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Launched in 2009, the La Trobe Institute for Molecular Science (LIMS) brings together La Trobe University’s leading researchers to work on some of the most critical problems at the interface of health and science.

The Institute’s vision is achieved through excellence in six areas of research strength: Cancer, Infection and Immunity, Neurobiology, Molecular Design, Molecular Imaging and Molecular Sensing.

Its research agenda is supported by a state-of-the-art facility where scientists in different disciplines work together in well equipped, shared work-spaces to achieve outcomes that would not be possible in traditional academic settings.

LIMS also has two embedded biotech companies: Hexima Limited, who are developing plant-derived proteins and peptides for application as human therapeutics and the genetic modification of crops; and AdAlta Limited, who are developing the next generation antibody platform, the i-body, to deliver high affinity and specific biologics against a variety of therapeutic and diagnostic targets.

LIMS has outstanding links with the Australian Synchrotron. Several of the Institute’s physicists design and build synchrotron components.

Game changing partnerships also enhance the Institute’s efforts to raise its research capabilities to new levels of national and international significance. An important collaboration with the Olivia Newton-John Cancer Research Institute facilitates the sharing of knowledge, skills, training and facilities.
EXPLORE LIMS

Translatable research
To conduct high quality basic research at the interface of health and science. To recruit and retain leading scientists in areas of strength, and build upon existing platform technologies to support a multi-disciplinary research environment.

Outstanding students
To train the next generation of Australian scientists. To provide postgraduate students and early career researchers with exposure to high impact projects, access to the latest equipment and integrated workplace learning with a focus on employability.

Game changing partners
To develop game changing partnerships to raise research capabilities to new levels of national and international significance. To build upon existing partnerships with the Olivia Newton-John Cancer Research Institute and the Australian Synchrotron in the sharing of knowledge, skills, research training and facilities.

Industry connections
To support and collaborate with embedded biotech companies and develop new industry partnerships. To become the interface between local and global biotechnology companies.

* Based on field receiving a top rating at two-digit level and the number of top-rated fields at the supporting 4-digit level.

LIMS

AUD $100 MILLION RESEARCH HUB.

56 RESEARCH AND SUPPORT LABORATORIES.

3000 SQUARE METRES OF TEACHING FACILITIES.

400 ACADEMIC STAFF AND POSTGRADUATE STUDENTS.

REGIONAL NODE IN BENDIGO.

RESEARCH

AUSTRALIA’S BEST UNIVERSITY FOR BIOLOGICAL SCIENCES (EQUAL WITH THE AUSTRALIAN NATIONAL UNIVERSITY AND THE UNIVERSITY OF QUEENSLAND).*

VICTORIA’S BEST UNIVERSITY FOR ANALYTICAL CHEMISTRY AND BIOCHEMISTRY AND CELL BIOLOGY.

EQUAL FIRST IN VICTORIA FOR PHYSICAL SCIENCES INCLUDING CONDENSED MATTER PHYSICS AND OPTICAL PHYSICS.

TOP THREE IN VICTORIA FOR INORGANIC CHEMISTRY AND GENETICS.

Murri Totems is a sculptural work by contemporary Indigenous artist Reko Rennie, commissioned for LIMS. The bright, geometric sculptures draw on traditional indigenous culture, contemporary art and Western science.

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Marri Totems is a sculptural work by contemporary Indigenous artist Reko Rennie, commissioned for LIMS. The bright, geometric sculptures draw on traditional indigenous culture, contemporary art and Western science.
FACILITIES

COMPREHENSIVE PROTEOMICS PLATFORM
A SUITE OF SYNERGISTIC CAPABILITIES FOR THE CHARACTERISATION OF PROTEINS.

CENTRE FOR MATERIALS AND SURFACE SCIENCE
AUSTRALIA’S MOST COMPREHENSIVE SUITE OF SURFACE SCIENCE AND SURFACE ANALYSIS EQUIPMENT.

BIOIMAGING
A SUITE OF CONFOCAL AND CONVENTIONAL WIDEFIELD MICROSCOPES FOR OPTICAL IMAGING OF LIVE CELL DYNAMICS AND FIXED BIOLOGICAL SPECIMENS.

FLOW CYTOMETRY
SOPHISTICATED EQUIPMENT FOR CELL ANALYSIS AND CELL SORTING.

HISTOLOGY
A SUITE OF PRECISION INSTRUMENTS FOR HIGH QUALITY SPECIMEN PREPARATION AND SECTIONING.
LIMS uses basic research to connect the multidisciplinary dots at the interface of health and science. It features an innovative and broad-ranging research portfolio that spans biochemistry, chemistry, genetics, physics and pharmacy.

In 2015, our senior leadership team developed a new strategic plan that positioned LIMS as our external face, and the School of Molecular Sciences as our teaching and administrative arm within La Trobe University. It also organised researchers into themes that encompass both biomedical and technological areas of research. Our strategic plan now informs recruitment and retention, and ensures that our interdisciplinary research is published in the best journals and translatable into real world practice.

In 2016, we bedded down our themes with workshops and seminars that encouraged researchers to think outside traditional academic settings. Theme leaders worked closely with our senior leadership group to develop a successful bid around next generation antibiotics. This research initiative–awarded $2.2M over three years by the University–aims to develop new molecules to combat disease in humans, animals and plants. Our theme groups also worked to establish facilities, such as the Comprehensive Proteomics Platform, that benefit the University’s broader scientific community.

This year our scientists were recognised for their research excellence and innovation, and for making discoveries of global importance. Emeritus Professor Nick Hoogenraad AO, Dr Amelia Johnston, Dr Hamsa Puthalakath and Dr Megan Maher, together with Professor Andrew Scott (Olivia Newton-John Cancer Research Institute), Dr John Silke (Walter and Eliza Hall Institute), and Professor Ulf Eriksson (Karolinska Institute), were awarded $2.5M funding by the Victorian Cancer Agency for their research on cachexia, a muscle wasting disease that kills up to one third of people with late-stage cancers.

Dr Brian Abbey and an international team of more than 20 scientists discovered how to create a new type of crystal using light more than ten billion times brighter than the sun. Their findings, published in Science Advances, reverse what has been accepted thinking in crystallography for more than 100 years.

LIMS embedded biotech AdAlta Limited were successful in raising almost $10M in their initial public offering on the Australian Securities Exchange. The company will use the funds to complete the first phase of a clinical study of its candidate drug, which shows promise in treating fibrotic diseases, notably idiopathic pulmonary fibrosis.

Dr Ivan Poon and Dr Brian Abbey received Young Tall Poppy Awards for their world-class research. Professor Marilyn Anderson was named an Officer of the Order of Australia for her distinguished service to science and higher education.

Through the LIMS Endowment Fund, we awarded a Bruce Stone fellowship to Dr Yuning Hong, who builds fluorescent molecules that allow scientists to visualise the protein lifecycle in cells and identify biomarkers for early diagnosis of neurodegenerative diseases. We also appointed Patrick Humbert as our new Professor of Cancer Biology. Professor Humbert is a National Health and Medical Research Council Senior Research Fellow. He oversees a research team that investigates how cell shape and orientation controls how they mutate, proliferate and spread during the onset and establishment of cancer.

I was appointed Pro Vice-Chancellor of the College of Science, Technology and Engineering at La Trobe University in late 2016. It is a tremendous honour, and I look forward to shaping the direction of the College in research, and student recruitment and retention. Professor Andrew Hill, an expert on neurodegenerative diseases, has been appointed Director of LIMS. His leadership will ensure that the Institute builds upon its strong research reputation and industry partnerships.
LEADERSHIP TEAM

LIMS is led by an experienced team who understand the importance of scientific innovation and translatable research.

Director, Professor Robert Pike, has over ten years’ experience in senior academic and research leadership roles.

Professor Andrew Hill, Professor Brian Smith and Dr Michael Angove are the Heads of Department, and Dr Mark Hulett is Research Director.

The wider executive team includes Dr Adam Mechler and Dr David Wilson, who lead the Graduate Research Team and Teaching and Learning Committee respectively. Dr Megan Maher and Dr Matthew Perugini lead the Postgraduate Coursework and Research Infrastructure portfolios. Dr Anne Evans is Business Support Manager.

Professor Robert Pike

Professor Robert Pike is Director of LIMS and Head of the School of Molecular Sciences.

Professor Pike obtained his PhD in Biochemistry from the University of Natal in South Africa in 1991. He held postdoctoral positions at the University of Georgia (USA) and the University of Cambridge (UK) before establishing his own laboratory in the Department of Biochemistry and Molecular Biology at Monash University in 1997. At Monash, he served as Head of Biochemistry and Molecular Biology (2006-11), Head of the School of Biological Sciences (2012) and Deputy Dean (Academic Planning) in the Faculty of Medicine, Nursing and Health Sciences (2013-14). He was appointed Director of LIMS and Head of the School of Molecular Sciences in 2015.

Professor Pike is a biochemist specialising in the study of enzymes involved in innate immunity and host defence against bacteria and other pathogens. He is interested in the enzymes used by pathogens to attack the host. He has published over 100 research papers and supervised over 20 PhD students to completion.
Professor Andrew Hill

Professor Andrew Hill is Head of the Department of Biochemistry and Genetics and Director of La Trobe University’s Research Focus Area, Understanding Disease.

Professor Hill obtained his PhD at Imperial College London in 1998. He held postdoctoral positions in the MRC Prion Unit (London) and The University of Melbourne. Professor Hill joined the Department of Biochemistry and Molecular Biology at The University of Melbourne in 2002 and moved his laboratory into the Bio21 Institute when it opened in 2005. In 2015, Professor Hill was appointed Head of Biochemistry and Genetics at La Trobe University and Director of the University’s Research Focus Area, Understanding Disease. In 2016 he was elected president of the International Society for Extracellular Vesicles (ISEV).

Professor Hill’s research team uses in vitro and in vivo models to look at how abnormal proteins and RNA travel from cell to cell and are involved in neurodegenerative diseases. He has published over 150 research papers and edited three books.

Professor Brian Smith

Professor Brian Smith is Head of the Department of Chemistry and Physics.

Professor Smith obtained his PhD in Chemistry at The University of Melbourne. He held a postdoctoral position at the Research School of Chemistry in Canberra before returning to Melbourne in 1991 to join the Biomolecular Research Institute (BRI) as a research scientist. After the demise of the BRI in 2000 he moved to the Walter and Eliza Hall Institute as a founding member of the Structural Biology division. In 2011 he moved to La Trobe University, where he was appointed the inaugural LIMS Principal Research Fellow. In 2015 he became Head of the Department of Chemistry and Physics.

Professor Smith is a Fellow of the Royal Australian Chemical Institute, and is president of the Association of Molecular Modellers of Australasia. He is skilled in the determination of protein structure by X-ray crystallography, in the analysis of protein structure, and the design of protein mimetics and small-molecule inhibitors of protein function. He has published over 140 research papers.

Dr Michael Angove

Dr Michael Angove is Head of the Department of Pharmacy and Applied Science.

Dr Angove obtained his PhD in surface chemistry and soil science at La Trobe University. He became Head of the Department of Pharmacy and Applied Science in 2008. Dr Angove also serves as Academic Director of Transnational Education for PSB Academy, a partner institution delivering La Trobe University courses in Singapore.

Dr Angove specialises in environmental chemistry, with a particular focus on soils impacted by human activity and bushfires. He has worked with a range of organisations, including EPA Victoria, on the management of contaminated soils, water and sediments. He has worked on projects in the Victorian high country, investigating the long term impact of the 2003, 2008 and 2013 bushfires on soil environments. Other recent projects focus on the cycling of phosphorous in soil environments, including organic phosphorous and phosphorous-based fire retardants.

Dr Mark Hulett

Dr Mark Hulett is Research Director of LIMS.

Dr Hulett completed his PhD at The University of Melbourne on the structure-function of leukocyte Fc receptors. He was awarded an NHMRC Postdoctoral Fellowship (1995-98) to continue his work on Fc receptors at the Austin Research Institute. Dr Hulett moved to the John Curtin School of Medical Research (JCSMR) in 1999 where he cloned the heparan sulphate-degrading enzyme heparanase and described its important role in tumour progression. He was awarded a Viertel Senior Medical Research Fellowship in 2002, and established an independent laboratory at the JCSMR to study molecular aspects of cell invasion. In 2008 Dr Hulett moved his research group to La Trobe University. Dr Hulett is a past-president of the Australian Society of Medical Research and became Research Director of LIMS in 2012.

Dr Hulett’s research interests include the function of heparanase in cancer and inflammatory disease, and therapeutic applications of innate defence molecules. He has published over 90 research papers and holds eight patents.
LIMS ADVISORY BOARD

The LIMS Advisory Board, chaired by Professor Frances Shannon, provides strategic advice on the Institute’s research agenda.

Professor Frances Shannon
Professor Shannon is Deputy Vice-Chancellor (Research) at the University of Canberra. She was previously Director of the John Curtin School of Medical Research at the Australian National University. Her leadership at the University of Canberra has seen it enter world rankings for the first time and achieve well above world standard in a number of fields in Excellence in Research for Australia 2015.

Professor Marilyn Anderson AO
Professor Anderson AO is Professor of Biochemistry at La Trobe University and the Chief Scientist of Hexima Limited. She is a Fellow of the Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering. She was awarded the Lemberg Medal from the Australian Society of Biochemistry and Molecular Biology in 2014.

Professor Andrew Hill
Professor Hill is Head of the Department of Biochemistry and Genetics at La Trobe University and Director of the University’s Research Focus Area, Understanding Disease. Professor Hill is a National Health and Medical Research Council Senior Research Fellow and previous holder of an Australian Research Council Future Fellowship (Level 3).

Professor Keith Nugent
Professor Nugent is Deputy Vice-Chancellor (Research) at La Trobe University. He is a Fellow of the Australian Academy of Science, the Australian Institute of Physics and the American Physical Society. He is a recipient of the 2004 Victoria Prize, the Pawsey Medal from the Australian Academy of Science, and the Boas Medal from the Australian Institute of Physics.

Professor Andrew Peele
Professor Peele is Director of the Australian Synchrotron. He is Professor of Physics at La Trobe University and was seconded to the Australian Synchrotron as Head of Science in 2011. He is a Principal Investigator in the ARC Centre of Excellence for Advanced Molecular Imaging and has published over 100 research papers.

Professor Robert Pike
Professor Pike is Director of LIMS and Head of the School of Molecular Sciences at La Trobe University. He has over ten years’ experience in academic and research leadership roles. Professor Pike is a biochemist specialising in enzymes. He has published over 100 research papers and supervised over 20 PhD students to completion.

Dr Tony Radford AO
Dr Radford AO is a Director of Nucleus Networks and ASX-listed Genetic Signatures Limited. He was previously CEO of ASX-listed Cellestis, from founding until its acquisition by QIAGEN NV in 2011. For his contributions to tuberculosis diagnosis and enterprise he received the Clunies Ross Award for application of technology, and is a Distinguished Alumnus of La Trobe University.

Dr Nick Samaras
Dr Samaras is Director of AGRF Pty Limited and MuriGen Therapeutics, Chairman of ASX-listed Genetic Signatures Limited, and Adjunct Professor at La Trobe University. He has over 25 years’ experience in the science industry, and has worked in senior roles with global life science companies including Applied Biosystems and Perkin Elmer.

Professor Graham Schaffer
Professor Schaffer is Pro Vice-Chancellor of the College of Science, Health and Engineering at La Trobe University. Professor Schaffer is a Fellow of the Australian Academy of Technological Sciences and Engineering, the American Powder Metallurgy Institute International and the Institution of Engineers Australia.

Dr Alan Watkinson
Dr Watkinson is inaugural Chief Advancement Officer at La Trobe University. He has presented around the world on various aspects of fundraising and philanthropy, and now heads a team with a simple but vital mission: to enrich the lives of our alumni and engage the community in support of the aspirations of La Trobe University.
Women comprise more than half of science PhD graduates and early career researchers, but only make up 17 per cent of senior academic positions in Australian universities and research institutes.

LIMS is a proud contributor to the Science in Australia Gender Equity (SAGE) Athena Swan Charter, a national program promoting gender equity and gender diversity in science, technology, engineering, mathematics and medicine.

La Trobe is one of forty Australian universities, medical and publicly-funded research agencies taking part in this prestigious program. However, La Trobe is one of only two institutions that have committed to apply the Charter’s principles of gender equity, diversity and inclusion of underrepresented groups across all disciplinary areas.

LIMS representatives serve on La Trobe University’s SAGE Self-Assessment Team (SAT), comprising more than fifty academic and professional staff members. SAT will undertake research and develop action plans to provide practical solutions to the issues around gender equity.

LIMS has also established a Special Assistance Travel Award to enable researchers with young families or other special needs to attend conferences and grant review panels, or undertake technical training at international facilities.
Outstanding students

Through LIMS, La Trobe University offers one of Australia’s largest teaching programs in biotechnology, nanotechnology and molecular sciences.

LIMS prides itself on its simultaneous pursuit of excellence and inclusiveness, providing students with integrated workplace learning and a focus on employability. Students have access to the latest equipment and exposure to high impact research projects.

Solid growth in student recruitment is also achieved through a partnership between La Trobe and PSB Academy – one of Singapore’s largest education providers – to deliver bachelor degrees in biomedical sciences, pharmaceutical sciences, chemistry and molecular biology.

EDUCATING 1500+ UNDERGRADUATE STUDENTS.

EDUCATING 180+ POSTGRADUATE STUDENTS.

OUR COURSES INCLUDE WORK PLACEMENTS SO STUDENTS CAN APPLY THEIR SKILLS TO INDUSTRY-BASED PROJECTS.

STUDENTS HAVE ACCESS TO THE LATEST SCIENTIFIC EQUIPMENT AND EXPOSURE TO HIGH-IMPACT RESEARCH PROJECTS.
The LIMS Endowment Fund was established to create new and sustainable opportunities for scientists with outstanding potential.

**THE INAUGURAL BRUCE STONE FELLOWSHIP IN CHEMICAL BIOLOGY AND NICHOLAS HOOGENRAAD FELLOWSHIP IN MOLECULAR SCIENCES WERE AWARDED IN 2015.**

**FELLOWSHIPS ARE NAMED AFTER TWO LONG-SERVING LEADERS.**

**PROFESSOR BRUCE STONE WAS THE FOUNDATION PROFESSOR OF BIOCHEMISTRY FROM 1972-1989.**

**PROFESSOR NICHOLAS HOOGENRAAD WAS THE FIRST DIRECTOR OF LIMS.**

### Dr David Greening  
**STONE FELLOW**

Dr David Greening completed his undergraduate studies at The University of Melbourne and PhD at the Ludwig Institute for Cancer Research, before completing postdoctoral studies at the Ludwig Institute for Systems Biology (USA) and La Trobe University.

Dr Greening has published 44 research papers (19 first author, 16 corresponding/senior author, >1300 citations), in prestigious journals including *Molecular Cell*, *Proteomics*, *Seminars in Cell and Developmental Biology*, and *Biological Reproduction*. His research has been selected for journal covers twice and reviewed on Faculty1000 Biology (influential new findings). In 2016, Dr Greening received a high citation award from the Web of Science and a research excellence distinction award from the American Physiological Society.

Dr Greening’s research focuses on the functional role of the cancer secretome, defining purification and characterisation of distinct types of extracellular vesicles and mechanisms promoting cancer progression. More recently, he discovered extracellular vesicles are functionally important for embryo implantation.

### Dr Yuning Hong  
**STONE FELLOW**

Dr Yuning Hong completed her PhD in nanoscience and technology at the Hong Kong University of Science and Technology (HKUST) in 2011. She then worked as a Postdoctoral Research Associate at Dartmouth College (USA) in biophysical chemistry, and later as a Research Assistant Professor in Chemistry at HKUST. She was a McKenzie Fellow at The University of Melbourne before moving to LIMS in 2016.

Dr Hong has published over 70 research papers (>7000 citations and a H-index of 34) and holds six US patents. Her research focuses on building fluorescent molecules that allow scientists to visualise the dynamic motions of biomolecules and related biological events. In particular, she has developed new biosensors to monitor the folding of G-quadruplex DNA, the key indicator of heart disease, and a range of photostable cell imaging agents for visualising cell structures and environment.

Her current research interest focuses on discovering new methods to visualise the protein lifecycle in cells and identify biomarkers for early diagnosis of neurodegenerative diseases.

Dr Hong’s research has been featured in mainstream media including *The Age*, *The Australian*, *South China Morning Post*, *Daily Mail* and *The Guardian*. Dr Poon was awarded the 2016 Victorian Young Tall Poppy Award.

### Dr Ivan Poon  
**HOOGENRAAD FELLOW**

Dr Ivan Poon has over 11 years’ experience in the field of cell death and clearance. He completed his undergraduate degree at Monash University and PhD at the John Curtin School of Medical Research, Australian National University, before joining La Trobe University as a postdoctoral fellow in 2009. He was visiting assistant professor at the Center for Cell Clearance at the University of Virginia (2011-13).

Dr Poon has published 38 research papers (13 first author, nine senior author, >1500 citations) in high impact journals including *Nature*, *Nature Reviews Immunology*, *Nature Communications*, *Nature Protocols*, *eLife* and *Blood*. He has made several significant discoveries including the mechanism of cell fragmentation during cell death, viral protein-induced cell death, antimicrobial peptide-mediated cell lysis, and dying cell uptake via pattern recognition molecules.

Dr Poon’s research has been featured in mainstream media including *The Age*, *The Australian*, *South China Morning Post*, *Daily Mail* and *The Guardian*. Dr Poon was awarded the 2016 Victorian Young Tall Poppy Award.
Cancer

The Cancer theme investigates the mechanisms of cancer initiation and progression, the crosstalk between cancer cells and the surrounding environment, and the potential of novel therapeutic approaches for combating disease. Research spans the fields of cancer metastasis, cancer cell crosstalk with the microenvironment, tumour architecture, pro- and anti-tumour immunity, and therapeutic sensitivity and resistance.

Members have expertise in in vivo bioluminescent and fluorescent imaging, confocal microscopy, fluorescence-activated cell sorting, 3D cell cultures, Drosophila genetics, proteomic profiling, gene knockout/overexpression, DNA damage assessment, monitoring immune cell infiltration, activation and impact, stem cells, cancer cell invasion, EMT, and metastasis assays and DNA/RNA sequencing.

Current projects
Current projects work to identify key drivers of cancer progression including secreted or exosomal factors, and loss of cell polarity; the targets, mechanisms of resistance and side effects of therapeutics; development of novel biomarkers for predicting cancer spread; and identification of ways that cancer cells co-opt the immune system to promote progression.
Theme leaders

Patrick Humbert
PROFESSOR OF CANCER BIOLOGY
Cancer biology, cell polarity and tissue architecture

Determines how cell asymmetry and tissue organisation can regulate cancer initiation, progression and metastasis. Examines how the cell polarity genetic program may be involved in tissue regeneration as well as developmental processes such as blood cell production and function.

Belinda Parker
SENIOR RESEARCH FELLOW AND ARC FUTURE FELLOW
Cancer microenvironment and immunology

Determines the properties of tumour cells and interacting cells in the surrounding tissue that promote metastatic spread in clinically relevant models of breast and other cancers. Designs new anti-metastatic therapies that block the invasion and growth of cancer cells in distant tissues.

Christopher Bradley
LECTURER
Cancer chemotherapy: using small molecule inhibitors to enhance established therapies

Explores the ways in which tumours repair their DNA and resist cell death. Identifies targets for small molecules to sensitize tumour cells to the effects of radiation and cytotoxic drugs, to minimise side effects and impact on normal tissues and organs.

Suresh Mathivanan
ARC DECRA FELLOW
Exosomes, secretome and systems biology

Explores the role of extracellular matrix components (soluble secreted proteins and extracellular vesicles) in cancer and intercellular communication using proteomic, genomic and bioinformatics methodologies. Undertakes basic science projects including the biogenesis of exosomes and the role of exosomes in intercellular communication.

Mark Hulett
SENIOR LECTURER
Inflammation and tumour progression

Investigates molecular regulators of cell invasion in tumour progression and inflammation. Focuses on the enzyme heparanase and serum protein histidine-rich glycoprotein in these processes to develop new targeted therapies for the treatment of cancer and inflammatory disease.

Erinna Lee
ARC FUTURE FELLOW
Apoptosis, autophagy, cancer, cell and structural biology and drug discovery

Examines the molecular mechanisms underlying cell fate decisions dictated by the processes of apoptosis and autophagy through the use of biochemistry, cell biology and structural biology approaches. Identifies novel factors that enable crosstalk between these two biological processes.

Suzanne Cutts
SENIOR RESEARCH FELLOW
Cellular responses to anticancer drugs

Develops new therapeutic strategies for cancer treatment. Examines the mechanism of action in anticancer drugs doxorubicin (an anthracycline) and mitoxantrone (an anthracenedione). Works to restrict the killing properties of these drugs to cancerous cell types to minimise their toxic side effects.

Members

Julian Pakay
LECTURER
Signal transduction, cancer biology and bioenergetics

Studies signal transduction and cancer biology, particularly where these intersect with cellular and mitochondrial bioenergetics. Specialises in teaching and education scholarship with a focus on quantitative literacy. Developing an environmental metagenomic database for undergraduate programs.
Helena Richardson
ASSOCIATE PROFESSOR
Cell polarity, cell signalling and cancer

Uses the vinegar fly, Drosophila melanogaster, to determine how regulators of cell shape (polarity) and the cell skeleton (actin cytoskeleton) impact on cell signalling and cancer development. Identifies novel pathways that cooperate with the Ras oncogene in cancer.

David Greening
BRUCE STONE FELLOW IN CHEMICAL BIOLOGY
Extracellular vesicles, exosomes, cancer biology and uterine biology

Uses an integrated system biology approach to understand how cellular fragments called vesicles (exosomes), as well as secreted molecules (the secretome) in the extracellular environment influence cancer progression and uterine biology.

Adam Hart
LECTURER
Molecular regulation of stem cells and cancer

Studies the key genes and molecular pathways that regulate stem cells during normal growth and development. Works to identify how these genes are re-activated in the adult to cause cancer. Focuses on breast cancer, myeloid leukaemia and germ cell cancers.

Richard Simpson
PROFESSOR
Extracellular vesicles, exosomes and cancer biology

Uses an integrated proteomic, RNA profiling, bioinformatics and live-cell imaging strategy to understand the seminal role of vesicles in cell-cell communication in the extracellular environment during cancer progression and cancer plasticity.

Nick Hoogenraad
EMERITUS PROFESSOR AO
Development of therapeutic antibodies against cachexia

Specialises in cancer cachexia, a complication of cancer that affects up to 80% of patients with solid tumours and is responsible for around 25% of cancer deaths. Produces monoclonal antibodies that block cachexia, giving rise to the prospect of a treatment for this condition.

Christine Hawkins
ASSOCIATE PROFESSOR
Cell death regulation in cancer and viral infection

Studies apoptotic regulation in normal, cancerous and virally-infected cells. Explores the potential for drugs that directly induce apoptosis to successfully treat cancers without causing DNA damage, to prevent survivors from developing new, therapy-related cancers.

Chanh Tran
LECTURER
Interactions of X-rays with matter, optical coherence and X-ray imaging

Specialises in propagation-based X-ray imaging. With collaborators, developed the X-ray Extended Range Technique to quantify the interaction cross-sections between X-rays and a range of elements and compounds. Develops quantitative full field imaging techniques using polychromatic X-ray sources.

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Discoveries

Treating osteosarcoma
Osteosarcoma is a bone cancer that most frequently afflicts teenagers. Current treatments fail to cure over a third of osteosarcoma patients, and they can cause serious side effects. Better and safer therapies are urgently needed. PhD student Tanmay Shekhar and Dr Christine Hawkins found that a new class of cancer drugs called IAP antagonists could sensitise osteosarcoma cells to destruction by TNFα, a chemical messenger produced by immune cells. Their findings, published in *Oncotarget*, suggest that particular IAP antagonist drugs may be effective anti-osteosarcoma agents.

Colorectal Cancer Atlas
Bowel cancer is the second most common cancer in Australia, with about 17,000 people diagnosed every year. PhD student David Chisanga, Dr Shivakumar Keerthikumar and Dr Suresh Mathivanan have developed the Colorectal Cancer Atlas, an integrated web-based resource that catalogues scientific data on bowel cancer. The Atlas allows researchers to analyse a diverse range of material – everything from patient samples to cell lines – to advance our understanding of the development and progression of the disease.

Tumour environment and cancer progression
Epithelial-mesenchymal transition (EMT) – a process whereby cells lose their organisational and adhesion properties – plays a critical role in cancer progression and early metastasis. Dr David Greening and Professor Richard Simpson have discovered cell components that signal EMT and promote tumour growth. Their findings, published in *Scientific Reports*, provide new insights into how the tumour environment can affect cancer progression.

HUMANS AND FLIES SHARE 70% OF THE SAME DISEASE-CAUSING GENES.
Flies reveal cancer-causing genes

Look at a common vinegar fly under a microscope, and you may be surprised. Known as *Drosophila melanogaster*, these insects are a mere 2.5 millimetres long, with blood orange eyes and a genetic profile that may help scientists to unlock some of the key molecular mechanisms of disease.

Dr Helena Richardson and Professor Patrick Humbert use vinegar flies to understand cell polarity – how the shape and structure of cells control their function. Disruption of cell polarity leads to the disorganisation of tissue and organs, which can result in disease.

Dr Richardson’s lab holds around 3000 flies, each with a set of distinct gene mutations that allows this research team to observe the consequences of genetic mutations on health and lifespan. “Flies share around 70% of the same disease-causing genes as humans,” said Dr Richardson, “so any findings we make in *Drosophila* are relevant to human cells and, therefore, to medical research and industry.”

Dr Richardson and Professor Humbert are applying this model to cancer research. “Abnormal cell shape and polarity is one of the earliest hallmarks of cancer,” said Professor Humbert, “and understanding the pathways that regulate these processes is critical to understanding cancer development.” The team have recently discovered a new gene that works with the Ras protein – one of the most deadly drivers of cancer – to accelerate disease progression in lung and pancreatic cancers.

Richardson and Humbert are now working with collaborators at the Institute of Molecular Biotechnology in Austria to identify the mechanisms by which this gene affects cell shape and cell communication. They will then translate their findings into human cell analysis. “We hope our research will identify new diagnostic and therapeutic tools that will aid us in the fight against cancer,” said Dr Richardson.
Infection and Immunity

The Infection and Immunity theme studies the molecules used by viruses, bacteria, parasites and fungi to infect humans, animals and plants, and the immune response associated with this and other immunological/cell biological events, such as stress and programmed cell death. The overarching aim is to develop the next generation of antibiotic molecules to fight infection and to develop molecules that regulate cell death and combat inflammatory and autoimmune diseases.

Members have expertise in X-ray crystallography, mass spectrometry, enzymology, protein-protein interactions, gene transfection/transduction systems, cell phenotyping, flow cytometry and multi-colour cell sorting, confocal imaging, transgenic and gene-knockout models, human T cell culture and cloning, and monoclonal antibody production and generation.

Current projects

Current projects include the role of complement and defensins in fighting bacterial and fungal infections; design of novel molecules to combat autoimmune conditions; migration and death of white blood cells in sepsis; cell stress and autophagy; and infection by viruses such as influenza and cytomegalovirus, and the immune response to them.

latrobe.edu.au/
lims/research/infection-and-immunity
Theme leaders

Weisan Chen
PROFESSOR
Cellular immunity to Influenza A virus

Specialises in CD8+ T cell biology and antigen processing and presentation in the development of cross-protective immune responses to the influenza virus. Investigates interactions between T cells and antigen-presenting cells, macrophages and monocytes and their impact on influenza induced lung pathogenesis.

Begoña Heras
ARC FUTURE FELLOW
Bacterial virulence factors: structure and function

Studies the molecular mechanisms underlying Gram-negative bacterial infections. Uses X-ray crystallography, molecular biology and biochemistry to investigate the structure-function relationships in proteins involved in bacterial pathogenesis and develop antibacterial drugs.

Hamsa Puthalakath
ASSOCIATE PROFESSOR
Regulation of apoptosis by Bcl-2 family proteins

Studies apoptosis regulation by Bcl-2 family protein in different patho-physiologies using in vitro and in vivo models. This includes death of lymphocytes during polymicrobial sepsis leading to lymphopenia, and the death of heart muscle cells leading to cardiomyopathy and heart failure.

Tatiana Soares da Costa
NHMRC RESEARCH FELLOW
Drug discovery, enzymology, allosteric regulation and bacteriology

Uses a combination of biochemical, biophysical and structural techniques to probe the structure-function relationship of essential bacterial and plant enzyme targets, to provide insight into the design of novel antibiotics and herbicides.

Joseph Tucci
ASSOCIATE PROFESSOR
Bacteriophage as alternatives to antibiotics, pharmacogenomics and pharmacy practice

Studies the use of bacteriophage (viruses that specifically attack bacteria) as an alternative to antibiotics. Examines the personalisation of medicine to fit a patient’s genetic profile, and patient management of medication in the treatment of chronic diseases.

Lakshmi Wijeyewickrema
RESEARCH FELLOW
Proteases, inhibitors and receptors: relationship to disease states

Researches enzymes, called proteases, which operate at the interface between a host, such as a human being, and microbes that cause disease. Studies the biology of enzymes, from bacteria and humans, to develop compounds to protect against diseases.

Members

Marilyn Anderson AO
CHARLES LA TROBE PROFESSOR
Plant innate immunity proteins

Specialises in protection of humans and crops from pathogens by studying natural defences of plants and the biology of the pathogens themselves. Identifies insecticidal and antifungal molecules in Australian native plants for commercial applications in crop protection and human antifungal therapeutics.

David Dougan
ARC RESEARCH FELLOW
Protein homeostasis in health and disease

Studies large ATP-dependent multi-subunit machines that are responsible for the regulated removal of unwanted proteins in bacterial cells and eukaryotic organelles. Identifies new components that control these machines and novel chemicals that dysregulate them.
Doug Fairlie  
**SENIOR RESEARCH FELLOW**  
Apoptosis, autophagy, cancer, drug development and peptides

Uses biochemical, cell biology, structural biology and medicinal chemistry approaches to understand the molecular mechanisms that control apoptosis. Develops new reagents, including drugs that could target and inhibit the actions of the key pro-survival proteins that keep cancers alive.

Mick Foley  
**ASSOCIATE PROFESSOR**  
Use of single domain antibodies as therapeutics in fibrosis and other chronic diseases

Uses a library of shark antibodies and a library of the human version of these antibodies to identify molecules that will bind to proteins that have been shown to be involved in human diseases including HIV, pulmonary fibrosis and Alzheimer’s disease.

Robert Pike  
**PROFESSOR AND DIRECTOR OF LIMS**  
Proteases, inhibitors and receptors: relationship to disease states

Researches enzymes, called proteases, which operate at the interface between a host, such as a human being, and microbes that cause disease. Studies the biology of enzymes, from bacteria and humans, to develop compounds to protect against diseases.

Ivan Poon  
**NICHOLAS HOODENRAAD FELLOW IN MOLECULAR SCIENCES**  
Apoptotic cell disassembly and clearance

Studies the machinery that controls how dying cells can disassemble into smaller pieces. Specialises in the importance of cell disassembly in disease settings, such as influenza A infection and atherosclerosis, to identify new drugs to control this process.

Dr Lakshmi Wijeyewickrema specialises in understanding the complement system; part of the innate immune response that plays a critical role in the body’s defence against disease. “The complement system is, essentially, a protective system,” she said. “It is a collection of key proteins in the blood that enhances the ability of antibodies and immune cells to clear pathogens like bacteria. It also activates the inflammatory response, sending out signals to recruit more cells to help at the site of infection.”
Treating sepsis
Sepsis or blood poisoning kills more people than HIV/AIDS, breast and prostate cancers combined. It is a condition where a systemic infection leads to multiple organ failure, immune paralysis and death. Dr Hamsa Puthalakath and PhD student Marcel Doerflinger have identified the mechanism of immune cell death and developed a treatment strategy using a bile acid derivative. Their findings, published in *Scientific Reports*, may lead to new therapeutic options for the treatment of the condition.

Polyphosphate, a novel regulator of the complement system
Inorganic polyphosphate (polyP) is a polymer that is widespread in biology and has many functions. Dr Lakshmi Wijeyewickrema, Dr Lillian Hor and Professor Robert Pike, together with collaborators from the University of British Columbia, have shown that polyP has an effect in the modulation of proteins involved in the complement system. The complement system orchestrates and connects various responses during inflammatory reactions. The finding that polyP can play a role in the mechanisms that shape the inflammatory response and its resolution provides further insight into the role of complement in pathological processes and in exploiting complement targets for therapeutic modulation.

Studying late stage apoptosis
In the human body, billions of cells die every day in a regulated process known as apoptosis. PhD students Lanzhou Jiang and Rochelle Tixeira, under the supervision of Dr Ivan Poon, have developed a new method for studying late stage apoptosis and, in particular, the role of apoptotic bodies (or particles) in cell communication and clearance. Their method, published in *Nature Protocols*, will allow scientists to further explore the apoptotic process in human health and disease.
When cells become stressed or damaged they commit suicide by a finely controlled process known as apoptosis. It is critical to the development and survival of all multicellular organisms. Genetic defects sometimes arise that allow cells to survive when they should otherwise be removed, and this can lead to cancer.

The key players that determine cellular fate have been known for decades, but the mechanisms by which cells make their life or death decision are still being explored. Dr Doug Fairlie, Dr Erinna Lee and Professor Brian Smith, together with collaborators at the Walter and Eliza Hall Institute, have developed a physiological model that sheds new light on some of the critical molecular interactions that govern apoptosis.

“For more than a decade, the way in which apoptosis is orchestrated inside cells has been the subject of considerable debate,” said Dr Fairlie. “This is due to the technical difficulties associated with disentangling the different interactions between the key proteins that dictate whether a cell lives or dies.”

Dr Fairlie and his collaborators have discovered that the interaction between two proteins (called “Bcl-xl” and “Bak”) is critical for maintaining survival of blood cells, in particular those cells that are involved in blood clotting and an important subset of white blood cells.

“Our study shows that when this protein interaction is disrupted, cells die more readily when treated with drugs used to kill cancer cells,” explained Dr Fairlie. “This critical information can now be used for the development of new and more effective drugs to treat cancers that are resistant, or respond poorly, to current treatments.”
Neurobiology

The Neurobiology theme investigates the biology and diseases associated with the nervous and musculoskeletal systems. Members have research interests ranging from anatomical and physiological studies, to biophysical studies of proteins, cellular and molecular analyses, and the use of in vivo models to study the pathophysiology of neuronal biology. The group focuses on the interaction of exercise in health and disease, and the general biology of disorders of the nervous system including Alzheimer’s, Parkinson’s and prion diseases, and Multiple Sclerosis.

Members have technical expertise in analytical ultracentrifugation, molecular interaction analysis, histology, the use of yeast and Drosophila models, next generation sequencing and bioinformatics, cell biology, molecular biology and single cell biochemistry.

Current projects

Current projects include the study of protein-protein interactions in Alzheimer’s disease; the development of new diagnostics for neurodegenerative diseases; investigating the pathogenesis of Multiple Sclerosis; understanding how cells deal with misfolded proteins; and changes that occur in the musculature with exercise, in diseases such as osteoarthritis and with ageing.
**Theme leaders**

**Andrew Hill**  
**PROFESSOR AND HEAD OF BIOCHEMISTRY AND GENETICS**  
Neurodegenerative diseases, extracellular vesicles and noncoding RNAs

Investigates neurodegenerative diseases such as Alzheimer’s, prion and Parkinson’s diseases. Studies exosomes and microvesicles as vehicles for the transfer of misfolded proteins between cells.

**Rodney Green**  
**ASSOCIATE PROFESSOR**  
Clinical anatomy

Pioneers techniques to insert intramuscular electrodes into muscles at both the hip and shoulder to understand their role in the human body. Develops targeted rehabilitation programs to improve quality of life for elderly populations with chronic musculoskeletal illness.

**Di Hughes**  
**LECTURER**  
Oxidative stress, erythrocyte morphology and haemorheology

Researches peripheral oxidative stress in Parkinson’s disease and rheumatoid arthritis. Studies erythrocyte morphology and haemorheology parameters to mark peripheral oxidative stress, and whole blood antioxidant capacity.

**Christine Kettle**  
**LECTURER**  
Autonomic and central nervous system regulation of metabolism

Examines the physiology of metabolism to find novel drug targets that activate brown adipose tissue (BAT) thermogenesis. Activation of BAT is a possible pathway to target for reducing obesity.

**Kaye Truscott**  
**SENIOR RESEARCH FELLOW**  
Mitochondrial protein homeostasis

Studies the function of proteins engaged in the biogenesis and maintenance of mitochondria, the cell’s power plant and manufacturer of essential biomolecules. Investigates strategies to modulate mitochondrial function for the prevention of mitochondrial disorders and neurodegenerative diseases including Parkinson’s disease.

**Anita Zacharias**  
**LECTURER**  
Gross anatomy, histology and embryology

Analyses hip stabiliser muscle function in a population with hip osteoarthritis using MRI and intramuscular electromyography techniques. Greater understanding of these muscles could lead to the development of improved rehabilitation programs targeting specific muscle segments within the hip stabilisers.
Dr Robyn Murphy specialises in understanding key proteins involved in a variety of muscular dystrophies. She investigates them using exercise as an intervention in healthy people. “When you exercise, some of the changes your muscles undergo to produce energy are also happening at rest in disease states,” she said. “We take a muscle biopsy from a rested person’s thigh, then intervene with exercise, with biopsies taken after every intervention. We emulate disease conditions in a healthy person using exercise, and examine the intracellular changes.”
Discoveries

Benefits of exercise for older adults
The benefits of high-intensity interval training are well known, but does it deliver the same results for older people? Dr Robyn Murphy and Dr Victoria Wyckelsma, together with collaborators from Victoria and Monash universities, put a group of older adults on a 12-week program and monitored their ability to create energy-rich organelles known as mitochondria. Their findings, published in the Journal of Physiology, demonstrate that older adults were able to increase their mitochondrial content over the course of the program, with benefits comparable to what was seen in younger cohorts.

Parkinson’s disease drug target
Parkinson’s disease (PD) is characterised by the loss of neurons in the brain that are involved in movement. Developing drugs that protect these neurons from dying is critical to managing the disease. Dr Lesley Cheng and PhD student Camelia Quek, together with collaborators from The University of Melbourne, tested a drug compound that showed a reversal of PD symptoms, and mapped the genes that were recovered. Their findings, published in Scientific Reports, identify new drug targets associated with preventing neuronal loss.

Rehabilitating injured muscles
Rotator cuff muscles act as stabilisers of the shoulder joint. They play a critical role in the most versatile but unstable joint in the body. In world-first research on living subjects, PhD student Sangeeta Rath and Dr Rodney Green have shown that the contraction of rotator cuff muscles increases stability of the joint in a direction-specific manner. Their findings may offer new treatment options for the rehabilitation of these commonly injured muscles.

18,000 hip replacement operations are performed in Australia each year.
Osteoarthritis affects about a quarter of all women and 16 per cent of men over the age of 55. In Australia more than 18,000 hip replacement operations are carried out every year. PhD student Anita Zacharias and Dr Rodney Green led a research team that have discovered people with hip osteoarthritis suffer from shrinkage of a special group of deep gluteal muscles.

Dr Green said it is well-known that people with hip osteoarthritis have reduced muscle strength, but until this latest study, there was no clear evidence of physical muscle wastage. Exercise is widely regarded as the most effective treatment, yet recent research has revealed no benefit for patients.

“We think this may be due to currently prescribed exercise programs not targeting the correct muscle segments,” said Dr Green.

The hip is stabilised by various muscles, particularly the gluteus medius and gluteus minimus. “Our laboratory previously established that two of these fan-shaped gluteal stabiliser muscles (gluteus medius and minimus) are composed of functionally unique muscle segments,” he said.

Using MRI, the latest study discovered a reduction in size of these two muscle groups in the limb of hip osteoarthritis patients when compared to the opposite limb and also when compared to people with normal hips. “This reduction was associated with the severity of osteoarthritis,” Dr Green said.

Electromyography analysis is now underway to identify specific segments of these muscle groups that have altered function. “Once these have been identified we hope to create better rehabilitation programs targeting these specific segments of muscle - rather than the muscle as a whole - that could help improve overall joint function,” said Dr Green.
Molecular Design

The Molecular Design theme uses molecules to solve real world problems across a broad range of disciplines. Researchers have diverse interests ranging from computational studies on the interaction of drugs with proteins, to molecular synthesis, and surface and material science.

Members have expertise in NMR spectroscopy, X-ray crystallography, mass spectrometry, chemical synthesis and separations, computational analysis of systems (ranging from species as large as proteins to as small as a single proton) and analysis of surfaces using advanced techniques such as atomic force microscopy.

Current projects

Current projects include the design of new metal-based radiopharmaceuticals; synthesis of drugs targeting resistant strains of malaria and hospital borne superbacteria; generation of anti-microbial surfaces using peptides; small molecule platelet inhibitors; and the design of metal catalysts to form difficult bonds, such as the C-F bond found in many pharmaceuticals.
Belinda Abbott  
**LECTURER**  
Medicinal chemistry and synthetic organic chemistry  
Uses synthetic organic chemistry to make novel compounds for testing in biological assays, in order to study the structure-activity relationships of how the compounds interact with the target. Treatments for bacterial infection, malaria, cardiomyopathy and motor neurone disease.

Peter Barnard  
**LECTURER**  
Synthetic organic and inorganic chemistry  
Synthesis of coordination complexes for diagnostic imaging applications and sensor development. Specialises in small molecule organic and inorganic synthesis in combination with analytical techniques for generation and characterisation of new compounds.

Carmel Abrahams  
**LECTURER**  
Supramolecular chemistry and single crystal X-ray diffraction characterisation of small molecules  
Investigates the design, synthesis and characterisation of supramolecular systems. Studies the use of the biodegradable porous compound Zn(saccharate) and its ability to act as a host for molecules such as small aromatic hydrocarbons.

Jasim Al-Rawi  
**SENIOR LECTURER**  
Heterocyclic compounds as PNA-PK, PI3K PDE3 inhibitors for treatment of cancer  
Synthesis of novel 8-aryl and/or 7,8-substituted-2-orpholino-1,3-benzoxazines as DNA-PK, PI3K inhibitors for more effective treatment of cancer. PI3K isoform selectivity as well as DNA-PK selectivity over PI3K. Molecular modelling to explain drug receptor optimum interaction.

David Wilson  
**SENIOR LECTURER**  
Computational chemistry and quantum chemistry  
Uses computational quantum chemistry to model molecular structures, properties and spectroscopies, as well as energetics of reactions. Focuses on understanding fundamental properties of chemical bonding and electronic structure in the design of new chemistry and new materials.
Professor Brian Smith is an expert on molecular modelling. “My particular interest is modelling interactions between small molecules that might be drugs, and their targets, which are typically proteins. We use quantum-mechanical methods to design new molecules that improve the stability and activity of medications, such as insulin.”
Discoveries

Forcing cancer cells to self-destruct
Cell death, a process whereby normal cells are programmed to self-destruct, is critical to human development and good health. Cancer cells manage to evade this process. Finding ways to switch on this death mechanism, known as apoptosis, is key to fighting the disease. Professor Brian Smith and PhD student Nicholas Smith are part of an international research team that have discovered a mechanism that forces cancer cells to self-destruct. Their findings, published in *Nature Communications*, may lead to new treatments for cancer.

Frogs may help fight bacteria
Antimicrobial peptides are nature’s “magic bullets” that hunt bacteria at sites of potential infection. These peptides may help fight drug resistant bacteria, if more was known about their mechanism of action. Dr Adam Mechler led a research team that described the antimicrobial action of a peptide originating from the Australian golden bell frog. Their findings, published in *Scientific Reports*, may lead to the development of a peptide that can protect humans, not just frogs, from life threatening infections.

Visualising protein density
Every cell in the human body is packed with proteins: they are essential for the maintenance of body function. Understanding how proteins interact in the cell is, therefore, critical to understanding health and disease. Dr Yuning Hong, together with collaborators from The University of Melbourne, has developed new technology based on small chemical probes that allow scientists to examine how changes in the cellular environment influence protein density in the cell. Their findings, published in *ChemComm*, provide researchers with an innovative new tool for drug development.

EVERY THREE SECONDS
SOMEONE IN THE WORLD DEVELOPS DEMENTIA. OF THOSE, UP TO 70% WILL HAVE ALZHEIMER’S DISEASE.
Compound sheds light on Alzheimer’s disease

Alzheimer’s disease (AD) is the most common form of dementia. While scientists have made significant progress toward understanding the fundamental biology of AD, it’s the development of effective and readily available diagnostic tools that remains the missing piece in the therapeutic puzzle.

PhD student Chung Ying Chan and Dr Peter Barnard are using synthetic chemistry to make the early diagnosis of AD a reality. They have discovered a new compound that may identify amyloid plaque in the brain using cost-effective, widely available imaging technology. "Alzheimer’s disease is characterised by the appearance of amyloid plaques and neurofibrillary tangles in the brain,” said Dr Barnard. “Both are major causative factors in the development of the disease.”

These plaques and tangles begin to form many years before a patient shows any symptoms of the disease. By the time an individual experiences memory loss or changes in behaviour, significant brain damage has already occurred.

Chan and Barnard’s tracer has been specifically designed for single photon emission computed tomography (SPECT). “SPECT scans involve the injection of a small amount of a radiopharmaceutical agent into the patient,” explains Dr Barnard. “These agents contain gamma-ray emitting radioisotopes and, when imaged, they provide a three-dimensional picture of the location of the radiopharmaceutical in the body.”

SPECT imaging is widely available in hospitals and is more cost-effective than its counterpart, positron emission tomography (PET). “PET tracers are now available for AD,” said Dr Barnard, “but developing SPECT based tracers for AD will be game-changing when it comes to providing cheap and widely available diagnostics for this disease.”
Molecular Imaging

The Molecular Imaging theme uses a broad range of methods to characterise molecular structure and function. Understanding the fundamental science that underpins disease and ageing, as well as the complex interplay between organisms and their environment, inherently relies upon molecular imaging. The group uses the latest technologies for characterising molecules and their dynamics to understand molecular processes at the organism, cellular and macromolecular scale.

Members have expertise in a range of advanced techniques for molecular and cellular characterisation including super-resolution and electron microscopy, nuclear magnetic resonance and X-ray crystallography. Many of our members are regular users of the Australian Synchrotron.

Current projects

Current research projects include using molecular imaging and spectroscopy to investigate the inhibition of cell-death by viruses; understanding the role of metals in cells; and developing new techniques for the visualisation of molecular function within live cells.
Theme leaders

Brian Abbey
ARC FUTURE FELLOW AND ASSOCIATE PROFESSOR
Coherent X-ray science and materials characterisation
Combines elements of optics, nanofabrication, synchrotron science and X-ray free electron lasers to develop new approaches to imaging materials and structures at the atomic, molecular and cellular level. Develops techniques for interpreting patterns of coherently scattered light.

Mihwa Lee
ARC DECRA FELLOW
Structural biology in gene regulation and DNA damage repair pathway
Uses molecular biology, protein chemistry, cell biology and X-ray crystallography to characterise the macromolecular complexes (protein-protein and protein-nucleic acid complexes) in the nucleus to understand their fundamental roles in gene regulation and the DNA damage repair pathway.

Mark Hinds
ASSOCIATE PROFESSOR
Protein structure and interactions
Determines structure and interactions of biomolecules in solution using nuclear magnetic resonance spectroscopy. Investigates structure, function and interactions of viral proteins regulating apoptosis with their host cell targets. Examines biomolecular interactions using biophysical and biochemical techniques.

Shanshan Kou
LECTURER
Bio-imaging and bio-photonics, optical micro- and nano-scopy, and biomedical instrumentation
Studies the interactions between light and biological matter to explore and discover the complex mechanisms behind cellular and sub-cellular events and processes. Develops novel bio-imaging modalities and instrumentation to be used in new diagnostic and therapeutic tools.

Members

Marc Kvansakul
ARC FUTURE FELLOW AND ASSOCIATE PROFESSOR
Structural biology of cell death and host pathogen interactions
Examines how viruses hijack cellular defence systems to ensure their own proliferation and survival. Studies the role of small proteins that act as a first line of defence against microbial targets, and the mechanisms they use to destroy target cell membranes.

Megan Maher
SENIOR LECTURER
Metallobiology
Studies the mechanisms by which trace metals are regulated within biological systems. This regulation relies on proteins that fulfill specific roles within the cell. Examines the functions of these proteins by defining their three-dimensional architectures by X-ray crystallography.

Grant van Riessen
LECTURER
Experimental condensed matter and materials physics, and coherent X-ray imaging development
Develops methods of probing condensed matter and material properties using coherent X-ray imaging, electron spectroscopy and nanofabricated devices. Develops synchrotron instrumentation and high-performance computing methods for reconstructing quantitative images from very large datasets.
Discoveries

Understanding African Swine Fever
African Swine Fever is a highly contagious, hemorrhagic virus, with high mortality rates in pigs. It is endemic in sub-Saharan Africa and Eastern Europe and, currently, there is no effective vaccine to prevent the disease. PhD student Suresh Banjara and Dr Sofia Caria, with Dr Marc Kvensakul, Dr Mark Hinds and collaborators at the Pirbright Institute, have identified how African Swine Fever hijacks cells to establish infection. Their findings, published in the Journal of Virology, may lead to new therapeutics to combat the disease.

Developing optical systems
In the future, our means of communication and data storage will be governed by optical systems. Dr Shanshan Kou, together with collaborators from The University of Melbourne, RMIT and Nanyang Technological University (Singapore) is working on this cutting-edge technology, developing an ultra-thin film that enables the coding of light at the nanoscale. Their findings, published in Nature Communications, will find applications in optical storage, data transfer and bio-sensing, and pave the way toward commercialisation of optical communications technology.

New imaging techniques
Protein microcrystallography enables biologists and immunologists to image the structure of proteins, an important step for understanding disease and drug development. The technique uses tiny crystals made up of proteins and by diffracting x-rays from them, is able to image their constituent molecules. PhD student Hannah Coughlan, Dr Brian Abbey and Dr Connie Darmanin, have developed new imaging techniques to characterise the interaction of protein microcrystals and X-rays. Their findings, published in the Journal of Synchrotron Radiation, will allow for better optimisation of protein microcrystallography experiments.

THE WORLD’S FIRST
HARD X-RAY FREE ELECTRON LASER, BASED AT STANFORD UNIVERSITY IN THE UNITED STATES, OPENED IN 2009.
An international team led by Dr Brian Abbey, in collaboration with Associate Professor Harry Quiney at The University of Melbourne, discovered how to create a new type of crystal using light more than ten billion times brighter than the sun. Their findings reverse what has been accepted thinking in crystallography for more than 100 years.

The team exposed a sample of crystals, known as Buckminsterfullerene or Buckyballs, to intense light emitted from the world’s first hard X-ray free electron laser (XFEL), based at Stanford University in the United States. The molecules have a spherical shape forming a pattern that resembles panels on a soccer ball.

Every molecule in the crystal changed from being shaped like a soccer ball to being shaped like an AFL ball at the same time. This effect produced completely different images at the detector. It also altered the sample’s optical and physical properties.

“It was like smashing a walnut with a sledgehammer and instead of destroying it and shattering it into a million pieces, we created a different shape—an almond!” Dr Abbey said.

“This change means that when we use XFELs for crystallography experiments we will have to change the way we interpret the data,” Dr Abbey added. “The results give the 100-year-old science of crystallography a new, exciting direction.”

“Currently, crystallography is the tool used by biologists and immunologists to probe the inner workings of proteins and molecules; the machines of life. Being able to see these structures in new ways will help us to understand interactions in the human body and may open new avenues for drug development.”
Molecular Sensing

The Molecular Sensing theme combines chemistry, physics and biology to identify and quantitate key chemical and biochemical species in the environment and in the human body. Research encompasses both fundamental and applied science with a view to real world applications in areas such as medical diagnostics, environmental sensing, food testing and remote atmospheric sensing.

Members have a wide range of expertise in surface science and analysis, condensed matter physics, infrared spectroscopy, fluorescence spectroscopy, electrochemistry, water quality, soil chemistry and pharmaceutical science.

Current projects
Current projects include the development of advanced luminescent sensing materials; remote sensing of small molecules in the upper atmosphere; new sensing strategies based on surface doped diamond; and development of a point-of-care test for early diagnosis of sepsis.

latrobe.edu.au/
lims/research/molecular-sensing
Theme leader

Members

Conor Hogan
ASSOCIATE PROFESSOR
Electrochemistry, photochemistry, chemical sensing and biosensing

Conducts fundamental and applied research to expand the bounds of analytical science. A world leader in the application of electrochemiluminescence (ECL) detection to mobile phone readable paper microfluidic sensors, and the development of potential resolved multicoloured ECL or 3D ECL.

Michael Angove
HEAD OF PHARMACY AND APPLIED SCIENCE
Colloid, environmental and pharmaceutical science

Uses colloid chemistry to research environmental and agricultural soil systems so that we are better placed to manage soil environments, and even rehabilitate damaged or contaminated soils. Studies pharmaceutical products that utilise colloidal particles and systems.

Narelle Brack
SENIOR LECTURER
Surface modification and characterisation of advanced materials

Creates materials at the nanometer scale. Explores chemical and molecular properties and processes at surfaces and at interfaces. Develops surface modification strategies for material systems including next generation aircraft materials, carbon nanomaterials and electrospun nanofibres.

Courtney Ennis
ARC DECRA FELLOW
Spectroscopy of planetary and interstellar environments

Uses advanced infrared techniques to trace chemical reactions observed throughout our Solar System and beyond into interstellar space. Develops our understanding of the Earth’s chemical origins and improves sensing methods for biologically significant molecules that may remain undetected in space.

Evan Robertson
SENIOR LECTURER
Optical spectroscopy of atmospheric and biological molecules

Uses powerful light sources, such as lasers and the Australian Synchrotron’s infrared beamline, to study the shape of neurotransmitter molecules relevant to pharmaceutics, greenhouse gas molecules, ice cloud particles and even molecules in the interstellar medium.

Dongchen Qi
LECTURER
Nanophysics and quantum materials

Creates and understands the surfaces and interfaces of functional materials at the molecular scale to develop new technologies and material platforms for next-generation devices. Uses advanced spectroscopic techniques, based on synchrotron radiation, to examine surface and interface phenomena and physics essential to device operation.
Dr Conor Hogan combines low-cost sensors made from paper with smartphone technology for early disease detection. “At the moment analytical chemistry is something that’s done by people in white coats in a lab. I’d like to take it out of the hands of scientists and put it into the hands of people like doctors, nurses and patients. We are identifying ways to make analytical chemistry easier to do, and less expensive, so that people can readily access vital information about their own health.”
Discoveries

New diagnostics
Antibodies fight infection. Their presence in our blood has allowed scientists to develop diagnostic tests for viruses like HIV and hepatitis. The orientation of the antibodies in the sample, however, is critical to the accuracy of the test. PhD student Nicholas Welch and Dr Paul Pigram, together with collaborators from CSIRO, have developed a surface that improves antibody orientation and enhances the sensitivity of disease detection in blood tests. Their findings, published in Biointerphases, may lead to a new generation of diagnostics.

Predicting the extent of global warming
Most of us associate global warming with greenhouse gases, which absorb radiation that is emitted by the earth. But clouds and aerosols also have a huge impact on climate change, reflecting sunlight and absorbing infrared light. Dr Evan Robertson specialises in icy aerosol particles, including those that are found in clouds at high altitudes. Forming artificial clouds in the lab helps reveal their properties, and how they absorb and scatter radiation. His research will help to improve models that predict the extent of global warming.

Developing diamond devices
The surface of diamond, when functionalised with an atomically thin layer of hydrogen, develops a surface conductivity that can be applied to a variety of electronic and biosensing applications. PhD student Golrokh Akhgar, along with Professor Chris Pakes and collaborators, has developed diamond devices that are capable of operating at temperatures of -273 °C; close to the lowest temperature possible. Their findings, published in Nano Letters, may lead to a new generation of low-power electronic devices that use the quantum mechanical spin of an electron, rather than its charge, to process information.

TITAN’S DIAMETER IS 50 PERCENT LARGER THAN EARTH’S MOON, MAKING IT AMONG THE LARGEST NATURAL SATELLITES IN THE SOLAR SYSTEM.
Titan may unlock Earth’s origins

Commercial space travel may be tourism’s next frontier but, odds are, Titan will not be on anyone’s wish list. The largest of Saturn’s frozen moons, Titan’s methane-infused rainfall creates hydrocarbon-filled seas, and its clouds of cyanide gas freeze into toxic snowflakes.

Surprisingly, this inhospitable environment may actually unlock the origins of Earth’s organic material, according to astrochemist Dr Courtney Ennis. “Recent exploration of Titan by NASA’s Cassini probe has uncovered a range of compounds familiar to Earth,” he said.

“Compounds such as acetonitrile, which is commonly used as a solvent in chemistry labs. This molecule is produced by reactions between methane and hydrogen cyanide in the Titan atmosphere.”

Dr Ennis and PhD student Rebecca Auchettl have recreated Titan’s atmosphere—cyanide snow and all—in a specialised gas cell at the Australian Synchrotron. Their findings, published in Physical Chemistry Chemical Physics, will help telescope surveys observe cyanide chemistry in exotic environments.

“Cyanide ice exposed to high levels of radiation gives rise to amino acids, which are essential building blocks for life.” said Dr Ennis. “It is strange yet remarkable that Titan’s cyanide snowflakes could provide a pathway for life beyond Earth.”

“As new worlds are detected the challenge for scientists is to learn as much as we can about distant planetary bodies using modern sensing methods. By looking at cyanide signatures we can locate far away worlds where life could find a foothold.”
### External Funding

<table>
<thead>
<tr>
<th>Project</th>
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<tr>
<td>AdAlta Limited</td>
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<td>Development of human single domain antibodies for use in inflammation and fibrosis (Michael Foley)</td>
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<td>Australian Research Council Centre of Excellence</td>
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<td>ARC Centre of Excellence in Advanced Molecular Imaging (administered by Monash University – Brian Abbey)</td>
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<td>Cell wall structure and dynamics in emerging fungal pathogens of crops (Marilyn Anderson)</td>
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<td>Complex II proteostasis in mammalian mitochondria (Kaye Truscott and David Dougan)</td>
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<td>Crosstalk between breast cancer cells and the microenvironment to promote metastasis (Belinda Parker)</td>
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<td>Molecular basis of synergy between proteinase inhibitors and plant and animal defensins against fungal pathogens (Marilyn Anderson)</td>
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<td>Molecular mechanisms for copper trafficking across membranes (Megan Maher)</td>
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<td>Multi-colour electrogenerated chemiluminescence (administered by Deakin University – Conor Hogan and David Wilson)</td>
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<td>Planetary nitrile chemistry; synchrotron and laboratory spectroscopic investigations (Courtney Ernits)</td>
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<td>Structural studies of host-pathogen interactions (Marc Kvansakul)</td>
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<td>Surface doping of diamond: a new platform for 2D carbon-based spintronics (Christopher Pakes)</td>
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<td>The LINK to regulating lysine levels in wheat (Matthew Perugini)</td>
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<td>The molecular mechanisms of dual nucleic acid specificities of SFPQ (Mihwa Lee)</td>
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<td>Understanding the role of exosomes in intercellular communication (Suresh Mathivanan)</td>
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<td>Unraveling mechanisms of aggregation and biofilm formation critical for bacterial antibiotic resistance (Begoña Heras)</td>
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<td>Electrochemically-sensitized luminescence: a new bio-detection paradigm (Conor Hogan)</td>
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<td>Hexima Limited</td>
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<td>Anti-fungal activity in plant defensins; discovery of novel insecticidal proteins; interaction between matriptase and proteinase inhibitors (Marilyn Anderson)</td>
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<td>Investigating the effectiveness of plant defensins as a treatment for vaginal candidiasis (Marilyn Anderson)</td>
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<td>National Health and Medical Research Council</td>
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<td>Blocking human cytomegalovirus: targeting host organelle remodelling and the viral assembly complex (Rommel Mathias)</td>
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<td>Broad spectrum inhibition of an enzyme antibiotic target (Tatiana Soares da Costa)</td>
<td>79,693</td>
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<td>Cellular and molecular characterisation of erythroid enucleation (Patrick Humbert)</td>
<td>114,405</td>
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<td>Complement inhibitors for treatment of chronic inflammatory diseases (Robert Pike)</td>
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<td>Deciphering the role of Scribble in development and disease (Marc Kvansakul and Patrick Humbert)</td>
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<td>Determining fundamental mechanisms compromised in Kir-linked disease states (administered by the Walter and Eliza Hall Institute – Brian Smith)</td>
<td>36,856</td>
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<td>Developing a new treatment method to prevent lymphopenia associated with sepsis (Hamsa Puthalakath)</td>
<td>143,655</td>
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<td>Disorderly conduct and disturbing the peace: how loss of cell polarity and tissue architecture drives cancer progression (Patrick Humbert)</td>
<td>73,660</td>
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<td>DsbA inhibitors: from hits to leads (Begoña Heras)</td>
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<td>Endometrial exosomes: a new paradigm in endometrial-embryo cross-talk (administered by Monash University – Richard Simpson)</td>
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<td>Function and molecular mechanism of histidine-rich glycoprotein in necrotic cell and pathogen clearance (Mark Hulett)</td>
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<td>Limiting the impact of Influenza (administered by The University of Melbourne – Weisan Chen)</td>
<td>353,114</td>
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<td>Mechanism of anoxic iron acquisition in pathogenic bacteria (administered by The University of Sydney – Megan Maher)</td>
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<td>NHMRC Fellowship SRFB (Helena Richardson)</td>
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<td>Sirtuins and pathogenesis of human cytomegalovirus (Rommel Mathias)</td>
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<td>The molecular basis for manganese uptake by pathogenic bacteria (Megan Maher)</td>
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<td>The role of natural protein inhibitors in blocking breast cancer invasion (Belinda Parker)</td>
<td>23,862</td>
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<td>The role of the asymmetry gene GPSM2 in breast cancer (Patrick Humbert)</td>
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<td>Project</td>
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<td>Victorian Cancer Agency</td>
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<td>Understanding the biological basis of cancer cachexia (Nick Hoogenraad)</td>
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<td>Understanding the molecular mechanisms regulating chemotherapeutic drug resistance (Lahiru Gangoda)</td>
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<td><strong>Other</strong></td>
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<td>Investigation of the active components of bromelain (Robert Pike)</td>
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<td>Testing the efficacy and safety of SM-164 for osteosarcoma treatment (Christine Hawkins)</td>
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<td>Micrometre scale imaging of residual elastic strain fields in whole components via strain tomography (Brian Abbey)</td>
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<td>Research services – Bell, Cochrane &amp; Associates (Paul Pigram)</td>
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<td>DNA Nation project (Robert Mitchell)</td>
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<td>The role of myoepithelial proteins in blocking breast cancer invasion (Hendrika Duivenvoorden)</td>
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<td>New treatments for metastatic breast cancer (Suzanne Cutts)</td>
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<td>The characters of prostate cancer – getting to know the enemy (Nikola Baschuk)</td>
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<td>UpaB has a surprising architecture and dual mode of action on the bacterial cell surface (Begoña Heras)</td>
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<td>Research services – CSR Bradford Construction Fabrics (Paul Pigram)</td>
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<td>Victoria Latin America Doctorial Scholarship 2016 (Begoña Heras)</td>
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<td>Connecting ANFF nodes through data (Paul Pigram)</td>
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<td>i-bodies as biomarkers for idiopathic pulmonary fibrosis (Michael Foley)</td>
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<td>Investigating the effectiveness of plant defensins as a treatment for vaginal candidiasis (Marilyn Anderson)</td>
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<td>Automotive diode project (Paul Pigram)</td>
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<td>Research services – Fosterville Gold Mine (Paul Pigram)</td>
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<td>Ian Potter Foundation travel grant (Leonie Flueckiger)</td>
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<td>Identification of breast cancer subtypespecific tumour antigens using the local immune response (Suresh Mathivanan)</td>
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<td>Keeping the seeds of metastasis grounded: understanding how stem cell regulator and asymmetric cell division gene GPSM2 controls breast cancer stem cells and metastatic spread (Patrick Humbert)</td>
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<td>Melbourne Centre for Nanofabrication – NCRIS funding (Paul Pigram)</td>
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<td>Data management and resource repository for the exRNA Atlas (Suresh Mathivanan)</td>
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<td>MANGOfa differentiating B-cell depleting strategies during CNS autoimmunity in rodents (Jacqueline Orian)</td>
<td>67,212</td>
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<td>Does FTY720 (Fingolimod) ameliorate emotional and cognitive defects in EAE? (Jacqueline Orian)</td>
<td>10,000</td>
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<td>Reconceptualising mathematics and science teacher education programs through collaborative partnerships between scientists and educators (administered by The University of Melbourne – David Hoxley)</td>
<td>169,718</td>
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<td>SIMS analysis of internal surfaces of glass vials (Paul Pigram)</td>
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<td>ToF-SIMS analysis of powder samples (Paul Pigram)</td>
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<td>Prostate cancer bone metastasis (ProMis) (administered by the Garvan Institute–Belinda Parker)</td>
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<td>Exploring better and safer treatments for osteosarcoma (Christine Hawkins)</td>
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<td>ToF-SIMS analysis of gold/titanium contracts – University of Newcastle research service (Paul Pigram)</td>
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<td>Personalised medicine for HIV infection in PNG is achievable (Joseph Tucci)</td>
<td>42,500</td>
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<td>Provision of research services (Paul Pigram)</td>
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<td>Detecting brain specific exosomal miRNA for the diagnosis of Alzheimer’s disease (Andrew Hill)</td>
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<td>XPS analysis of whey powders – Victoria University research service (Paul Pigram)</td>
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<td>Victorian Life Sciences Computation Initiative, Life Sciences Computation Centre (Brian Smith)</td>
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<td>Pharmacogenetic targeting of polarity-impaired Ras-driven breast cancer (Helena Richardson)</td>
<td>82,476</td>
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