The La Trobe Institute for Molecular Science (LIMS) is committed to solving global problems and improving the welfare of human societies.

The Institute embodies La Trobe University’s strategic vision: to be globally recognised for its excellence, creativity and innovation in relation to the big issues of our time.

Launched in 2009, LIMS brings together the University’s leading scientists to create new levels of collaboration, and a multi-disciplinary approach to drive innovation and produce translatable research outcomes.

The LIMS complex has 56 research and support laboratories, advanced research equipment, a 200-seat auditorium, and over 3,000 square metres of teaching facilities. Around 400 La Trobe academics, research fellows, postgraduate students and support staff are based at the Institute. LIMS also has an important regional node: many of its scientists work at La Trobe’s Bendigo campus.

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.

LIMS also has two embedded companies: Hexima Ltd, who are developing plant-derived proteins and peptides for application as human therapeutics and the genetic modification of crops; and AdAlta Ltd, 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 research 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, research, training and facilities.
EXPLORE LIMS

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.

The Institute’s research agenda is supported by a state-of-the-art facility, where researchers in different disciplines work together in well-equipped, shared workspaces to achieve research outcomes that would not be possible in traditional academic settings.
### Excellence in Research for Australia (ERA)

<table>
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<tr>
<th>Australia’s best university</th>
<th>One of Australia’s largest teaching programs in biotechnology, nanotechnology and molecular sciences.</th>
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<tbody>
<tr>
<td>for Biological Sciences (equal with ANU).</td>
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<tr>
<td>Victoria’s best university</td>
<td>Educating 800+ undergraduate students.</td>
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<td>for Analytical Chemistry and Biochemistry and Cell Biology.</td>
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<td>Equal first</td>
<td>Educating 180+ postgraduate students.</td>
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<td>in Victoria for Physical Sciences including Condensed Matter Physics and Optical Physics.</td>
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<tr>
<td>Top three</td>
<td>Our courses include work placements so students can apply their skills to industry-based projects.</td>
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<td>in Victoria for Inorganic Chemistry and Genetics.</td>
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### Flagship facilities

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<th>Comprehensive proteomics platform</th>
<th>Students have access to the latest scientific equipment and exposure to high-impact research projects.</th>
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<td>A suite of synergistic capabilities for the characterisation of proteins.</td>
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<tr>
<td>Centre for Materials and Surface Science</td>
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<tr>
<td>Australia’s most comprehensive suite of surface science and surface analysis equipment.</td>
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<td>Bioimaging</td>
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<td>A suite of confocal and conventional widefield microscopes for optical imaging of live cell dynamics and fixed biological specimens.</td>
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<td>Flow Cytometry</td>
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<td>Sophisticated equipment for cell analysis and cell sorting.</td>
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<td>Histology</td>
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<td>A suite of precision instruments for high quality specimen preparation and sectioning.</td>
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From the Director

In 2015, I commenced in my new position as Director of LIMS. It’s a role I am deeply honoured to have, and a challenge I relish in terms of further establishing LIMS as a premier institute in molecular science.

LIMS encompasses a broad range of disciplines, spanning physics, chemistry, biochemistry, genetics, pharmacy, and some of the basic biomedical sciences, including anatomy and physiology. Our scientists are supported by state-of-the-art facilities, where researchers in different disciplines work together in well-equipped, shared laboratories to achieve outcomes that would not be possible in traditional academic settings. It is what makes us unique, and allows us to push the boundaries of multidisciplinary research at the interface of health and science.

This year, our senior leadership team developed a new strategic plan, one that positions LIMS as our external research face, and the School of Molecular Sciences as our teaching and administrative arm within La Trobe University.

It also organises our researchers into themes that encompass both biomedical and technological areas of research. This internal reorganisation will now inform recruitment and retention. It will ensure that our interdisciplinary research is published in the best journals, but is also translatable into real world practice. It gives rise to our overall vision statement, “translatable molecular discoveries.”

In 2015, our scientists were recognised for their research excellence and innovation, and for making discoveries of global importance. Emeritus Professor Nick Hoogenraad AO and Dr Amelia Johnston led an international research team that discovered the cause of cancer cachexia, a condition that kills up to one third of late-stage cancer patients.

Dr Ivan Poon and Georgia Atkin-Smith captured the death of a human white blood cell for the first time. And Dr Karen Harris and Professor Marilyn Anderson AO, together with collaborators at the University of Queensland, identified and produced the key enzyme that can turn small proteins known as linear peptides into more robust and chemically stable circular ones. The discovery makes the peptides a leading candidate for future pharmaceutical drug design.
Our research is published in the best journals, but is also translatable into real world practice.

LIMS is known for its research, but it is also a training centre, providing students and early career researchers with access to the latest equipment and exposure to high impact research projects. This year, we awarded our inaugural Hoogenraad and Stone fellowships to two outstanding early career researchers, Dr Ivan Poon and Dr David Greening.

We also expanded our equipment portfolio with a $1M mass spectrometer: a Thermo Scientific Q-Exactive HF with UltiMate 3000 RSLCnano.

And, we welcomed two new research leaders: Dr Helena Richardson, a specialist in cell polarity and cancer, and Professor Andrew Hill, an expert in neurobiology who also serves as Head of Biochemistry and Genetics and Director of the University’s Research Focus Area, Understanding Disease.

The achievements of 2015 lay the foundation for the next phase of our development as an Institute, and a new era of research excellence.

Professor Robert Pike
Director
OUR OBJECTIVES

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 recruit and train the next generation of Australian scientists. To provide postgraduate students and early career researchers with exposure to high impact research 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 start-up companies and develop new industry partnerships. To become the interface between local and global biotechnology companies.
Leadership Team

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

Director, Professor Robert Pike, has over 10 years’ experience in senior academic and research leadership roles.

Professor Andrew Hill, Professor Brian Smith and Dr Michael Angove are 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 leads the Postgraduate Coursework portfolio and Dr Matthew Perugini leads the Research Infrastructure portfolio. Dr Anne Evans is Business Support Manager.

PROFESSOR ROBERT PIKE
Director of LIMS
Head, School of Molecular Sciences

Professor Pike obtained his PhD in Biochemistry from the University of Natal (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 became 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  
Head, Department of Biochemistry and Genetics  
Director, Research Focus Area, Understanding Disease  
Professor Hill obtained his PhD at Imperial College London. He held postdoctoral positions in the MRC Prion Unit (London) and the Department of Pathology at The University of Melbourne as a Wellcome Trust Prize Travelling Research Fellow. 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.  
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. His laboratory also works on the biology of small noncoding RNA and their potential use as diagnostics in neurological and infectious diseases. He has published over 120 research papers.

PROFESSOR BRIAN SMITH  
Head, 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 as a research scientist. 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 the current 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 in the design of protein mimetics and small-molecule inhibitors of protein function. He has published over 140 research papers.

DR MARK HULETT  
LIMS Research Director  
Dr Hulett obtained 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), Australian National University 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 his own 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 70 research papers and eight patents.
LIMS Advisory Board

The LIMS Advisory Board, chaired by Professor Frances Shannon (Deputy Vice-Chancellor Research, University of Canberra) 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 (ERA) 2015.

PROFESSOR MARYLyny ANDERSON AO
Professor Anderson AO is Professor of Biochemistry at La Trobe University and the Chief Scientist of Hexima Ltd. 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 10 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 Ltd. 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 Ltd, MuriGen Therapeutics, Chairman of ASX listed Genetic Signatures Ltd, 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 La Trobe University’s inaugural Chief Advancement Officer. 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 serve the University, enrich the lives of our alumni and engage the community in support of the aspirations of La Trobe University.
The LIMS Endowment Fund was established to create new and sustainable opportunities for scientists with outstanding potential.

The inaugural Bruce Stone Fellowship in Biological Chemistry and Nicholas Hoogenraad Fellowship in Molecular Sciences were awarded in 2015.

Both fellowships are named after two long-serving leaders: Professor Bruce Stone was the foundation professor of Biochemistry from 1972–1989, succeeded by Professor Nicholas Hoogenraad, who later became the first Director of LIMS. Professor Hoogenraad retired in 2014.

DR DAVID GREENING
Bruce Stone Fellow in Biological Chemistry

Dr David Greening completed his PhD at the Ludwig Institute, focusing on endogenous extracellular tumour-derived peptides. Dr Greening held a postdoctoral position at the Ludwig Institute. He was a visiting postdoctoral fellow at the Institute for Systems Biology (USA), before moving to LIMS in 2011.

Dr Greening has 33 publications (16 first author, five senior author, >800 citations). He has discovered novel methods for production, isolation, and purification of extracellular vesicles (exosomes), which are regarded as standard practice in extracellular biology and cell communication. He has investigated the functional characterisation of the cancer secretome, defining mechanisms promoting tumorigenesis, and regulating angiogenesis.

Dr Greening’s work also encompasses uterine biology, and has important implications for research into novel interventions designed to reduce infertility and establish a successful pregnancy.

DR IVAN POON
Nicholas Hoogenraad Fellow in Molecular Sciences

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 26 research papers (13 first author, two senior author, >1000 citations) in high impact journals including Nature, Nature Reviews Immunology, Nature Communications, eLife and Blood. He has made several significant discoveries including the mechanism of viral protein-induce cell death, antimicrobial peptide-mediated cell lysis, and dying cell uptake via pattern recognition molecules.

Dr Poon’s research has also been featured in mainstream media including The Age, The Australian, South China Morning Post, Daily Mail and The Guardian.
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.

Members have expertise in *in vivo* bioluminescent and fluorescent imaging, confocal microscopy, fluorescence-activated cell sorting, 3D cell cultures, 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 work to identify key drivers of cancer progression including secreted or exosomal factors; 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.

latrobe.edu.au/lims/research/themes/cancer
THEME LEADER

BELINDA PARKER
Senior Research Fellow and ARC Future Fellow
Cancer microenvironment and immunology
Determine 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. Design 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
Explore the ways in which tumours repair their DNA and resist cell death. Identify 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.

SUZANNE CUTTS
Senior Research Fellow
Cellular responses to anticancer drugs
Develop new therapeutic strategies for cancer treatment. Examine the mechanism of action in anticancer drugs doxorubicin (an anthracycline) and mitoxantrone (an anthracenedione). Work to restrict the killing properties of these drugs to cancerous cell types to minimise their toxic side effects.

DOUG FAIRLIE
Senior Research Fellow
Apoptosis, autophagy, cancer, drug development and peptides
Use biochemical, cell biology, structural biology and medicinal chemistry approaches to understand the molecular mechanisms that control apoptosis. Develop new reagents, including drugs that could target and inhibit the actions of the key pro-survival proteins that keep cancers alive.

MARK HULETT
Senior Lecturer
Inflammation and tumour progression
Investigate molecular regulators of cell invasion in tumour progression and inflammation. Focus on the enzyme heparanase and serum protein histidine-rich glycoprotein in these processes to develop new targeted therapies for treating cancer and inflammatory disease.

ERINNA LEE
ARC Future Fellow
Apoptosis, autophagy, cancer, cell and structural biology and drug discovery
Examine 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. Identify novel factors that enable crosstalk between these two biological processes.

SURESH MATHIVANAN
ARC DECRA Fellow
Exosomes, secretome and systems biology
Explore the role of extracellular matrix components (soluble secreted proteins and extracellular vesicles) in cancer and intercellular communication using proteomic, genomic and bioinformatics methodologies. Undertake basic science projects including the biogenesis of exosomes and the role of exosomes in intercellular communication.

JULIAN PAKAY
Lecturer
Signal transduction, cancer biology and bioenergetics
Study signal transduction and cancer biology, particularly where these intersect with cellular and mitochondrial bioenergetics. Specialise 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
Use the vinegar fly, Drosophila, to determine how regulators of cell shape (polarity) and the cell skeleton (actin cytoskeleton) impact on cell signalling and cancer development. Identify novel pathways that cooperate with the Ras oncogene in cancer.

RICHARD SIMPSON
Professor
Extracellular vesicles, exosomes and cancer biology
Use an integrated proteomic, RNA profiling, bioinformatics and live-cell imaging strategy to understand the seminal role of extracellular vesicles in cell-cell communication in the extracellular environment during cancer progression and cancer plasticity.

CHANH TRAN
Lecturer
Interactions of X-rays with matter, optical coherence and X-ray imaging
Research various forms of 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. Develop quantitative full field imaging techniques using polychromatic X-ray sources.

DAVID GREENING
Bruce Stone Fellow in Biological Chemistry
Extracellular vesicles, exosomes, cancer biology and uterine biology
Use 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
Study the key genes and molecular pathways that regulate stem cells during normal growth and development. Work to identify how these genes are re-activated in the adult to cause cancer. Focus on breast cancer, myeloid leukaemia and germ cell cancers.

CHRISTINE HAWKINS
Associate Professor
Cell death regulation in cancer and viral infection
Study apoptotic regulation in normal, cancerous and virally-infected cells. Explore 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.

NICK HOOGENRAAD
Emeritus Professor AO
Development of therapeutic antibodies against cachexia
Specialise 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. Produce monoclonal antibodies that block cachexia, giving rise to the prospect of a treatment for this condition.
Cancer discoveries

Research spans cancer metastasis, cancer cell crosstalk with the microenvironment, pro- and anti-tumour immunity, and therapeutic sensitivity and resistance.

Identification of a key breast cancer preventing protein

With current screening methods, 25% of breast cancer patients are diagnosed in the very early stages of the disease, when cancer is still inside the breast ducts. Of those patients, it is difficult to predict who will go on to develop invasive cancer. Hendrika Duivenvoorden, under the supervision of Dr Belinda Parker, discovered a cancer suppressor protein in the cells that surround the breast duct. This marker could eventually be used to classify cases into low risk and high risk categories, sparing some patients from radiotherapy or mastectomy.

Understanding how cancer cells spread

Understanding how cancer cells spread and become invasive is an important step towards inhibiting metastasis therapeutically. By investigating secreted molecules, Dr David Greening and Professor Richard Simpson have identified a mechanism whereby cancer cells recruit blood vessels to promote tumour progression.

Lowering the risk of therapy related cancers

Tanmay Shekhar, under the supervision of Dr Christine Hawkins, found that two new classes of anti-cancer agents failed to damage the DNA of surviving cells, in contrast to chemotherapy drugs that provoked significant DNA damage. This data provides hope that cancer survivors treated with these new drugs would have a lower risk of developing therapy-related cancers than those treated with chemotherapy or radiotherapy.
Dr Amelia Johnston and Emeritus Professor Nick Hoogenraad led a 28-member international research team that discovered a cause of cachexia, the muscle wasting disease that kills up to one third of people with late-stage cancers.

Cancer-cachexia manifests itself as muscle loss, fat loss and overall metabolic imbalance. It was always thought that the condition resulted from cancer spreading and consuming the body, with loss of appetite and nutritional complications causing muscles to waste away. Johnston and Hoogenraad’s research has shown otherwise, revealing that Fn14, a receptor on a cell’s membrane which is often present on cancer cells, can cause cachexia.

“Fn14 has been known to be involved in cancer, but it was a surprise to us that it caused the wasting condition,” said Dr Johnston.

“Our treatment is an antibody directed against Fn14, and because antibodies are very specific to their target, this means treatment is less likely to come with the unwanted side effects of other therapies, such as many chemotherapy drugs.”

The discovery brings the scientists closer to finding a way to stop cachexia and may have potential to help fight cancer directly. In some cases, treatment with the antibody therapy that blocked the cachexia also slowed tumour growth. “If we can arrest cachexia it will give people extra time, improved quality of life, make them stronger and allow for therapy to continue,” said Professor Hoogenraad.

The research team, in collaboration with scientists at the Olivia Newton-John Cancer Research Institute, are now converting the antibody therapy into a treatment appropriate to trial in humans.
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.

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 mouse models, human T cell culture and cloning, and monoclonal antibody production and generation.
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; and infection by viruses and the immune response to them.

latrobe.edu.au/lims/research/themes/infection-and-immunity
THEME LEADERS

WEISAN CHEN
Professor
Cellular immunity to influenza A virus

Specialise in CD8+ T cell biology and antigen processing and presentation in the development of cross-protective immune responses to the influenza virus. Investigate 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

Study the molecular mechanisms underlying Gram-negative bacterial infections. Use a multidisciplinary approach combining X-ray crystallography, molecular biology and biochemistry to investigate the structure-function relationships in proteins involved in bacterial pathogenesis and develop antibacterial drugs with novel modes of action.

MARILYN ANDERSON AO
Charles La Trobe Professor
Plant innate immunity proteins

Specialise in protection of humans and crops from pathogens by studying natural defences of plants and the biology of the pathogens themselves. Identify 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

Study large ATP-dependent multi-subunit machines that are responsible for the regulated removal of unwanted proteins in bacterial cells and eukaryotic organelles. Identify new components that control these machines and novel chemicals that dysregulate them.

MATTHEW PERUGINI
Associate Professor
Rational drug design targeting infection and age-related diseases

Study the structure, function, regulation and inhibition of essential oligomeric enzymes, such as dihydrodipicolinate synthase, from the lysine biosynthesis pathway of bacteria. Characterise the role of apolipoprotein E in cardiovascular and Alzheimer’s diseases.

ROBERT PIKE
Professor and Director of LIMS
Proteases, inhibitors and receptors: relationship to disease states

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

IVAN POON
Nicholas Hoogenraad Fellow in Molecular Sciences
Apoptotic cell disassembly and clearance

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

HAMSA PUTHALAKATH
Associate Professor
Regulation of apoptosis by Bcl-2 family proteins

Study 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.
MICK FOLEY
Associate Professor
Use of single domain antibodies as therapeutics in fibrosis and other chronic diseases
Use 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.

MARC KVANSAKUL
ARC Future Fellow and Associate Professor
Structural biology of cell death and host-pathogen interactions
Examine how viruses hijack cellular defence systems to ensure their own proliferation and survival. Study the role of small proteins that act as a first line of defence against microbial targets, and the mechanism they use to destroy target cell membranes.

ROMMEL MATHIAS
NHMRC Research Fellow
Hijacking of host organelles by human cytomegalovirus
Study human cytomegalovirus to identify novel host defence proteins and viral factors eliciting infection. Identify host organelles that are targeted by viral proteins, and characterise the molecular mechanisms of action using virology, molecular biology, microscopy, genomics, proteomics and bioinformatics.

TATIANA SOARES DA COSTA
NHMRC Research Fellow
Drug discovery, enzymology, allosteric regulation and bacteriology
Use 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
Study the use of bacteriophage (viruses that specifically attack bacteria) as an alternative to antibiotics. Examine the personalisation of medicine to fit a patient’s genetic profile, and patient management of medication in the treatment of chronic diseases.
Infection and Immunity discoveries

Research spans the development of the next generation of antibiotic molecules to fight infection, to molecules that combat inflammatory and autoimmune diseases.

**Human cell death captured for the first time**
Dr Ivan Poon and Georgia Atkin-Smith captured the complex stages of the death of a human white blood cell using time-lapse microscopy. Previously, scientists had thought the breakdown of dying cells was a random process. Dr Poon and Ms Atkin-Smith’s work, published in *Nature Communications*, has determined that it is, in fact, highly regulated.

**Dodging suicide at the molecular level**
Dr Marc Kvansakul and Dr Bevan Marshall discovered that the smallpox virus uses a mechanism to counter cellular suicide defence systems to establish an infection. Previously, it was assumed that smallpox worked in the same fashion as its much less dangerous relative, vaccinia virus. Dr Kvansakul and Dr Marshall have discovered that the mechanism used by smallpox is different and can be targeted to counteract this dangerous virus.

**Unravelling the secrets of bacterial survival**
Antimicrobial resistance is a threat to global health. Today there is widespread resistance to some of the most commonly used antibiotics, and the discovery of novel antibiotics to kill these resistant pathogens is urgently needed. Dr James Micevski and Jessica Zammit, under the supervision of Dr David Dougan, discovered the molecular mechanism of three novel bacterial proteins that contribute to bacterial survival during stress. These findings will aid efforts to develop novel inhibitors with the ability to destroy pathogenic bacteria in their host.

**TOP RIGHT**

*Dr Karen Harris is harnessing the properties of plants for future pharmaceutical drug design.*
Dr Karen Harris and Professor Marilyn Anderson AO, together with collaborators from the University of Queensland, have identified and produced the key enzyme that can turn small proteins known as linear peptides into more robust and chemically stable circular ones.

The discovery makes the peptides a leading candidate for future pharmaceutical drug design; a plant-based alternative to the existing industrial processes.

Circular peptides are a class of proteins exceptionally resistant to chemicals, enzymes and heat because of their unique structural scaffold. Dr Harris said they were less likely to be broken down by gastric acids than linear peptides currently in use, and can react more specifically with target molecules, with fewer side effects.

“Our enzyme comes from the original African plant in which the first circular peptides were discovered more than 40 years ago,” she said. “That plant was used by women in the Congo to accelerate childbirth.”

Scientists can synthesise circular peptides using sophisticated chemical methods, but this is the first time that the cyclising enzyme from a plant has been produced in bacteria and used to make circular peptides in the laboratory.

“Until now it has not been possible to produce these peptides in the quantities required for clinical trials,” explained Professor Anderson. “We are hoping this work will make the dream of producing new generation pharmaceuticals a reality.”
The Neurobiology theme investigates the biology and diseases associated with the nervous system. Research interests range from biophysical studies of proteins, to cellular and molecular analyses, and the use of \textit{in vivo} models to study the pathophysiology of neuronal biology and disease.

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 biochemistry.
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; and understanding how cells deal with misfolded proteins.
THEME LEADER

ANDREW HILL
Professor and Head of Biochemistry and Genetics
Neurodegenerative diseases, extracellular vesicles and noncoding RNAs
Investigate neurodegenerative diseases such as Alzheimer’s, prion and Parkinson’s diseases. Study exosomes and microvesicles as vehicles for the transfer of misfolded proteins between cells.

DI HUGHES
Lecturer
Oxidative stress, erythrocyte morphology and haemorheology
Research peripheral oxidative stress in Parkinson’s disease and rheumatoid arthritis. Study erythrocyte morphology and haemorheology parameters to mark peripheral oxidative stress, and whole blood antioxidant capacity.

JACQUELINE ORIAN
Senior Research Fellow
Neurodegenerative diseases
Identify potential therapeutic targets for Multiple Sclerosis (MS) which are specific to the brain and to the disease, by following changes on the surface of the brain vasculature and surrounding tissue. Use experimental autoimmune encephalomyelitis, to generate proof-of-concept for pathological and molecular mechanisms to evaluate MS drugs.

MATTHEW PERUGINI
Associate Professor
Rational drug design targeting infection and age-related diseases
Study the structure, function, regulation and inhibition of essential oligomeric enzymes such as dihydrodipicolinate synthase, from the lysine biosynthesis pathway of bacteria. Characterise the role of apolipoprotein E in cardiovascular and Alzheimer’s diseases.

CHRISTINE KETTLE
Lecturer
Autonomic and central nervous system regulation of metabolism
Examine 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.

ROBYN MURPHY
Associate Professor
Skeletal muscle biochemistry
Study the various aspects of skeletal muscle biochemistry in health and disease. Examine how changes in protein abundance as a result of exercise, disease and ageing can affect the ability of muscle to produce force and confer strength and stability.

YOSSI RATHNER
Lecturer
Autonomic and central nervous system regulation of metabolism
Research the neurobiology and neurochemistry that underlies the physiology of metabolism. Examine the neurochemistry of the central autonomic circuits involved in controlling brown adipose tissue thermogenesis to achieve metabolism of free fatty acid and improved glucose stasis.

KAYE TRUSCOTT
Senior Research Fellow
Mitochondrial protein homeostasis
Study the function of proteins engaged in the biogenesis and maintenance of mitochondria, the cell’s power plant and manufacturer of essential biomolecules. Investigate strategies to modulate mitochondrial function for the prevention of mitochondrial disorders and neurodegenerative diseases including Parkinson’s disease.
Neurobiology discoveries

Research focuses on disorders of the nervous system including Alzheimer’s, Parkinson’s, prion diseases and Multiple Sclerosis.

Maintaining healthy mitochondria

Many age-dependent neurodegenerative diseases such as Parkinson’s are associated with the accumulation of protein aggregates; damaged proteins that join together in long fibers that are toxic to cells. In mitochondria (the cellular power plant), the key “waste disposal” machines that protect this subcellular structure against the accumulation of protein aggregates are not well defined. Dr Ayenachew Bezawork-Geleta, under the supervision of Dr Kaye Truscott, has discovered the key molecular machine in human mitochondria responsible for destroying damaged proteins before they aggregate. This discovery could aid in the development of therapeutic strategies to prevent specific age-related neurodegenerative disorders.

Skeletal muscle changes with age, but exercise works just the same

Exercise is key to maintaining healthy muscle, but do we reap the same benefits as we age? Dr Robyn Murphy and her team discovered that while skeletal muscle changes with age, a high-intensity exercise regime offered similar benefits to muscle function for people aged 67-76 years as it is expected to in younger participants.

Spreading bad proteins and RNA in the brain

A common feature of neurodegenerative diseases, including Alzheimer’s, Parkinson’s and the prion diseases, is the spread of misfolded (damaged) proteins in the brains of affected individuals. Professor Andrew Hill and his research group are interested in the study of this spreading mechanism and, in particular, small particles called exosomes which carry these misfolded proteins between cells. Exosomes also contain genetic material and Dr Lesley Cheng has led studies highlighting the potential of exosomes for early diagnosis of brain disorders using blood samples.

Dr Jacqueline Orian is evaluating MS drugs.
New treatment options for Multiple Sclerosis

Dr. Jacqueline Orian is working to identify new treatment options for patients with Multiple Sclerosis (MS). The cause of the disorder is unknown. By the time a definitive diagnosis is made, MS has the hallmarks of both neurodegeneration and autoimmunity against the central nervous system. No biomarker has been identified to date, making prognosis almost impossible.

In collaboration with Novartis Pharmaceuticals, Dr. Orian and her research group are testing an improved immunomodulatory drug known as Gilenya, Fingolimod, or FTY720. It targets the sphingosine-1 phosphate (S1P) receptor, a G-protein coupled receptor to block the release of aggressive immune cells from entering circulation. This alleviates the symptoms associated with MS, including vision problems and fatigue.

“Our laboratory is investigating this compound to better understand the mechanism of drug action and to establish the relationship between the different sub-types of pathology,” Dr. Orian explained.

Data indicates that the drug eliminates all types of lesions, suggesting a common mechanism for lesion formation. On the other hand, it appears that the mechanism of destruction of the neuronal cell body differs from that of the axon, even though these are components of the same cell.

Dr. Orian is now examining brain regions associated with common MS symptoms, but where no lesions are detectable. She hopes to reveal the benefits of Gilenya on reducing symptoms, demonstrating the potential of targeting the S1P receptor to improve the quality of life for patients with MS.
The Molecular Design theme uses molecules to solve real world problems across a broad range of disciplines.

Members have expertise in NMR spectroscopy, X-ray crystallography, mass spectrometry, chemical 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 include the design of new metal-based radiopharmaceuticals; synthesis of drugs targeting resistant strains of malaria and hospital borne superbacteria; generation of antimicrobial 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.

[latrobe.edu.au/lims/research/themes/molecular-design]
JASON DUTTON
Senior Lecturer
Organic, organometallic and inorganic chemistry from synthetic and theoretical perspectives
Examine the fundamental chemistry of a wide variety of systems (literally spanning the periodic table from beryllium to iodine) using both synthetic and computational approaches. Discover new structure, bonding and reactivity for a variety of elements.

BELINDA ABBOTT
Lecturer
Medicinal chemistry and synthetic organic chemistry
Use synthetic organic chemistry to make novel compounds and test them in biological assays, in order to study the structure-activity relationships of how the compounds interact with the target. Develop novel antibacterial agents to inhibit targets not previously studied.

CARME ABRAHAMS
Lecturer
Supramolecular chemistry and single crystal X-ray diffraction characterisation of small molecules
Investigate the design, synthesis and characterisation of supramolecular systems. Study the use of the biodegradable porous compound Zn(Saccharate) and its ability to act as a host for molecules such as small aromatic hydrocarbons.

PETER BARNARD
Lecturer
Synthetic organic and inorganic chemistry
Synthesis of coordination complexes for diagnostic imaging applications and sensor development. Specialise in small molecule organic and inorganic synthesis in combination with analytical techniques for generation and characterisation of new compounds.

ADAM MECHLER
Senior Lecturer
Bioinspired self-assembling nanostructures
Study the principles of self-assembly in lipid membranes, peptide fibrillogenesis and peptide-membrane interactions. Apply these design rules in the development of biomimetic membrane platforms, novel peptide antibiotics and peptide based metamaterials.

BRIAN SMITH
Professor and Head of Chemistry and Physics
Modelling molecular interactions
Use quantum-mechanical methods to understand enzyme mechanism, molecular mechanical methods to explore the dynamics of proteins, and a variety of tools to predict how molecules interact. Use X-ray crystallography to determine the structures of complexes of proteins, polypeptides and small molecules.

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
Use computational quantum chemistry to model molecular structures, properties and spectroscopies, as well as energetics of reactions. Focus on understanding fundamental properties of chemical bonding and electronic structure in the design of new chemistry and new materials.
Molecular Design discoveries

Research encompasses computational studies on the interaction of drugs with proteins, molecular synthesis, and surface and material science.

**Water soluble iridium complexes for analytical chemistry**

Dr David Wilson, in collaboration with researchers from Deakin University and The University of Melbourne, designed new compounds containing the element, iridium, that are both water soluble and emit in the blue region of visible light. Previous attempts to increase water solubility for analytical applications have resulted in an unwanted change in the colour of the emitted light. This research shows, for the first time, how to increase both water solubility and blue light emission.

**Turning nature’s defences against human disease**

Autoimmune diseases include diabetes mellitus, Multiple Sclerosis, rheumatoid arthritis and psoriasis. Professor Brian Smith, in collaboration with researchers at Monash University and in the United States, has taken venom from a sea anemone and transformed it into a potential treatment for these diseases. These modified venoms will target the human immune system but with significantly fewer side effects than current drugs on the market.

**New software to model molecular science**

Dr David Wilson contributes to the DALTON quantum chemistry program, which is a powerful tool to model a wide range of molecular properties. The DALTON program is used at over 2000 institutions worldwide, with the latest version expanding the capabilities to model larger molecular systems such as nanostructures or biomolecules.

*Dr Jason Dutton is using gold compounds to produce Au-OH, a rare class of material.*
Golden chemistry

Hydrogen gas (H₂) has been described as a green fuel of the future, with the potential to power anything from cars to space shuttles. The only products required for the combustion of H₂ are a large amount of energy and water (H₂O). Dispensing with petroleum-based fuels in favour of H₂, however, is some way off. At present, the production of H₂ requires more energy than is gained from its use and it is also very expensive.

Metal-based chemistry may have the answer by discovering alternative ways to convert H₂O into H₂ and O₂, providing a green method of H₂ production. Before this can be realised a detailed understanding of the interaction between metal-based systems and water must be undertaken.

Dr Jason Dutton, in collaboration with Dr David Wilson, Dr Peter Barnard and Dr Conor Hogan, discovered a completely novel family of gold compounds that allowed for the isolation of a key intermediate in the metal based decomposition of water, an Au-OH complex.

The lab work was performed by APA scholar Robert Corbo who simply added a drop of water to the new compound and was able to form the Au-OH bond, a very challenging and rare class of material.

“Previously, the synthetic methods used to produce Au-OH were onerous and relied on expensive reagents,” explained Dr Dutton. “In contrast, our ‘just add water’ method simplifies the process, which is highly significant. Eventually, water must be used as the ‘fuel’ for the ultimate goal of using metals to convert H₂O into H₂.”
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, relies upon molecular imaging.

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. They are regular users of the Australian Synchrotron.
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.
GROUP LEADER

BRIAN ABBEY
ARC Future Fellow and Associate Professor
Coherent X-ray science and materials characterisation
Combine 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. Develop techniques for interpreting patterns of coherently scattered light.

MARK HINDS
Associate Professor
Protein structure and interactions
Determine structure and interactions of biomolecules in solution using nuclear magnetic resonance spectroscopy. Investigate structure, function and interactions of viral proteins regulating apoptosis with their host cell targets. Biomolecular interactions using biophysical and biochemical techniques.

SHAN SHAN KOU
Lecturer
Bio-imaging and bio-photonics, optical micro- and nano-scopy, and biomedical instrumentation
Study the interactions between light and biological matter to explore the complex mechanisms behind cellular and sub-cellular events and processes. Develop novel bio-imaging modalities and instrumentation to be used in new diagnostic and therapeutic tools.

MARC KVANSAKUL
ARC Future Fellow and Associate Professor
Structural biology of cell death and host pathogen interactions
Examine how viruses hijack cellular defence systems to ensure their own proliferation and survival. Understand 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.

MEMBERS

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

MEGAN MAHER
Senior Lecturer
Metallobiology
Use X-ray crystallography to study the mechanisms by which trace metals are regulated within biological systems. This regulation relies on proteins that fulfill specific roles, from membrane proteins which ‘gate’ nutrients from entering and exiting the cell, to proteins within the cell that ‘chaperone’ metals to where they are required.

GRANT VAN RIESSEN
Lecturer
Experimental condensed matter and materials physics, and coherent X-ray imaging development
Develop novel methods of probing condensed matter and material properties using coherent X-ray imaging methods, electron spectroscopy and nanofabricated devices. Develop synchrotron instrumentation and high-performance computing methods for reconstructing quantitative images from very large datasets.
Molecular Imaging discoveries

Research uses the latest technologies for characterising molecules and their dynamics to understand molecular processes at the organism, cellular and macromolecular scale.

Discovering proteins critical to gene regulation
Turning genes on or off at the right time and right places is critical to human development and health. Abnormal gene regulation often results in cancer and other disorders. Dr Mihwa Lee, in collaboration with researchers from the University of Western Australia, reported the first structure of SFPQ, a human protein that plays an important role in gene regulation. Uncovering the molecular detail of this protein will allow scientists to further examine its multifunctional role in the cell nucleus.

Coded aperture for photon-spin sensing
A phenomenon known as extraordinary optical transmission (EOT) has enormous potential for chemistry and bio-sensing, which can be important in the diagnosis of disease using molecular markers. At present, EOT has a “blind-spot” for detecting the chiral properties of the transmitted light, an identifier useful in distinguishing different molecules. In collaboration with an international research team, Dr Shan Shan Kou, Dr Eugeniu Balaur and Dr Brian Abbey used nanostructures to guide the EOT so that bio-sensing of molecules may be possible through sensing of the chirality of light.

Small crystals may be tougher than expected
Understanding the structure and function of proteins is critical to new drug development. The primary method for solving protein structures involves X-ray diffraction using large, high quality crystals. Hannah Coughlan, under the supervision of Dr Brian Abbey, investigated radiation damage in tiny, micron-sized protein crystals and showed that they can survive longer than previously thought. This discovery may be used to speed up the process of determining protein structures, shortening the development timeline for new drugs.

Dr Megan Maher has captured the rapid process of electron transfer.
Capturing electron transfer

Dr Megan Maher, in collaboration with researchers at LIMS, the Centenary Institute, the University of Sydney and the University of Queensland, has described the crystal structure of a protein complex active in electron transfer.

Electrons are particles that form part of the structure of every atom. In biological systems, electrons must flow (much like an electrical current) from one protein to another. This action is critical to the most fundamental processes of life, including respiration in mammals and photosynthesis in plants.

“The process of electron transfer between proteins is a little like a relay,” explained Dr Maher. “The electron is the baton and the proteins are the runners. Like runners in a relay, the proteins must come together and quickly exchange the baton so it can be passed to the next runner in the race.”

Dr Maher and her team were able to capture the proteins together in the process of exchanging the electron by using X-ray crystallography, a technique that allows scientists to see the inner workings of atoms and molecules.

“In the case of protein crystallography, we grow crystals of proteins and shine light through them (in this case, high-intensity X-rays) in order to discover the positions of atoms and therefore protein molecules in the crystal,” said Dr Maher. “We can then map the three-dimensional architecture of a protein. Once we know what a protein looks like, we can understand how it works.”

The snapshot of electron transfer, the first of its kind, reveals that while the exchange process is rapid, the proteins interact much more extensively than scientists had previously thought. “Changes to the shape of one of the proteins during the exchange allow the electrons to be transferred quickly,” said Dr Maher.
The Molecular Sensing theme combines chemistry, physics and biology to identify and quantitate key chemical and biochemical species in the environment and the human body.

Members have expertise in surface science and analysis, condensed matter physics, infrared spectroscopy, fluorescence spectroscopy, electrochemistry, water quality, soil chemistry and pharmaceutical science.
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 point-of-care test for early diagnosis of sepsis.

latrobe.edu.au/lims/research/themes/molecular-sensing
THEME LEADER

CONOR HOGAN
Associate Professor
Electrochemistry, photochemistry, chemical sensing and biosensing
Conduct 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 multi-coloured ECL or 3D ECL.

MICHAEL ANGOVE
Head of Pharmacy and Applied Science
Colloid, environmental and pharmaceutical science
Use 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. Study pharmaceutical products that utilise colloidal particles and systems.

NARELLE BRACK
Senior Lecturer
Surface modification and characterisation of advanced materials
Create materials at the nanometer scale. Explore chemical and molecular properties and processes at surfaces and at interfaces. Develop surface modification strategies for material systems including next generation aircraft materials, carbon nanomaterials and electrospun nanofibres.

DAVID HOXLEY
Lecturer
Biosensing applications of wide bandgap semiconductors
Study the surfaces of semiconductor crystals, particularly diamond, and how they react to the world around and within us. Research ways of making coaching possible in the tertiary education system, primarily through combining modern educational psychology with information technology.

IAN POTTER
Senior Lecturer
Analytical and environmental chemistry
Prepare polymer inclusion membranes and polymer-based microspheres for use as small-scale chemical reactors and sensors for biological, environmental and industrial applications. Develop methods to analyse plant biomarkers. Develop forensic analysis methods to determine the production method and source of dangerous chemicals.

EAST CHEN QI
Lecturer
Nanophysics and quantum materials
Create and understand the surfaces and interfaces of functional materials at the molecular scale to develop new technologies and material platforms for next-generation devices. Use advanced spectroscopic techniques, based on synchrotron radiation, to examine surface and interface phenomena and physics essential to device operation.

IAN POTTER
Senior Lecturer
Optical spectroscopy of atmospheric and biological molecules
Use 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.

COURTNEY ENNIS
ARC DECRA Fellow
Spectroscopy of planetary and interstellar environments
Use advanced infrared techniques to trace chemical reactions observed throughout our Solar System and beyond into interstellar space. Develop our understanding of the Earth’s chemical origins and improve sensing methods for biologically significant molecules that may remain undetected in space.

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Molecular Sensing discoveries

Research encompasses both fundamental and applied research with a view to real world applications in medical diagnostics, food testing, environmental and remote atmospheric sensing.

Light work of heavy snow
Clouds affect daily weather and long term climate by absorbing and scattering visible and invisible light. Many high altitude clouds consist of tiny, nanometre scale ice particles that can interact with radiant infrared light more strongly than liquid droplets or water vapour. Dr Evan Robertson’s studies of ice made from heavy (deuterated) water provide greater understanding of how this occurs.

A bright future for sensing applications
Materials that emit and absorb specific colours of light are needed for applications such as LEDs and analytical sensing. Dr Peter Barnard, Dr Conor Hogan and Dr David Wilson have synthesised and studied a new class of brightly emitting iridium-metal based molecules that have exceptional electrochemical properties. They may form the basis for new highly sensitive chemical and bio-sensors.

Understanding gas adsorption at single-molecular level
Nitrogen fixation is the process whereby nitrogen in the form of a gas in the atmosphere is incorporated into biomolecules, such as proteins found in the human body. Dr Dongchen Qi and Chris Wright, in collaboration with colleagues at the National University of Singapore and Brookhaven National Lab, have found a new kind of molecule that is able to aid in nitrogen fixation. This discovery may assist efforts to artificially fix nitrogen, which is important, for example, in the industrial production of plant fertilizer.
Dr Courtney Ennis and PhD student Rebecca Auchettl are mapping the release of nitriles into the atmosphere; cyanide-type molecules harmful to humans and ecosystems.

“The recent peatland fires that have engulfed Sumatra, Borneo and Tasmania have released large quantities of airborne volatile organic compounds (VOCs), including high levels of organic nitriles,” explains Dr Ennis. “Commonly used in the chemical industry as solvents, exposure to nitrile fumes can cause respiratory ailments in humans. Once dissolved, they show acute toxicity to aquatic vegetation and wildlife.”

Most VOCs are broken down by chemical reactions and by exposure to UV light from the sun. Nitriles, however, show some resistance to these decomposition pathways, and can be absorbed into growing water particles before returning to earth mixed in raindrops. This is known as atmospheric washout.

To improve our understanding of the fate of nitriles in the environment, Dr Ennis and Ms Auchettl have used a unique gas cell at the Australian Synchrotron to simulate the washout process under atmospheric conditions. By applying infrared sensing methods, they placed constraints on nitrile uptake by water aerosols, traced mixed droplet growth rate and particle size, and gathered spectroscopic signatures to assist remote detection of nitrile species.

“This new data will enable us to better map the release of nitriles into the atmosphere and track how they disperse with smoke plumes and rain clouds,” said Dr Ennis.

“Most importantly, it will allow us to more accurately predict where they will end up when they return to earth, and pinpoint locations where damaging cyanide compounds may accumulate.”
External funding

**AdAlta Ltd ($1,330,699)**
Development of human single domain antibodies for use in inflammation and fibrosis (Michael Foley, 6 years, $1,330,699)

**Australian Research Council Centre of Excellence ($5,600,000)**
ARC Centre of Excellence in Advanced Molecular Imaging (administered by Monash University – Keith Nugent and Brian Abbey, 7 years, $5,600,000)

**Australian Research Council ($2,884,838)**
Planetary nitrile chemistry: synchrotron and laboratory spectroscopic investigations (Courtney Ennis, 3 years, $110,000)

Base stabilized dicarbon as a new building block for supramolecular organometallic chemistry (Jason Dutton, 4 years, $125,000)

The molecular mechanisms of dual nucleic acid specificities of SFPQ (Mihwa Lee, 3 years, $127,000)

Understanding the role of exosomes in intercellular communication (Suresh Mathivanan, 3 years, $125,000)

Unraveling mechanisms of aggregation and biofilm formation critical for bacterial antibiotic resistance (Begona Heras, 3 years, $110,000)

BioPPSy: an open source BIOchemical Property Prediction System (Brian Smith, 3 years, $90,000)

Surface doping of diamond: a new platform for 2D carbon-based spintronics (Christopher Pakes, 3 years, $60,000)

Electrochemically-sensitized luminescence: a new bio-detection paradigm (Conor Hogan, 3 years, $160,000)

Molecular mechanisms of regulatory proteolysis in *Escherichia coli* (David Dougan, 5 years, $85,000)

Complex II proteostasis in mammalian mitochondria (David Dougan, 3 years, $105,000)

Molecular basis of synergy between proteinase inhibitors and plant and animal defensins against fungal pathogens (Marilyn Anderson, 3 years, $139,000)

The LINK to regulating lysine levels in wheat (Matthew Perugini, 3 years, $120,000)

Molecular mechanisms for copper trafficking across membranes (Megan Maher, 3 years, $111,000)

The importance of exosomal membrane composition in intercellular signalling (Suresh Mathivanan, 3 years, $80,000)

How bacteria fold virulence factors to cause disease (Begona Heras, 4 years, $187,288)

Crosstalk between breast cancer cells and the microenvironment to promote metastasis (Belinda Parker, 4 years, $188,720)

Extending X-ray crystallography to allow structure retrieval from highly disordered crystals and nanocrystals (Brian Abbey, 4 years, $191,848)

Structural studies of host-pathogen interactions (Marc Kvansakul, 4 years, $187,630)

Crosstalk between cell survival and cell death pathways (Erlanna Lee, 4 years, $582,352)

**Cancer Council Victoria ($224,919)**
The role of myoepithelial proteins in blocking breast cancer invasion (Hendrika Duivenvoorden, 3 years, $29,017)

Tumour-targeted nanoparticles as sensitisers for cancer chemotherapy (Paul Pigram, 3 years, $95,902)

Regulation and function of RIP kinase 1 and RIP kinase 3 (administered by Walter and Eliza Hall Institute of Medical Research – David Vaux, 3 years, $100,000)

**Cooperative Research Centre ($6,000,000)**
Cooperative Research Centre for Biomarker Translation (Nick Hoogenraad, 7 years, $6,000,000)

**Hexima Ltd (10,758,822)**
Antifungal activity in plant defensins; discovery of novel insecticidal proteins; interaction between matriptase and proteinase inhibitors (Marilyn Anderson, 4 years, $10,758,822)

**National Health and Medical Research Council ($4,822,732)**
Broad spectrum inhibition of an enzyme antibiotic target (Tatiana Soares da Costa, 4 years, $77,359)

Targeting apoptotic pathways for the treatment of schistosomiasis (Erlanna Lee, 1 year, $34,931.57)

Centre for Research Excellence in Asbestos Related Diseases (administered by University of Western Australia – Richard Simpson, 5 years, $30,000)
Cachexia therapy (John Silke, 3 years, $418,928)
Sirtuins and pathogenesis of human cytomegalovirus (Rommel Mathias, 2 years, $73,723)
Limiting the impact of influenza (administered by The University of Melbourne – Weisan Chen, 5 years, $1,710,405)
How do small extracellular vesicles contribute to the development of prion disease (Andrew Hill, 1 year, $125,676)
Immune responses that dictate metastatic spread in breast cancer (Belinda Parker, 3 years, $177,122)
The role of natural protein inhibitors in blocking breast cancer invasion (Belinda Parker, 3 years, $138,129)
Determining fundamental mechanisms compromised in Kir-linked disease states (administered by Walter and Eliza Hall Institute – Brian Smith, 2 years, $36,856)
Contribution of Bcl-2 pro-survival proteins to cancer associated with dysregulated autophagy (Erinna Lee, 1 year, $35,472)
Physiological and pathological effects of oxidation on contractile function in skeletal muscle (Robyn Murphy, 4 years, $197,380)
Molecular basis of Ca2+-dependent disruption of EC-coupling and weakness in skeletal muscle (Robyn Murphy, 3 years, $178,164)
Developing a new treatment method to prevent lymphopenia associated with sepsis (Hamsa Puthalakath, 3 years, $149,166)
Function and molecular mechanism of histidine-rich glycoprotein in necrotic cell and pathogen clearance (Mark Hulett, 3 years, $168,164)
Altering macrophage phenotype for the treatment of chronic airway disease and lung cancer (David Vaux, 4 years, $216,271)
The molecular basis for manganese uptake by pathogenic bacteria (Megan Maher, 3 years, $204,378)
Mechanism of anoxic iron acquisition in pathogenic bacteria (administered by the University of Sydney – Megan Maher, 3 years, $279,967)
Endometrial exosomes: a new paradigm in endometrial-embryo cross-talk (administered by Monash University – Richard Simpson, 3 years, $104,037)
Complement inhibitors for treatment of chronic inflammatory diseases (Robert Pike, 3 years, $199,718)
A new strategy to prevent anthracycline-induced cardiotoxicity while improving anti-cancer activity (Suzanne Cutts, 3 years, $107,143)
NHMRC Fellowship SRFB (Helena Richardson, 2 years, $206,393)
Identifying key steps in the processing of proteins involved in Alzheimer’s and prion diseases (Andrew Hill, 1 year, $83,020)
NHMRC Senior Research Fellowship (Weisan Chen, 6 years, $112,500)
Other (1,306,857)
Pre-clinical evaluation of IAP antagonists in osteosarcoma (Christine Hawkins, 1 year, $26,000)
Micrometre scale imaging of residual elastic strain fields in whole components via strain tomography (Brian Abbey, 3 years, $7,500)
Structure determination from disordered protein crystals using oversampled data (Hannah Coughlan, 1 year, $6,400)
Molecular mechanism of cell disassembly during apoptosis and its modulation by common drugs (Ivan Poon, 1 year, $74,470)
Investigation of the structure, composition, coatings and treatments of various glass wool insulation products and associated research and development activities of currently manufactured products (Alexander Fink, 2 years, $110,000)
Genomic prediction of detailed fertility phenotypes and the role of non-additive genetic effects (Hassan Aliyo, 4 years, $2,951)
Novel co-reactants for multiplexed electrogenerated chemiluminescence (Noah Kebede, 3 years, $13,280)
Ionospheric research and meteorological applications using HF radars (Emma Bland, 3 years, $10,000)
Research Services Innovia 2015 (Paul Pigram, 3 years, $1,560)
Spinning disk confocal microscope with dual stages (administered by The University of Melbourne – Marilyn Anderson, 1 year, $40,000)
Blocking breast cancer cell Type I IFN signalling prevents immune recognition and allows metastatic progression to bone (Clare Stanley, 3 years, $90,000)
Australian National Fabrication Facility – NCRIS 2013 (administered by Monash University – Paul Pigram, 3 years, $100,000)
Data management and resource repository for the exRNA Atlas (Suresh Mathivanan, 5 years, $112,500)
Does FTY720 (Fingolimod) ameliorate emotional and cognitive defects in EAE? (Jacqueline Orian, 1 year, $250,000)
Prostate cancer bone metastasis (ProMis) (administered by the Garvan Institute – Belinda Parker, 3 years, $128,202.32)
Surface analysis – Rio Tinto (Paul Pigram, 2 years, $50,000)
Understanding the molecular basis of autoimmune disease ankylosing spondylitis (Weisan Chen, 1 year, $50,000)
Role of WNT signaling pathway in modulating the extracellular matrix components in colorectal cancer (Hina Kalra, 4 years, $30,000)
Provision of research services 2015– Trajan (Paul Pigram, 2 years, $4,200)
Regulation and function of RIP kinase 1 and RIP kinase 3 (top up funding for a CCV grant – David Vaux, 3 years, $65,497)
Pharmacogenetic targeting of polarity-impaired Ras-driven breast cancer (Helena Richardson, 2 years, $134,297)

Grand Total ($32,928,867)
Publications


Bezawork-Geleta A, Brodie EJ, Dougan DA and Truscott KN (2015) LON is the master protease that protects against protein aggregation in human mitochondria through direct degradation of misfolded proteins, Sci Rep., doi:10.1038/srep17397. [I, N]


Galuzzi L, Puthalakath H et al., Essential versus accessory aspect of cell death: recommendations of the NCCD 2015, **Cell Death Differ.**, 22(1): 58-73. [I]


Harris KS, Derek T, Kaas Q, Poth AG, Gilding EK, Conlan BF, Sado I, Daly NL, van der Weerden NL, Craik DJ and Anderson MA (2015) Efficient backbone cyclization of linear peptides by a recombinant asparaglin endopeptidase, **Nat Comm.**, 6: 10199, doi: 10.1038/ncomms10199. [I]


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Micevski D, Zammit JE, Truscott KN, ANNUAL REPORT 2015


Spers LBM, Tucci J and Seviour RJ (2015) The activated sludge bulking filament Elkelboom morphotype 0803 embraces more than one member of the Chloroflexi, *FEMS Micro and Ecol.*, 91(9): fiv100. [I]


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**Contributed equally to work**


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