEMENTS IN 2023

- Thank you to Dr Sarah Turpin-Nolan for chairing the cardiovascular and metabolic health TPA from 2021-2023. Congratulations to Dr Turpin-Nolan on her REDI fellowship at CSL in 2023.
- Welcome A/Prof Natalie Trevaskis as the new co-chair of the TPA from 2023.
- Congratulations TPA members Prof Denise Wooten, Prof Patrick Sexton and Dr Arisbel Gondin on receiving prestigious NHMRC Investigator Grants.
- Congratulations Prof Rebecca Ritchie and team receiving an NHMRC Ideas Grants for '*Enhancing cardiovascular cGMP to target hypertensive heart failure in females*'.
- Congratulations to Prof Ray Norton and team receiving an NHMRC Development grant for the '*Development of a Kv1.3 potassium channel inhibitor as a new class of treatment of diabetic kidney disease*'.
- Congratulations to Dr Chengxue Helena Qin who received a Diabetes Australia Millennium award to research '*A novel approach to treat diabetic kidney disease*'.
- Congratulations to Dr Sarah Turpin-Nolan and Dr Miles De Blasio for receiving Diabetes Australia Research grants on '*Targeting gut ceramides - a new way to improve systemic insulin sensitivity*' and '*Mitochondrial-targeted therapies to limit the structural and functional changes in diabetic cardiomyopathy*', respectively.
- National Drug Discovery Centre submission supported by the CM-TPA was successful – CIA Darren Riddy.

## GLOBAL HEALTH

Co-leads: Associate Professor Darren Creek & Pete Lambert

The Global Health TPA works to improve health and achieve equity in health for all people worldwide.

Our major activities focus on infectious diseases and maternal, child and reproductive health, along with capacity-building programs for pharmacy globally.

Our research ranges from the discovery of new drugs, vaccines and diagnostics, to improving medicines and treatment regimens to suit specific populations.

Existing collaborations operate in the Pacific, South and Southeast Asia and sub-Saharan Africa and we look to expand our reach further, aligning our activities with local, national and international frameworks to make a positive impact on global health.



### MAJOR ACTIVITIES OF 2023

#### EVENTS

- Hosting Victorian Infection and Immunity Network Young Investigator Symposium
- Sponsorship of Malaria in Melbourne 2023
- Support of the Malaria Seminar Series

#### COMMUNITY BUILDING ACTIVITIES

- Dissemination of global health events and funding opportunities to TPA members
- Convening of the MIPS antimicrobial resistance working group
- Engagement with Monash Malaysia colleagues around potential global health collaborative opportunities
- Engagement with Cumming Global Centre for Pandemic Therapeutics to facilitate opportunities for collaboration and funding
- Continued interaction with other global health leaders and initiatives across Melbourne (including Jane Fisher, Sophia Zoungas, Tony Capon, World Mosquito, and RISE).

#### LOBBYING/NETWORK REPRESENTATION

- Continued membership of the Australian Global Health Alliance (and attendance at multiple events)
- Membership of Victorian Infection and Immunity Network (and representation at events)
- Meeting with David Reddy, CEO, Medicines for Malaria Venture
- Engagement with DFAT Indo-Pacific Centre for Health Security

### MAJOR AWARDS AND OTHER ACHIEVEMENTS IN 2023

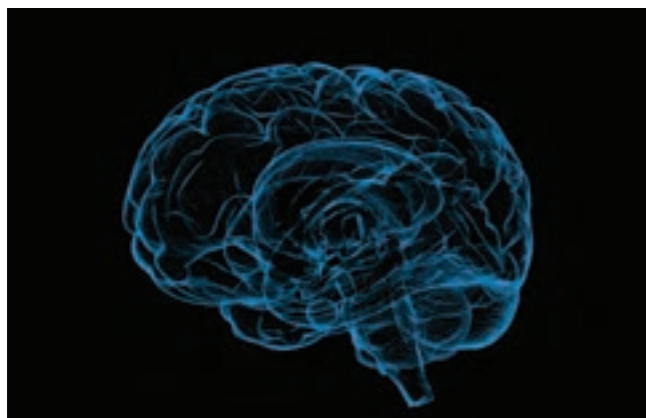
- Launch of the Monash Quality of Medicines Initiative (April 2023) following ~\$1M funding from Ripple Foundation
- Training workshops conducted on the quality of commodities used for management of postpartum haemorrhage in Nigeria and Guinea (leading to national policy change in Guinea)
- Integration of the Western Pacific Pharmaceutical Forum – of which John Jackson from MIPS is President - with the International Pharmaceutical Federation to establish a globally linked network to advance pharmacy practice, pharmaceutical sciences, and pharmacist education and workforce development.
- Completion of Phase 1 mRNA Covid vaccine clinical trial
- Completion of Phase 1 inhaled oxytocin clinical trial
- VMRAF and J&J Foundation grants to the inhaled oxytocin project (\$1.25M)
- Welcomed Stanley Xie, a new DECRA fellow, to MIPS to study antimicrobials for malaria and bacterial infections



## NEUROSCIENCE AND MENTAL HEALTH

Co-leads: Associate Professor Karen Gregory  
& Dr Manuela Jörg

The Neuroscience and Mental Health TPA aims to break down existing discipline-based research 'silos' to facilitate synergistic multidisciplinary teams to tackle unmet medical needs in psychiatry, neurodegeneration, pain, and other mental health conditions. To improve patient outcomes, we bring together experts in medicinal chemistry, structural biology, analytical pharmacology, drug disposition, translational models of disease and medicines use and safety. Additionally, we aim to increase the visibility of the excellent research of our members to diverse stakeholders.



### MAJOR ACTIVITIES OF 2023

#### EVENTS & COMMUNITY BUILDING ACTIVITIES

Multiple events were organised by the TPA or in collaboration with other groups, such as the early-mid career researcher (EMCR) committee, Her Research Matters (HRM) and PharmAlliance to increase the visibility of the research performed by our members, provide networking opportunities and support new collaborations.

This included:

- Tea & Talks (11 speakers and 2 networking sessions, March – December 2023)
- At-Home PharmAlliance Event (10 July 2023)
- Consumer Engagement Events, in collaboration with EMCR committee & HRM (25 & 27 October 2023)
- End-of-the-Year Networking Event and presentation of awards and grants (5 December 2023)

#### NETWORK REPRESENTATION

MIPS neuroscientists are represented on the Monash Neuroscience Network by two TPA members (Executive Committee member & EMCR sub-committee member) that helped organise the Monash Neuroscience Symposium (29 May 2023).

### TPA AWARD AND GRANT RECIPIENTS

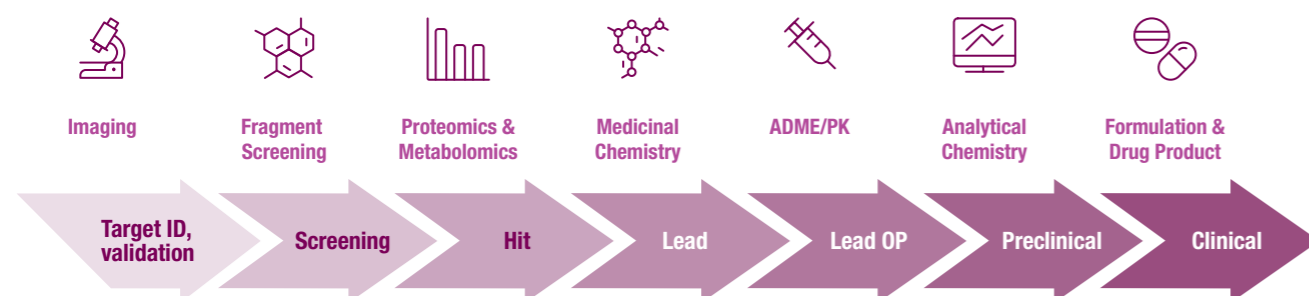
The Neuro TPA awards and funding opportunities recognise the excellent research of our members and support new collaborative and multidisciplinary research projects.

The 2023 recipients included:

- *Neuroscience Team Publication Award* recognising excellent neuroscience research led by a team at MIPS
- Manuela Jörg, Emma van der Westhuizen, Celine Valant and Peter Scammells.
- *Neuroscience Individual Publication Awards* recognising excellent neuroscience research led by an individual at MIPS
- Amanda Cross
- Monica Langiu
- *Neuroscience & Mental Health TPA Cross-Theme Project Grants* supporting the initiation of collaborative projects across themes at MIPS
- Aili Langford (CMUS), Manuela Jörg (Med Chem) and Lauren May (DDB)
- Amanda Cross (CMUS) and Monica Langiu (DDB)
- *MIPS TPA Discovery Accelerator Co-funding Program* supporting proof-of-concept, de-risking or capacity development studies

# DRUG DISCOVERY RESEARCH PLATFORMS

Our Research Platforms provide the technology, equipment and expertise that underpins our research. They support internal and external drug discovery programs across all stages of drug discovery from hit identification to candidate selection.



The Platforms vary in how they engage with users - through arrangements that include collaboration, partnerships and fee-for-service.

The **Centre for Drug Candidate Optimisation (CDCO)** is a unique group within MIPS being both a Research Theme and a Research Platform. The CDCO supports academic and commercial drug discovery teams to provide expertise and infrastructure in physicochemical property evaluation, drug metabolism and pharmacokinetics for improved compound design, selection and progression. For information about the activities of the CDCO in 2023 see page 30.



## MONASH FRAGMENT PLATFORM

DIRECTOR: PROFESSOR MARTIN SCANLON

The Monash Fragment Platform employs biophysical binding assays such as NMR, SPR and ITC to identify ligands that bind to therapeutic targets. Hits are either identified using DNA-encoded libraries (DEL) or fragment-based screening (FBS). FBS uses a high-quality, in-house fragment library designed to maximise chemical space coverage and enable rapid hit optimisation. Bespoke medicinal chemistry support subsequently facilitates Rapid Elaboration of Fragments into Leads, to power translation.

### MAJOR ACHIEVEMENTS OF 2023

Together with collaborators from Parkville's biomedical precinct, the platform hosted the inaugural Hit ID Symposium in October 2023. This was the first small molecule drug discovery symposium showcasing the hit identification infrastructure available within Melbourne's Parkville precinct, with a series of drug development success stories. More than 140 experts from both academia and industry met to present their success stories and network with local and interstate colleagues.

A new 500 MHz NMR spectrometer was commissioned that is optimised for the detection of <sup>19</sup>F-NMR. This new addition extends the available methods for monitoring protein-ligand interactions and expands the range of protein targets that can be investigated using FBDD.

MFP has continued to provide services in hit identification, hit validation and quantitative analysis to partners in industry and academia. In addition, MFP supported four successful TIA voucher applications to provide a range of services including screening, chemistry and biophysical interaction analysis.



## DRUG TARGET IDENTIFICATION PLATFORM

ACADEMIC LEADER: ASSOCIATE PROFESSOR DARREN CREEK

The Drug Target Identification Platform uses a range of cutting edge metabolomics, lipidomics and proteomics capabilities to identify and deconvolute new drug targets, to elucidate mechanisms of drug action and to discover novel biomarkers of drug action. Our analytical methods are suitable for samples arising from cell culture, animal studies or clinical trials, and our workflows are ideally suited to targeted or untargeted comparative analyses.

### MAJOR ACHIEVEMENTS OF 2023

The Parkville node of the Monash Proteomics and Metabolomics Facility underwent significant renewal and re-branding in 2023. We successfully obtained a competitive \$3M MRFF grant through the National Critical Infrastructure Initiative to establish Australia's first dedicated Drug Target Identification Platform, which will support academia and industry to progress new drug candidates by identifying mechanisms of drug action. Our proteomics capability received a substantial boost by installation of a new Orbitrap Astral mass spectrometer, which allows enhanced proteome-wide analysis of low-input samples with unprecedented throughput. Our metabolomics instrumentation was also upgraded to a state-of-the-art Orbitrap Exploris 120, with support from NCRIS-funded Bioplatforms Australia. We also welcomed Dr Ghizal Siddiqui as a full-time staff member of our node of MPMP to run our expanding proteomics and drug target identification portfolio. This doubling of capacity has enabled us to perform a wider range of proteomics, lipidomics and metabolomics studies in 2023, including some large clinical studies from Australia and Africa, and the implementation of new proteome-scale drug target deconvolution methods. Key publications from 2023 described profiling the impact of modulating short-chain fatty acids in hypertension (Nature Cardiovascular Research), understanding metabolic aging in a killifish model (Aging Cell) and revealing metabolic cross-talk between malaria parasites and their mammalian hosts (mBio).



## AUSTRALIAN TRANSLATIONAL MEDICINAL CHEMISTRY FACILITY

DIRECTOR: PROFESSOR PAUL STUPPLE

The ATMCF is a purpose-designed, outward-facing, collaborative facility that provides high-level medicinal chemistry know-how, both practical and theoretical, for translation of small molecules into therapeutic candidates. ATMCF provides medicinal chemistry insight, expertise and a translational bridge between early-stage biology and translational lead optimisation and pre-clinical development.

### MAJOR ACHIEVEMENTS OF 2023

ATMCF and collaborating partners were in the position of having a number of major grants awarded and funding opportunities open in 2023. Four grants; 3x NHMRC Development Grants (2-years each) and 1x NIH grant (4-years), were awarded and confirmed in 2023. The funding in these 4 grants totals over \$2.4M towards chemistry activity for the facility. The 3 Development Grants are a great example of the ATMCF and MIPS reputation, and acknowledge the translational experience of the team in leading these proposals. All of these four projects build on previous programs of work, and talks to the strength of the relationships the facility staff form with our collaborators.

The ATMCF also led the chemistry for 4 spin-out companies funded by CUREator, 3 of which are owned/part-owned by Monash. All 4 programs/companies began their chemistry within the ATMCF on the back of the Therapeutic Innovation Australia (TIA) Pipeline accelerator program. This is a great example of the facility driving translational outcomes, supporting medical research with commercial potential.

The ATMCF is further developing relationships across its client base to establish strategic partnerships on future projects, with the expectation that further industry funded medicinal chemistry will be undertaken within the facility across 2024.



## HELEN MACPHERSON SMITH TRUST ANALYTICAL LABORATORY

DIRECTOR: PROFESSOR MICHELLE MCINTOSH

The Helen Macpherson Smith Trust (HMST) Analytical Laboratory is an open-access analytical facility that uses sophisticated physical and chemical characterisation techniques to overcome challenges faced in modern drug development. Academic and industry researchers can access a comprehensive suite of advanced chemical characterisation instruments.

### MAJOR ACHIEVEMENTS OF 2023

The HMST Analytical Laboratory has supported numerous major research projects throughout 2023 through access to advanced instrumentation and method development, including supporting the establishment of the Quality of Medicines Initiative (QoMI) - a global medicines monitoring initiative to ensure safe supply of maternal medicines in low and middle income nations. The HMST Analytical Laboratory has also facilitated the establishment of highly advanced novel techniques, including high-resolution mass spectrometry imaging, immuno-capture analytical pharmacokinetic methods (down to femtogram quantitation in clinical samples), analysis of complex biologic medicines, pharmacokinetic analysis of peptide based drugs, pharmacokinetic analysis of volatile anaesthetics and characterisation of novel drug delivery formulations - in collaboration with academic, national and international pharmaceutical companies.

In 2023, the HMST Analytical Laboratory team supported over 10,400 instrument hours, trained over 90 students/researchers and supported 16 commercial research projects with both local and international partners. The laboratory has facilitated the commissioning of \$1.9M in advanced instrumentation (both sole and shared equipment). From work conducted in the lab, the HMST AL has supported 54 peer reviewed publications and 8 patents.



## MEDICINES MANUFACTURING INNOVATION CENTRE

DIRECTOR: PROFESSOR MICHELLE MCINTOSH

The Medicines Manufacturing Innovation Centre (MMIC) is an initiative established with the Victorian State Government to bring academic and industrial scientists together to optimise manufacturing processes, enhance current and new product development and build a highly skilled, industry-ready, workforce. MMIC provides specialist analytical and formulation development services via a team of experienced industrial scientists.

### MAJOR ACHIEVEMENTS OF 2023

#### NEW MMIC CLAYTON FACILITY

The MMIC welcomed a new, advanced \$9M facility, co-located at the Australian Synchrotron in late 2023. The purpose-built facility comprises offices and specialty laboratories for an additional 25 scientists and advances MIPS presence in the Monash Technology Precinct amongst present and future industry, research, and incubator partners. With facilities at Parkville and Clayton, this expansion commences an exciting new phase for the MMIC to provide a bespoke platform to enhance support for Australian pharmaceutical innovation, driving workforce development and job growth in the sector within Melbourne's two key biotechnology hubs.

#### ENGAGEMENT WITH INDUSTRY AND SUPPORTING CLINICAL TRIALS

As an innovation centre, the MMIC completed over 40 projects for industry clients in 2023, often addressing complex challenges in formulation design and assessment, targeted drug delivery, and scale-up manufacturing. Our innovative contributions to industry projects have led to our scientists being listed as co-inventors in at least three provisional patent applications. In addition to our engagement with industry, the MMIC actively supported three clinical trials initiated by Melbourne hospitals and institutions via our expertise in device assessment, formulation development and respiratory delivery.

#### TRAINING AND WORKFORCE DEVELOPMENT

As part of the MMIC's mandate to support workforce development and industry engagement, we hosted over 15 students throughout 2023 as part of our internship program. MMIC interns are assigned a mentor, participate in professional development workshops and actively contribute to research projects that add to our innovative capabilities. The success of the program was reflected in being awarded the 2023 Faculty of Pharmacy and Pharmaceutical Sciences Education Industry and Community Award. This recognition highlights our commitment to fostering collaboration between academia and industry & reflects the MMIC's ongoing dedication in developing the next generation of industry-ready professionals for the pharmaceutical sector.



## IMAGING, FACS & ANALYSIS CORE

LEADER: CAMERON NOWELL

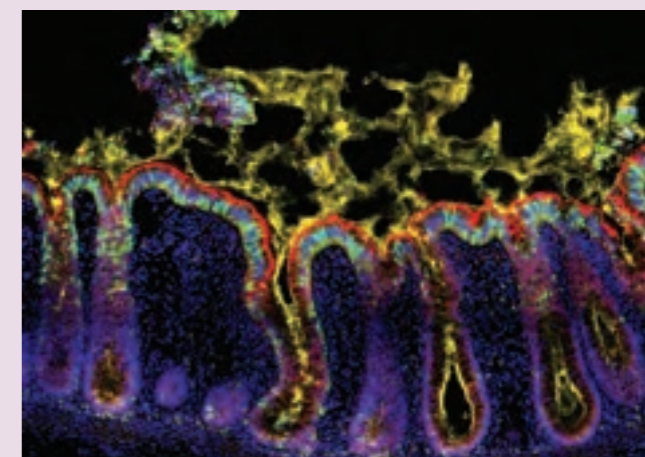
Imaging, FACS & Analysis Core (IFAC) uses the latest imaging, flow cytometry and analysis platforms for samples ranging from single molecules to whole animals. Our extensive range of ultra-precision microscopes include widefield, high throughput, holographic, hyperspectral, electron, super-resolution, confocal, multiphoton, lifetime imaging and label free. We also provide analytical and sorting flow cytometry capabilities.

### MAJOR ACHIEVEMENTS/SCIENCE OF 2023

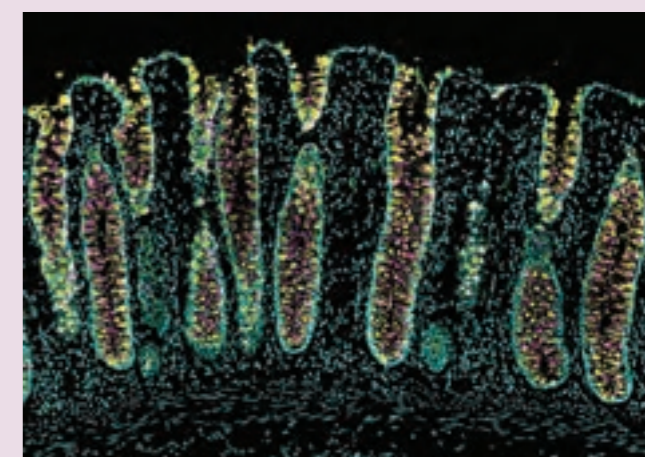
IFAC has continued to support imaging, FACS and analysis for both MIPS and external (national and international) users through support for project design, instrument training, technique development and custom analysis pipelines. The facility is now recognised within the imaging community as the go to place for trying something a little different or to develop unique pipelines for imaging and analysis. IFAC staff have also run numerous workshops on image analysis across Australia to a range of students, ECR and senior researchers.

New instrumentation was purchased (Leica DMI8 Microscope) that will allow users to easily image samples with up to 8 individual stains at a time allowing for in depth analysis and characterisation of increasingly complex models. Using AI and ML accelerated image analysis pipelines these complex data can be mined for patterns and interactions not possible before.

2023 saw IFAC support 168 users across 33 technology platforms for a total of 10,000 hours. Facility staff were listed as authors on 13 publications.



Description: Human colonic mucosa captured on a VT iSIM microscope using a 20x magnification objective. Image is labelled for DAPI (blue), MUC2 Precursor (Green), Mature MUC2 (Yellow) and Ezrin (Red). Credit: Matthew Rowe



Description: Deconvolved image of human colonic mucosa captured on a Leica DMI8 microscope using a 20x magnification objective. Image is labelled for DAPI (cyan), MUC2 Precursor (Green), TFF3 (Yellow) and Mature MUC2 (Magenta). Credit: Matthew Rowe

# MAJOR NATIONAL COLLABORATIONS

MIPS is a national leader in pharmaceutical sciences research and translation. However, drug discovery and development is a complex and multifaceted endeavour and as a result we collaborate widely with other experts to bring together teams to progress projects, deliver training and enhance translational outcomes to benefit human health.

The Australian Research Council Industrial Transformation Research Program supports university researchers to partner with industry in priority areas for Australia. Through the program's Industrial Transformation Training Centres (ITTCs) they support higher degree by research students and postdoctoral researchers to gain practical skills and experience through placements with industry. MIPS is proud to host the headquarters of two ITTCs - the Centre for Fragment Based Design, and the Centre for Cryo-electron Microscopy of Membrane Proteins - and is a participant in three other ITTCs - the Centre for Personalised Therapeutics Technologies, the Centre for Next-Generation Technologies in Biomedical Analysis, and the Centre for Cell and Tissue Engineering Technologies.

State and Federal Governments are investing in research and development programs led by MIPS. mRNA Victoria has funded the Victorian mRNA Innovation Hub hosted by MIPS, to develop next-generation mRNA vaccines and therapeutics. MIPS is also contributing to a number of other mRNA vaccine and antiviral therapeutic programs funded by mRNA Victoria. Through the Medical Research Future Fund National Critical Research Infrastructure program we are leading the establishment of MedChem Australia, a partnership with WEHI, the University of Sydney, and Therapeutic Innovation Australia to accelerate early stage drug discovery projects towards clinical trials and new medicines. The National Critical Research Infrastructure program has also funded the Drug Target Identification Platform at MIPS - see page 47 for more information on that platform.

The Neuromedicines Discovery Centre (NDC), a collaboration between Monash, The Florey, the Melbourne Brain Centre, and Neuroscience Trials Australia, is hosted at MIPS. The NDC is a catalyst for discovering and translating a new generation of trusted, evidence-based medicines and therapies for those experiencing mental health conditions.

## CENTRE FOR FRAGMENT-BASED DESIGN

DIRECTOR: PROFESSOR MARTIN SCANLON

The Centre for Fragment-Based Design (CFBD) is an Australian Research Council Industrial Transformation Training Centre. CFBD is a national multi-disciplinary training centre for identifying novel ligands for a range of protein targets, with collaborators from Griffith University and the University of Sydney and research partners including ANSTO, CSIRO, Takeda, and Vernalis.



## MAJOR ACTIVITIES IN 2023

2023 was a busy year for CFBD. Our members presented their research at more than 10 different cities across the world and won prizes at conferences on 3 continents. We also started our first industry placements. We sent two students to our industry partner Vernalis in the UK and one student to our industry partner Tetragenetics in Boston. Two more students started their domestic placements at CSIRO and Psylo.

In addition, the Centre hosted six in-person workshops at our different nodes in 2023. In April, we joined forces with the ARC CoE for Innovations in Peptide and Protein Science (CIPPS) to hold a workshop on scientific writing skills. In September, we all met in Sydney to improve our skills in statistics and the fundamentals of data analysis. This was followed by a day at Sydney's University of Technology with our industry partner Cytiva who gave our members in-depth training on their instruments.



## MAJOR ACHIEVEMENTS OF CFBD MEMBERS IN 2023

- Prof Ray Norton (Monash): NHMRC Development Grant (\$753,140)
- Prof Michael Kassiou (USyd): NHMRC Ideas Grant (\$1,037,875)
- Prof Joel Mackay (USyd): NHMRC Ideas Grant (\$1,133,816)
- Prof Sally-Ann Poulsen and Dr Louise Sternicki (Griffith Uni): 2023 Ramaciotti Biomedical Research Award (\$1,000,000)
- Prof Martin Scanlon (Monash): CUREator grant with Prof Bernie Flynn and Prof Colin Pouton (both Monash) (\$500,000)



## NEUROMEDICINES DISCOVERY CENTRE

DIRECTOR: PROFESSOR CHRIS LANGMEAD

The Neuromedicines Discovery Centre (NDC) is working to stimulate medical research into severe mental health conditions including depression, eating disorders, post-traumatic stress disorder, schizophrenia and substance use disorders to bring hope to those for whom current treatments are ineffective. The ultimate goal is to discover and develop a new class of precision psychiatric medicines called neuromedicines that are quick to act, require minimal dosing, have few side effects and are effective for longer periods of time than current medicines.

The NDC is a cross-disciplinary collaboration with the University of Melbourne and the Florey Institute of Neuroscience and Mental Health that spans the entire treatment pipeline - from drug discovery and optimisation, to clinical trials, new healthcare guidelines and into the public policy arena, taking an evidence-based approach to patient care. The three key research themes are:

- Better Medicines: drug discovery and development to advance treatment options
- Better Minds: studying effectiveness, duration, suitability and the value of treatment options, encompassing medicines and holistic therapies
- Better Futures: focus on awareness and education of decision makers and professional bodies.



## MAJOR SCIENCE OF 2023

The mission of the NDC in 2023 was to consolidate existing research on mental health medicines development and introduce programs of work that address new and emerging areas of therapeutic intervention, such as the use of psychedelic agents in the treatment of depression and PTSD. Highlights include:

- **New drug discovery for cognitive impairments in psychiatric disorders:** The NDC's spinout company, Phrenix Therapeutics, met all its milestones as a participant in the Medical Research Future Fund's CUREator scheme. The company, led by Chris Langmead (CEO) and Greg Stewart (Chief Scientific Officer) and in collaboration with the Florey, is using state-of-the-art technologies to build a pipeline of new small molecule therapeutics that specifically target cognition and comorbid symptoms for patients with schizophrenia, substance-use disorders, bipolar disorder, ADHD and beyond.
- **Unravelling a new schizophrenia drug's mechanism of action:** Across several publications, a team comprising the NDC's Founding Director, Arthur Christopoulos, along with Celine Valant and David Thal, provided major insights into the molecular mechanisms of action of the drug, xanomeline, at the muscarinic M4 receptor. Xanomeline, when co-formulated with another agent, trospium, forms the investigational new drug, KarXT, which has successfully completed phase 3 clinical trials for the treatment of schizophrenia and is likely to be approved in the US in 2024.
- **Use of psychedelics to treat mental health conditions:** In collaboration with BehaviourWorks Australia, the NDC published a paper outlining the broad support for the use of, and research into, psychedelic agents such as MDMA and psilocybin for the treatment of mental health conditions such as PTSD and depression. With the aid of a generous philanthropic gift, the NDC has now started a program of work between Monash and the University of Melbourne to develop practice guidelines for their clinical use.

## OTHER ACHIEVEMENTS OF 2023

- In November, NDC Director Professor Langmead led a panel of experts to discuss the opportunity of next-generation medicines for mental health conditions at the AusBiotech conference in Brisbane.
- In July, Professor Langmead joined a panel of experts at the PSYCH Symposium 2023, Access to Psychedelic Medicines session in London to discuss the reality of the new psychedelic market and the complicated framework healthcare professionals and policymakers need to work within, and what can be learnt from recent developments in Australia.
- In May, Professor Chris Langmead, along with Professor Cathy Mihalopoulos and Dr Mary Lou Catterton published an article for The Conversation on the tricky economics of subsidising psychedelics for mental health therapy.

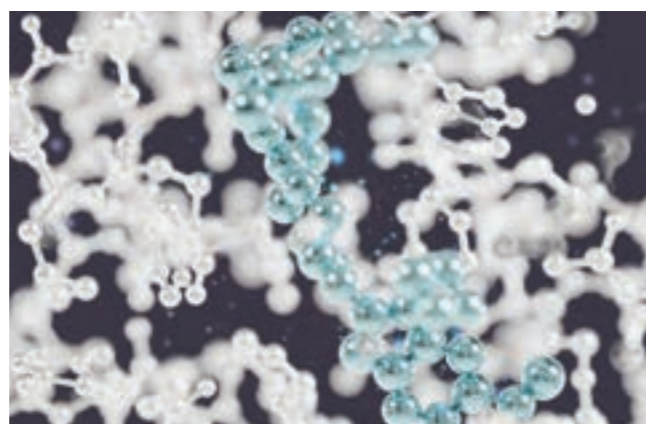
## MAJOR AWARDS AND OTHER ACHIEVEMENTS OF 2023

- NDC Director, Chris Langmead, contributed to several events and media to discuss the opportunity of next-generation medicines for mental health conditions, including expert panels at the AusBiotech conference (Brisbane), the PSYCH Symposium 2023: Access to Psychedelic Medicines (London), and the Victorian Collaborative Mental Health Nursing Conference (Melbourne).
- Chris Langmead and Greg Stewart visited Boston, USA to promote the NDC and its spinout ventures to both investors and industry.
- Chris Langmead, along with Professor Cathy Mihalopoulos and Dr Mary Lou Catterton, published an article for The Conversation on 'The tricky economics of subsidising psychedelics for mental health therapy.'
- The NDC welcomed its first Lived Experience Ambassadors, Holly Paterson and Michael Raymond, who provide insights and perspectives to help shape our research.

## CENTRE FOR CRYO-ELECTRON MICROSCOPY OF MEMBRANE PROTEINS

DIRECTOR: PROFESSOR PATRICK SEXTON

The Australian Research Council funded Centre for Cryo-electron Microscopy of Membrane Proteins, CCeMMP, focuses on training industry-ready, world class graduates in cryo-electron microscopy of membrane proteins. It is a collaboration between MIPS, WEHI, the University of Melbourne, and The University of Wollongong alongside 15 educational and industry partners to date.



'Atomic Jewelry' rendered by Dr Sarah Piper (Monash CCeMMP member) of GLP-1 receptor (white), an important drug target for diabetes and obesity, with a small molecule bound (blue). This image was runner up in the biannual NHMRC Science to Art Award 2023 that recognises outstanding imagery that has arisen from research funded by the NHMRC.

### MAJOR ACTIVITIES IN 2023

In 2023, the Centre expanded to 148 members with 16 students currently enrolled through the Centre's doctoral program. The successes of Centre members this year include 34 publications, 31 presentations at prestigious international and domestic conferences, five presentations delivered to industry, over 35 academic presentations, over 30 poster presentations and a special CCeMMP Satellite meeting as part of Lorne Proteins 2023. Further highlighting the magnitude of cutting-edge research in the Centre, members received over \$10.2 million in competitive funding from grants, \$410K in industry funding, and solved 27 deposited structures. Members have received major awards, including Professor Renae Ryan who was awarded the Order of Australia and Eureka Prize for Outstanding Mentor of Young Researchers 2023; Dr Alastair Stewart who was awarded the Commonwealth Health Minister's Award for Excellence in Health and Medical Research; and Professor Megan O'Mara who was awarded the McAuley-Hope Prize for Original Biophysics 2023. The Centre continues outreach activities to the scientific community by delivering the monthly CCeMMP Seminar series of domestic and international expert speakers; quarterly newsletters highlighting achievements and activities; and 13 free professional and scientific workshops to members and the scientific community to promote networking, collaboration and skill-building.

### MAJOR ACHIEVEMENTS OF CCEMMP MEMBERS IN 2023

- Professor Renae Ryan - Order of Australia
- Professor Renae Ryan - Eureka award for Outstanding Mentor of Young Researchers (Aug 2023)
- Professor Megan O'Mara - McAuley-Hope Prize for Original Biophysics, awarded at the 2023 Annual Meeting of the Australian Society of Biophysics
- Dr Alastair Stewart - Commonwealth Health Minister's Award for Excellence in Health and Medical Research.
- CCeMMP members were awarded over \$10M in competitive research funding in 2023.
- 34 publications, 20 international conference talks, 11 domestic conference talks, 5 presentations to industry, 36 academic presentations and 30 poster presentations

## MEDCHEM AUSTRALIA

DIRECTOR: PROFESSOR BRENDON MONAHAN

MedChem Australia is a new initiative that provides expert medicinal chemistry & DMPK capability at subsidised cost to enhance, accelerate, and enable the development of new small molecule therapeutics. MedChem Australia is headquartered at MIPS and brings together leading medicinal chemistry groups from Monash, WEHI and University of Sydney, each with a track record of success in commercially-focused drug discovery. MedChem Australia was established with \$15 million in funding from the Federal Government's Medical Research Future Fund, Therapeutic Innovation Australia (TIA), and the three Nodes, with an initial runway of 5 years.

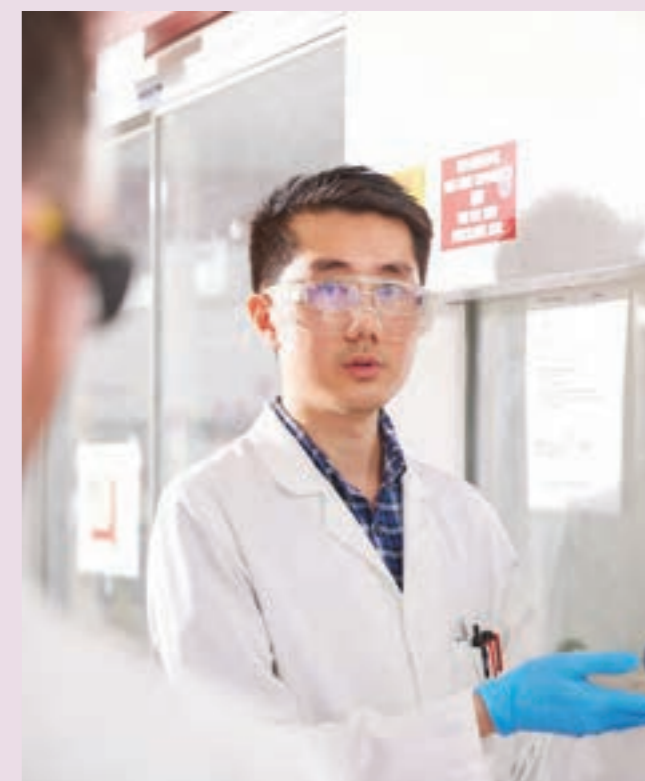


### MAJOR ACTIVITIES IN 2023

Following the funding announcement in June 2023, MedChem Australia was launched on 8 November by the Federal Assistant Minister for Health and Aged Care, the Hon. Ged Kearney. Following the launch, the MedChem Australia leadership team embarked on a roadshow, presenting nine information sessions across six states and territories. Following this great engagement, the first call for project applications was made and the inaugural Selection and Review Committee, which oversees the competitive and independent project selection process, was also announced. Successful projects will be partnered with MedChem Australia scientists who will plan the chemistry strategy for the project, design compounds, make compounds, generate DMPK data, and drive the project forward to an investment ready stage. Via support from MRFF, TIA and the node partners, MedChem Australia is able to provide collaborators with access to expert Medicinal Chemistry capabilities with an 80% cost subsidy. This aims to break down barriers to translation and to assist researchers in accessing medicinal chemistry to drive their drug discovery projects forward.



Federal Assistant Minister for Health and Aged Care, the Hon. Ged Kearney, presents a speech at the MedChem Australia Launch in Cossar Hall, Parkville Campus.



## mRNA HUB & THERAPEUTICS

PROGRAM LEADER: PROFESSOR COLIN POUTON

MIPS has adopted a comprehensive, multi-faceted approach towards building a therapeutic mRNA landscape to meet the overarching needs of mRNA research activities, facilitating transition to clinical trials and predicting pharmacological response utilising emerging computational technologies. Through 2023 MIPS and collaborating partners have launched three substantial programs totalling more than \$13 million to help enable lab-to-bedside pathways for potential mRNA therapeutics.

Headquartered at MIPS and funded by mRNA Victoria, the Victorian mRNA Innovation Hub (VMIH) comprises a collaborative team of researchers from MIPS, Monash Biomedicine Discovery Institute, the University of Melbourne and the Doherty Institute, aiming to advance technologies to develop mRNA therapeutics and vaccines with improved efficacy, affordability and production efficiency.

Complementary to the Hub, MIPS in collaboration with the Monash Biomedicine Discovery Institute, established mRNACore through \$5 million of funding from the MRFF mRNA Clinical Trial Program, to work collaboratively with researchers to accelerate development of novel mRNA products towards clinical trials.

In concert with our major mRNA programs including the Monash-Moderna Quantitative Pharmacology Accelerator, MIPS researchers are also highly active in smaller collaborative programs that seek to seed new mRNA therapeutics programs that will support our position at the forefront of mRNA research into the future.

### MAJOR ACTIVITIES OF 2023

The VMIH has actively developed collaborative research projects with the aim of improving RNA production and stability by integrating novel RNA elements, complemented with formulating and optimising next-generation nanoparticle delivery systems using novel materials to improve site-specific delivery of mRNA, focussing on viral vaccines and disease treatments.

Additionally, mRNACore has bolstered our RNA capabilities, producing mRNA for >15 diverse research projects with promising therapeutic prospects, and is continually improving production and analytical techniques for research-scale mRNA manufacturing.

In 2023, MIPS hosted a VMIH Scientific Meeting, attended by ~60 people from Monash University, the University of Melbourne, the Doherty Institute and mRNACore, catalysing new collaborations and ideas. VMIH members have also engaged in outreach activities, and showcased our research and capabilities to potential industry partners, government and international and local collaborators.

Leveraging mRNA manufacturing expertise and comprehensive RNA knowledge with pharmacological safety, the VMIH, mRNACore and the MMQPA engage in extensive collaboration with researchers and industry both in Australia and internationally, driving the development of potential novel mRNA therapeutics.

### MAJOR FUNDING AWARDS IN 2023

**MRFF mRNA** Clinical Trial Enabling Infrastructure Program  
\$5 million



# INTERNAL INITIATIVES ... TO GROW AND SUPPORT OUR STAFF AND STUDENT COMMUNITY

Both the Faculty and MIPS benefit from an extraordinarily active and engaged staff and student community. This is exemplified through the grass-roots driven initiatives of the Early- and Mid-Career Researchers Committee (EMCR Committee), Her Research Matters (HRM), and Multicultural Outreach and Support for Advancement, Inclusion and Community (MOSAIC). Each group has been established to represent and build a community in their areas, respectively EMCRs, research staff and students who are women, and staff and students of colour.

MIPS applauds the dedicated members of each group and recognises the challenges that they are working to help us address. Through their considerable efforts we have a growing community of young researchers, a pleasing number of whom are women. MOSAIC has recently been established to help improve the cultural and linguistic diversity across the Institute.

## EARLY AND MID-CAREER RESEARCHER COMMITTEE



The early and mid-career researchers' (EMCR) committee represents the community of developing researchers in the Faculty. The Committee promotes and runs specialised training programs and organises events to enable the exchange of scientific ideas and generate new collaborations.

## MAJOR ACTIVITIES OF 2023

In 2023, the FPPS EMCR committee focused on reinvigorating our vision and priorities to best suit the needs of our wonderful EMCR members. Our EMCR community continues to have success with grants, awards and publications, and we send our congratulations to everyone for these achievements. The ever-popular coffee catch-ups were again well attended, with over 80 EMCRs meeting for coffee to chat with their peers about everything science and beyond. Our EMCR newsletter continues to go from strength to strength under the guidance of our co-editors, Aili and Liam, with 3 issues in 2023 receiving wide readership and consistently positive feedback. In collaboration with HRM, our FASTTrack events focused on the importance of consumer engagement across three intensive workshops, which included both researchers and consumer advocates, and were attended by 25 people.

Some great new initiatives were launched, including our inclusion in the newly formed Melbourne Emerging leaders in Biomedical Research society. This group represents EMCRs from research institutes all around Melbourne, with events designed to increase networking among the wider postdoctoral community. A social event in August saw over 50 members meet up in Fitzroy to kick off the society in style, followed by a scientific symposium held at the Florey in September, in which four FPPS EMCRs were chosen to give presentations. More events, both internal and external, are already planned for 2024, and the committee looks forward to continuing to support and advocate for our EMCR community.



## HER RESEARCH MATTERS



Her Research Matters (HRM) is a grass roots-driven, outcome focused collective within the Faculty that promotes, sponsors and fosters an inclusive and equitable leadership environment to enable all women in academia to reach their full potential.

## MAJOR ACTIVITIES OF 2023

HRM had another busy and exciting year, thanks to the amazing engagement and enthusiasm of the whole collective. We were pleased to see MOSAIC established, and congratulate HRM member, Betty Exintaris, on her appointment as Associate Dean Equity Diversity & Inclusion. HRM maintained membership of ~120 in 2023 from diverse Faculty areas, including all themes and emerging and established leaders. We also welcomed Amelia Miklavec, whose role supports Communication and Outreach efforts.

HRM ran several events in 2023, including an IDAHOBIT panel on 'Together Always, United in Diversity', 'Perfect your Biography' panel, workshops on Consumer Engagement and a strategic review of NHMRC grants.

Five HRM members were sponsored to attend Science Meets Parliament. One attendee noted, 'Learning about skills for interacting with politicians, storytelling, and engaging with the media were invaluable.'

HRM helped revise the Faculty's Research Performance Standards, which are used as benchmarks for promotion. We advocated to include metrics around Engagement and Mentoring to reinforce that how we conduct research and education is as important as traditional measures of success. Associate Dean of Research, Prof Peter Scammells, said the metrics were '...explicitly incorporated to reflect the behaviours that the Faculty values and recognises.'

HRM looks forward to 2024 with a commitment to remain outcome-focused, seeking to leverage our collective networks, skills and voices to promote women research leaders at all levels.

## MULTICULTURAL OUTREACH AND SUPPORT FOR ADVANCEMENT, INCLUSION AND COMMUNITY



Multicultural Outreach and Support for Advancement, Inclusion and Community (MOSAIC) is a support network in the Faculty for people of colour, including those of culturally and linguistically diverse backgrounds, with the goal to increase representation of traditionally marginalised communities in decision-making groups and leadership positions.

### MAJOR ACTIVITIES OF 2023

The establishment of MOSAIC in mid-2023 marked a significant step forward in fostering diversity and inclusivity within our Faculty, growing to >28 members within 6 months.

This initiative addresses prevalent challenges encountered by people of colour in workplace settings including microaggressions, unconscious bias, and imposter syndrome, and serves as a platform for sharing experiences and providing mutual support. 'It's early days yet, but I hope the group's presence has sparked conversations and challenged perspectives', says Dr Amy Chen, Co-founder of MOSAIC.

MOSAIC congratulates our PPS-Ed representative, Dr Betty Exintaris on her appointment as the Associate Dean for Equity, Diversity, and Inclusion (EDI). Betty advocated for formal recognition of EDI efforts within the Faculty, and with support from Marian Costello, Faculty General Manager, this had led to the introduction of an annual EDI award starting in 2024.

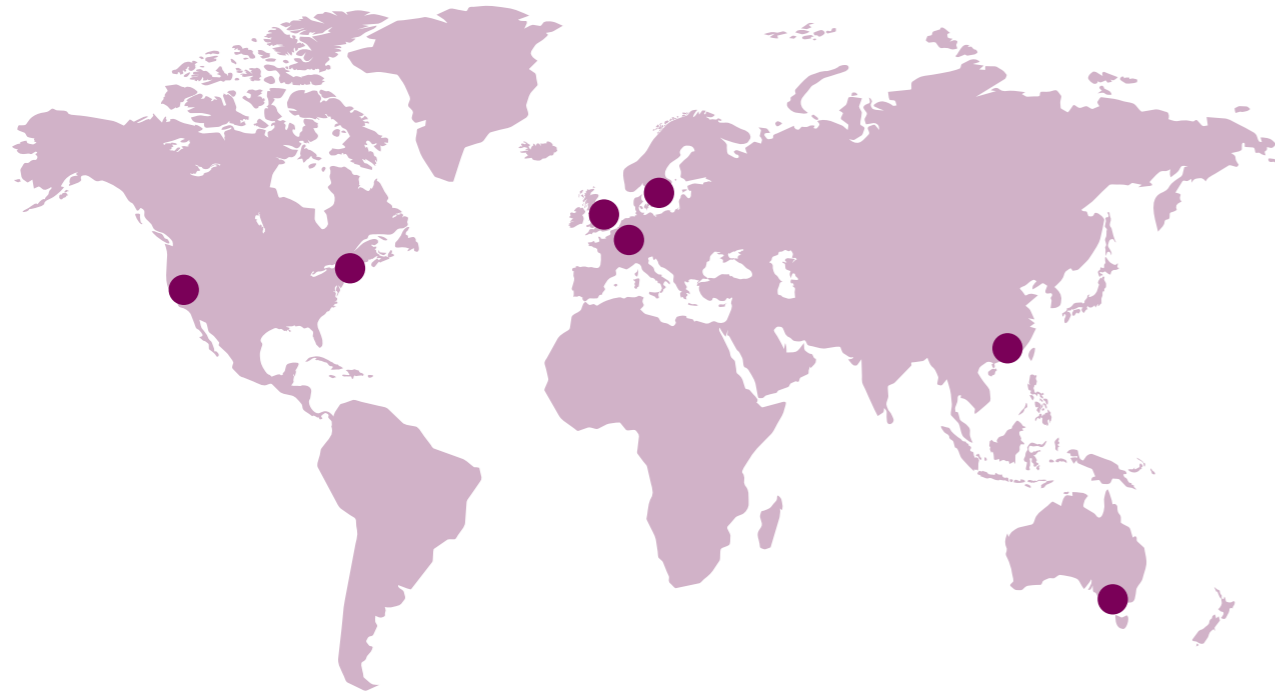
Looking ahead, MOSAIC is excited for our official launch in 2024, with the Monash EDI Director, Fiona Marshall slated to join us in celebrating this milestone.

'We are proud that at MIPS, we are actively implementing recommendations listed in the Australian Government's Pathway to Diversity in STEM Review', says Dr Amandeep Kaur, Chair and Co-founder of MOSAIC. These initiatives underscore our commitment to driving meaningful change and promoting inclusivity in academia.



# PARTNERSHIPS & COLLABORATIONS

We are a deeply international research institute. Our research staff and students have come from all over the world, and we partner with international experts and collaborators to achieve better health outcomes for all.



We are part of PharmAlliance, a strategic partnership between three global leaders: Eshelman School of Pharmacy at the **University of North Carolina at Chapel Hill, United States**; School of Pharmacy at **University College London, United Kingdom**; and the Faculty of Pharmacy and Pharmaceutical Sciences, **Monash University**.

Other major international collaborations:

- Moderna, Boston, USA
- Servier, Paris, France
- Vernalis, Cambridge, UK
- Takeda, Tokyo, Japan
- Pfizer, New York, USA
- PureTech Health, Boston, USA
- ThermoFisher Scientific, Massachusetts, USA
- Halozyme, San Diego, USA
- Medicines for Malaria Venture & Drugs for Neglected Diseases Initiative, Geneva, Switzerland
- University of Nottingham, UK
- University of Copenhagen, Denmark
- University of Hong Kong, China

A quarter of our awarded grants and research contracts are with an international partner and over 50% of our publications have an international co-author.

Our Australian research collaborations are equally important to us. They include Australian universities including all of the Group of Eight and medical research institutes such as the Baker, WEHI, the Florey and the Peter Doherty Institute. We work with the major health networks in Melbourne (Melbourne Health, Austin Health, Monash Health, Alfred Health/Hospital), as well as national scientific organisations including the CSIRO, Australian National Fabrication Facility and Therapeutic Innovation Australia.



# COMMERCIALISATION

Invention Disclosures

8 

Patent families under active management

15 

Spinouts and Startups

4 

Licences including options and assignments

7 

MIPS is excelling in translating its discoveries into tangible outcomes, including the delivery of better health outcomes and the generation of new companies and jobs that grow the Australian economy. With the largest critical mass of pharmaceutical researchers in Australia and a long history of research excellence in pharmaceutical science, MIPS has built key strengths in translational drug discovery and development. Our therapeutic foci place us at the forefront of research translation that addresses human health needs.

Alongside MIPS' core capabilities in pharmaceutical science sits a strong commercial acumen and business development support to advance our research towards commercial opportunities that have real-world impact. The identification, development and commercialisation of novel intellectual property is a key component of translating research at MIPS, and a dedicated team of business development and commercialisation professionals support research staff with contract management, strategic planning, forging and managing partnerships, development of commercial and business pathways that guide research translation, and building commercial value through technical de-risking. Researchers are supported during their commercialisation journey through mentorship, coaching and careful guidance.

Through its collegial culture of multidisciplinary collaboration combined with expertise in drug discovery and development, MIPS fosters an environment where entrepreneurship is embraced, evidenced by our spinout companies and licensing deals as well as long-standing partnerships with industry collaborators.

The combination of world-leading pharmaceutical researchers with expertise in drug development and commercialisation lends itself to MIPS' ability to excel in the development and translation of innovative strategies to treat disease. A snapshot of these activities during 2023 is highlighted below.



## 2023 KEY ACTIVITIES

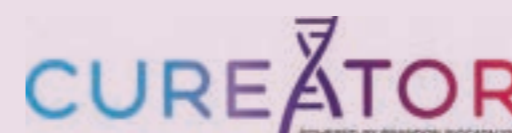
**Pacalis Therapeutics** was established in 2023 to develop a serotonin receptor-targeted agonist to revolutionise the treatment of mental health conditions.

**xCystence Bio** was spun out from Monash in 2023 supported by a \$500,000 grant by Australia's national biotech incubator, CUREator (delivered by Brandon BioCatalyst). xCystence Bio is developing a new treatment approach for polycystic kidney diseases. xCystence Bio's novel drug candidates prevent the formation of new cysts and the growth of existing cysts to slow disease progression. The company is based on work developed through a collaboration between Professor Paul Stuppelle and Dr Yichao Zhao from MIPS and Professor Ian Smythe and Dr Denny Cottle from the Monash Biomedicine Discovery Institute, who continue to work together to achieve xCystence Bio's ambition of developing a treatment for polycystic kidney disease.

**A polynucleotide-targeting drug discovery platform** led by Professors Bernie Flynn and Martin Scanlon at MIPS was also established in 2023, facilitated by the award of a \$500,000 CUREator grant. The platform seeks to expand the druggable genome by curating a library of small molecules that bind preferentially to nucleic acids such as RNA and DNA or to proteins that regulate nucleic acid activity.

**Cincera Therapeutics** is developing a novel drug class for the treatment of fibrotic diseases. Founded in 2021 and funded by Brandon Biocatalyst, Cincera also received CUREator funding in 2023 to further their drug discovery and development activities. Cincera Therapeutics is led by Professor Bernie Flynn at MIPS in collaboration with Professor Stuart Pitson from the University of South Australia.

**Other commercial successes** for MIPS during 2023 include the establishment of a NewCo (currently undisclosed) developing novel treatments for chronic diseases, as well as initiation of a research collaboration with a US biotech company who have an option to licence a MIPS technology to permit its development as a treatment for autoimmune and other chronic disease. MIPS has also forged a partnership with a commercialisation company who has an option to licence and commercialise MIPS intellectual property for illicit drug testing.

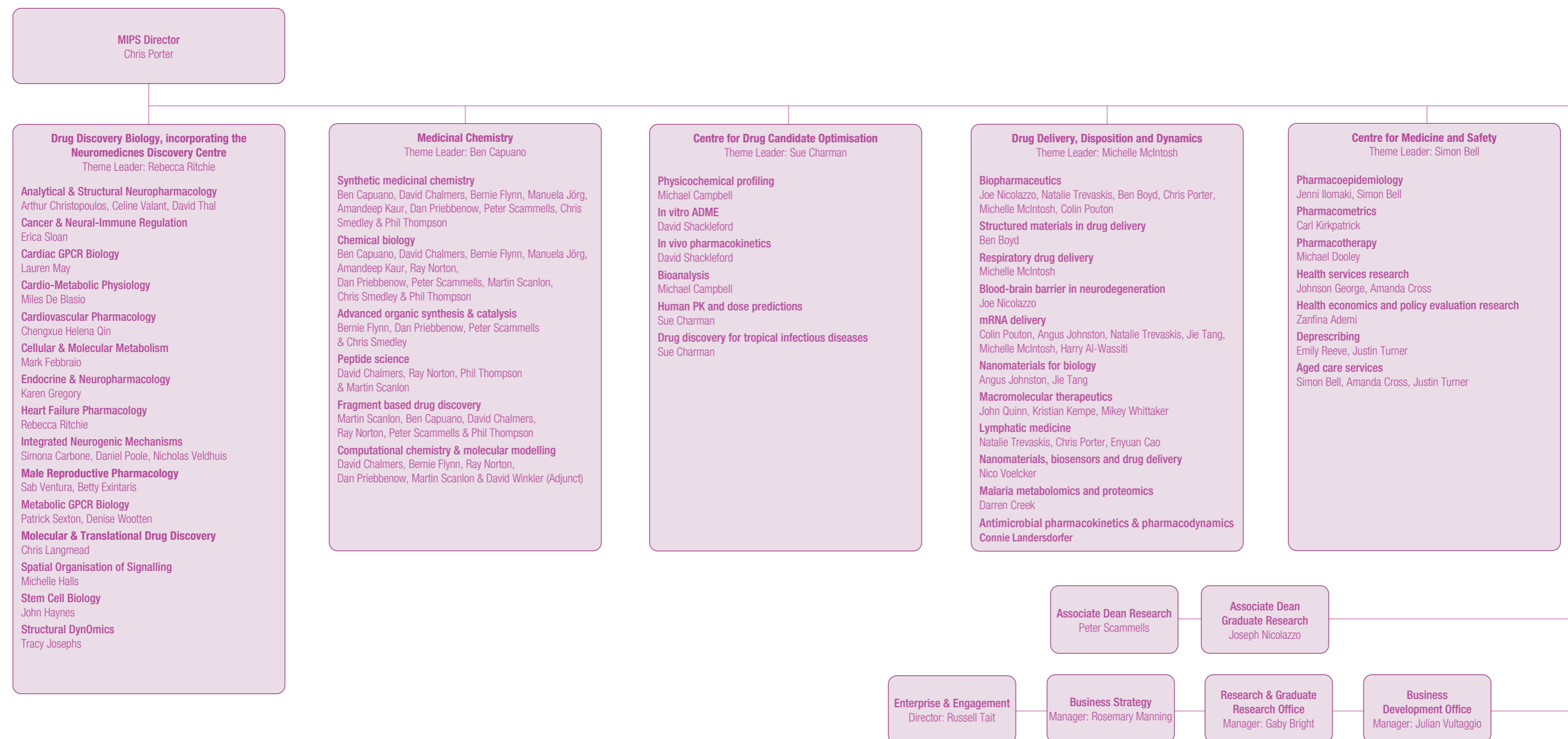


The successes in 2023 for MIPS scientific achievements extend beyond the Parkville campus and Australia. Professor Arthur Christopoulos, the Faculty Dean, along with Professor Patrick Sexton from DDB were two of the scientific co-founders of Septerna, a US-based start-up focussed on GPCR-targeting drug discovery. 2022 saw Septerna raise US\$100 million (AUD\$140 million) in Series A funding. The company built on this impressive achievement in 2023 with Series B fund raising of US\$150M (AUD\$220M).

In 2017 MIPS licenced what was to become the 'Glyph' lymph prodrug technology to PureTech Health, also in the United States. In 2021, the lead PureTech Glyph product candidate, LYT-300 (oral allopregnanolone), completed preclinical proof-of-concept, followed by Phase 1 clinical trials in 2022. The successes for PureTech Health and the Glyph technology continued in 2023 with the completion of Phase 2a clinical trials. The technology is being developed to treat neurological conditions including anxiety and depression.

# MIPS ORGANISATIONAL STRUCTURE AND EXPERTISE

All MIPS research staff and students are affiliated with one of the Research Themes. The MIPS Leadership group consists of the Theme Leaders, the Faculty Associate Deans of Research and Graduate Research, the Director of Engagement & Enterprise, and the Managers of Business Strategy, Research and Graduate Research, and Business Development.



# OUR GRADUATE RESEARCH STUDENTS

Graduate research students – those studying for a PhD or Masters by research – make up almost 50% of MIPS researchers. They contribute enormously to our research efforts while undertaking training with our world-leading researchers. Our students in the graduating cohort have embarked on varied careers across the globe – undertaking postdoctoral research fellowships at universities including Harvard, Hong Kong, Nottingham, and Oxford, working in scientific and clinical roles in industry including CSL, ThermoFisher and myDNA Life. Some haven't gone quite so far afield and are working here in Melbourne at various sites including the Murdoch Children's Research Institute, WEHI and MIPS.

Congratulations to all 49 of the graduates of 2023.

## DOCTOR OF PHILOSOPHY

### JANUARY

#### Dr Jianjun Cao

*Understanding structure and activation of amylin and calcitonin receptors*

Professor Patrick Sexton, Professor Denise Wootten, Dr Matthew Belousoff

[Drug Discovery Biology](#)

#### Dr Ellis Hancox (Joint PhD with The University of Warwick)

*High Chi Polymers from Hydrophobic Initiators for Ultra-Small Microphase Separation*

Professor Dave Haddleton (University of Warwick), Dr Mikey Whittaker

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Yih Ong

*Understanding the In Vivo Behaviour of Nanoparticle Therapies*

Associate Professor Angus Johnston, Dr Rob de Rose

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Anida Velagic

*Contrasting impact of nitroxyl and nitric oxide on the diabetic heart and vasculature*

Professor Rebecca Ritchie, Dr Barbara Kemp-Harper, Dr Chengxue Helena Qin

[Drug Discovery Biology](#)

### FEBRUARY

#### Dr Rukshar Gobarani

*Optimising the use of varenicline and smoking cessation interventions in primary and secondary care settings*

Associate Professor Johnson George, Dr Billie Bonevski, Professor Michael Abramson

[Centre for Medicine Use and Safety](#)

#### Dr Ankit Malhotra

*Functionalization of porous silicon nanovectors for triple-negative breast cancer treatment*

Professor Nico Voelcker, Dr Anna Cifuentes-Rius, Dr Wing Yin Tong, Dr Kylie Wagstaff

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Yingkai Wei

*Pain-on-a-chip: towards a cell-based microfluidic biosensor for the detection of nociceptive response in complex biological fluids*

Professor Nico Voelcker, Dr Tommy Tong, Dr Nik Veldhuis

[Drug Delivery, Disposition and Dynamics](#)

### MARCH

#### Dr Evon Chong

*Development of Caveospheres as a Targeted Analgesic Drug Delivery System*

Associate Professor Angus Johnston, Dr Nik Veldhuis, Professor Rob Parton

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Esther Firkin

*Engineered nano-bio cellular interfaces: Vertically aligned silicon nanowire arrays for human cell manipulation and neuronal progenitor cell differentiation*

Professor Nico Voelcker, Associate Professor Roey Elnathan, Dr Carmel O'Brien

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Yiling Low

*The Role of Fatty Acid-Binding Proteins in Microglial Docosahexaenoic Acid Uptake and Immunometabolism*

Associate Professor Joe Nicolazzo, Associate Professor Jen Short, Dr Yijun Pan

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Samad Mussa Farkhani

*Development of targeted gold nanoclusters for advanced cancer therapies*

Dr Anna Cifuentes-Rius, Professor Nico Voelcker, Dr Deeeepagan Veerasikku

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Thanh Nguyen

*Multi-omic Approaches Define New Functional Roles for the Transient Receptor Potential Vanilloid 4 (TRPV4) Ion Channel in Macrophages*

Dr Dan Poole, Dr Nik Veldhuis, Dr Ghizal Siddiqui

[Drug Discovery Biology](#)

#### Dr David Pizzi

*Chiral, Water-Soluble Poly(2,4-dialkyl-2-oxazoline)s As Next Generation Biocompatible Nanomaterials*

Dr Kristian Kempe, Professor Kris Thurecht

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Jessica Tait

*Dynamic infection models, metabolomics and mechanism-based modelling to investigate pharmacodynamic challenges of Pseudomonas aeruginosa*

Associate Professor Connie Landersdorfer, Associate Professor Darren Creek

[Drug Delivery, Disposition and Dynamics](#)

### APRIL

#### Dr Mohammad Abdallah

*Lipidation of brush polyethylene glycol polymers to extend plasma half-life and promote lymphatic uptake*

Associate Professor Natalie Trevaskis, Associate Professor John Quinn, Dr Mikey Whittaker

[Drug Delivery, Disposition and Dynamics](#)

#### Dr Petar Calic

*The Design, Synthesis and Evaluation of Novel Metalloaminopeptidase Inhibitors*

Professor Peter Scammells, Associate Professor Sheena McGowan

[Medicinal Chemistry](#)

#### Dr Vanessa Kee

*Dual incretin agonism in the treatment of Type 2 Diabetes and Obesity*

Professor Denise Wootten, Dr Dana Hutchinson, Professor Patrick Sexton, Dr Chris Choy

[Drug Discovery Biology](#)

#### Dr Mahta Mansouri

*The Development of a New Class of Plasmodium falciparum M1 and M17 Inhibitors as Potential Antimalarials*

Professor Peter Scammells, Associate Professor Sheena McGowan

[Medicinal Chemistry](#)

#### Dr Bairavee Ramachandran

*Systemic and Gastrointestinal Tract Directed Protease Activated Receptor-2 Modulators*

Professor Bernie Flynn,

Dr Giang Le

[Medicinal Chemistry](#)

#### Dr Liudi Zhang

*Structural insights into the inactive and active states of the A3 adenosine receptor*

Dr David Thal, Dr Lauren May,

Professor Arthur Christopoulos, Dr Jesse Mobbs

[Drug Discovery Biology](#)

## MAY

### Dr Syaza Binte Abu Bakar

*Investigations of a Formulated Substitute for Colostrum*  
Professor Ben Boyd, Dr Andy Clulow, Dr Kevin Nicholas,  
Dr Malinda Salim  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Jomo Kigotho

*Structure-Activity and Metabolic Relationships of 2-Aminobenzimidazole Antimalarials*  
Professor Peter Scammells, Dr Shane Devine,  
Associate Professor Darren Creek, Professor Ray Norton  
[Medicinal Chemistry](#)

### Dr Baolong Pan

*Development of Novel Heterobifunctional Degraders and Antifungal Agents*  
Professor Phil Thompson, Dr Simon Mountford  
[Medicinal Chemistry](#)

### Dr Shanti Sibuea

*Modulating development and maturation of human embryonic stem cell-derived midbrain dopaminergic neurons using growth and survival factors*  
Professor Colin Pouton, Dr John Haynes  
[Drug Delivery, Disposition and Dynamics](#)

## JUNE

### Dr Anal Desai

*Antibody-functionalised porous silicon nanoparticles for delivering tumour antigens to dendritic cells*  
Dr Anna Cifuentes-Rius, Associate Professor Angus Johnston, Professor Nico Voelcker  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Steven Ivulich

*Optimisation of Immunosuppression Post-Lung Transplantation*  
Professor Michael Dooley, Professor Carl Kirkpatrick  
[Centre for Medicine Use and Safety](#)

### Dr Daniel Truong

*Privileged scaffold-inspired drug discovery*  
Professor Phil Thompson, Dr Simon Mountford  
[Medicinal Chemistry](#)

## JULY

### Dr Shuqi Chen

*The development of methods for the rapid assembly of diverse sp<sup>2</sup>- and sp<sup>3</sup>-rich scaffolds*  
Professor Bernie Flynn, Dr Giang Le  
[Medicinal Chemistry](#)

### Dr Najma Fithri

*Near Infrared Photothermal Nanomaterials as Theranostics for Thrombosis*  
Dr Nghia Truong Phuoc, Dr Hang Ta,  
Professor Karlheinz Peter, Professor Pu-Chun Ke,  
Associate Professor Xiaowei Wang  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Zihnil Mazrad

*Multifunctional Poly(2-Oxazoline) Based Nanoparticles for Microglia-Targeting Therapeutics*  
Dr Kristian Kempe, Associate Professor Joe Nicolazzo  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Aparna Nandakumar

*Understanding Bio-Nano Interactions in Alzheimer's Disease and Cancer*  
Associate Professor John Quinn, Dr Pu-Chun Ke,  
Professor Tom Davis  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Ayame Saito

*Characterising the M1 muscarinic acetylcholine receptor in the gastrointestinal tract*  
Dr Celine Valant, Dr Dan Poole, Dr Simona Carbone,  
Professor Arthur Christopoulos  
[Drug Discovery Biology](#)

## AUGUST

### Dr May Lai

*Development of core crosslinked polymers for in vivo pretargeting click chemistry*  
Dr Kristian Kempe, Professor Tom Davis,  
Professor Kris Thurecht  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Jessica Lu

*Structural and Pharmacological Characterisation of Splice Isoforms of the Pituitary Adenylate Cyclase-Activating Polypeptide Type 1 (PAC1) Receptor*  
Professor Denise Wootten, Dr Elva Zhao, Dr Sarah Piper,  
Professor Patrick Sexton  
[Drug Discovery Biology](#)

### Dr Rekha Shandre Mugan

*Discovery of a novel Melanocortin receptor 5 agonist for Type 1 Diabetes*  
Professor Colin Pouton, Professor Phil Thompson  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Xiaohan Sun

*Magnetically-activated lipid-based colloidal systems as pulsatile on-demand drug delivery systems*  
Professor Ben Boyd, Dr Angel Tan  
[Drug Delivery, Disposition and Dynamics](#)

### Dr HaoZhe Yoh

*Engineered vertically-aligned polymeric nanostructures for intracellular delivery to mammalian cells*  
Professor Phil Thompson, Dr Simon Mountford  
[Drug Delivery, Disposition and Dynamics](#)

## SEPTEMBER

### Dr John Azietaku

*Profiling Glucagon-Like Peptide -1 Receptor Transducer Coupling, Signalling and Biased Agonism*  
Professor Denise Wootten, Dr Elva Zhao,  
Dr Madeleine Fletcher, Professor Patrick Sexton  
[Drug Discovery Biology](#)

### Dr Salem Moustafa

*Sophisticated application of pharmacogenomics in personalised medicine*  
Professor Carl Kirkpatrick, Associate Professor Les Sheffield,  
Dr Thomas Polasek  
[Centre for Medicine Use and Safety](#)

## OCTOBER

### Dr Grace Chin

*Electrochemical biosensing to unveil the role of exosomes as cancer biomarkers*  
Professor Beatriz Prieto-Simon, Associate Professor Rebecca Lim, Dr Roshan Vasani  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Khaled Elnahrir

*Structural and functional characterisation of peptide toxins from Australian sea anemones*  
Professor Ray Norton, Dr Dorothy Wai  
[Medicinal Chemistry](#)

### Dr Roisin McCague

*Characterisation of Endogenous Tachykinin Signalling at the Neurokinin-1 Receptor and Determining its Role in Neurological Outcomes after Experimental Stroke*  
Dr Nik Veldhuis, Associate Professor Connie Wong,  
Dr Dan Poole, Dr Arisbel Batista Gondin  
[Drug Discovery Biology](#)

### Dr Muhammad Razzak

*Structural Basis of Metabotropic Glutamate Receptor 5 (mGlu5) Allosteric Modulation*  
Associate Professor Karen Gregory, Dr Shane Hellyer  
[Drug Discovery Biology](#)

### Dr Ali-Reza Shokouhi

*Engineered Nano-Bio Cellular Interfaces: Nanostructural-Electroporation Platform for Intracellular Delivery*  
Associate Professor Roey Elnathan, Dr Maria Alba Martin,  
Dr Yaping Chen  
[Drug Delivery, Disposition and Dynamics](#)

### Dr Xiaotong Zhou

*Development and optimisation of lymph-directing prodrugs to enhance oral drug exposure*  
Professor Chris Porter, Associate Professor Natalie Trevaskis,  
Dr Sifei Han  
[Drug Delivery, Disposition and Dynamics](#)

## NOVEMBER

### Dr Joshua Morrow

*Nanotherapeutic biomaterials to modulate ferroptosis*

Dr Kristian Kempe, Professor Ashley Bush

[Drug Delivery, Disposition and Dynamics](#)

## DECEMBER

### Dr Cristina Ghijben

*Integration of the Emergency Medicine pharmacist into the reception and resuscitation of critically ill and injured patients*

Professor Michael Dooley, Professor Biswadev Mitra

[Centre for Medicine Use and Safety](#)

### Dr Weisen Zhang

*Optimisation of Nanoparticles for Crossing the Blood-brain Barrier Using a Microfluidic Chip Model*

Professor Nico Voelcker, Dr Lars Esser, Dr Tommy Tong,

Dr Pouya Dehghankelishadi

[Drug Delivery, Disposition and Dynamics](#)

## MASTER OF PHILOSOPHY

### Ms Jia Kuah

*HaloTag pseudotyped lentivirus: Quantifying uptake and internalisation in vitro using a fluorescent click sensor*

Associate Professor Angus Johnston, Dr Orlagh Feeney

[Drug Delivery, Disposition and Dynamics](#)

## GRADUATE RESEARCH COURSE REVIEW

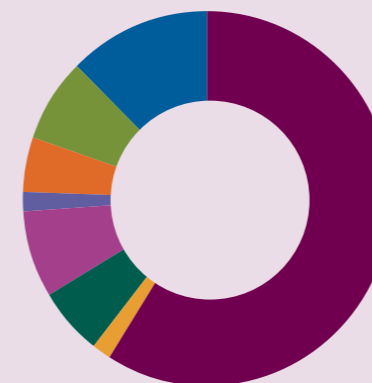
2023 was a significant year for the graduate research program as we undertook a 5-yearly review of the courses offered in the Faculty. The review included assessment by an external review panel who made a number of commendations and recommendations, including the expansion of the DDB mentoring program to all students, enhanced mental health support, and a review of the offerings of the Monash Doctoral Program. The Faculty is responding and acting on all the recommendations. Our thanks to the members of the external review panel: Chair, Professor Sarah Roberts-Thomson from the University of Queensland; Professor Kevin Batty from Curtin University; and Professor Sadequr Rahman from Monash University Malaysia.

# FINANCIAL SNAPSHOT

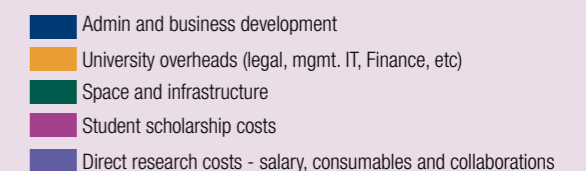
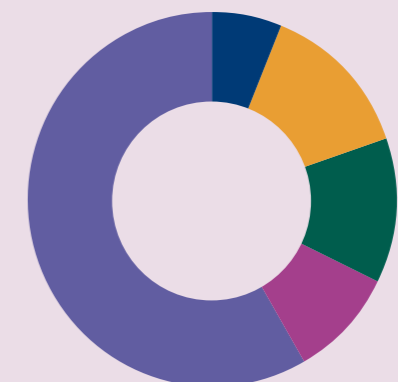
	2022	2023
	\$'000s	\$'000s
<b>Revenue</b>		
Australian Government (includes MRFF and infrastructure)	33,854	49,426
Victorian Government	6,364	1,350
Other Australian Competitive grants	4,162	4,920
Australian contracted research	9,752	6,403
Donations - research, scholarships and other	31	1,402
HDR Student fees	3,365	3,770
International grants and contracted research	5,435	6,231
Monash University allocations and funding	9,584	10,283
<b>Total</b>	<b>72,546</b>	<b>83,785</b>

	\$'000s	\$'000s
<b>Expenditure</b>		
Directorate management and business development	4,055	4,998
University overheads (legal, mgmt. IT, Finance, etc)	8,696	10,938
Space and infrastructure	9,468	10,174
Student scholarship costs	6,888	7,648
Direct research costs - salary, consumables and collaborations	41,208	46,821
<b>Total</b>	<b>70,315</b>	<b>80,579</b>
Carryover research commitments	2,231	3,206

### Revenue\*



### Expenditure



\* External revenue includes multi-year grants which have commitments for expenditure in future years

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This information was correct at the time of publication  
(June 2024).

*Monash University reserves the right to alter this  
information should the need arise.*

