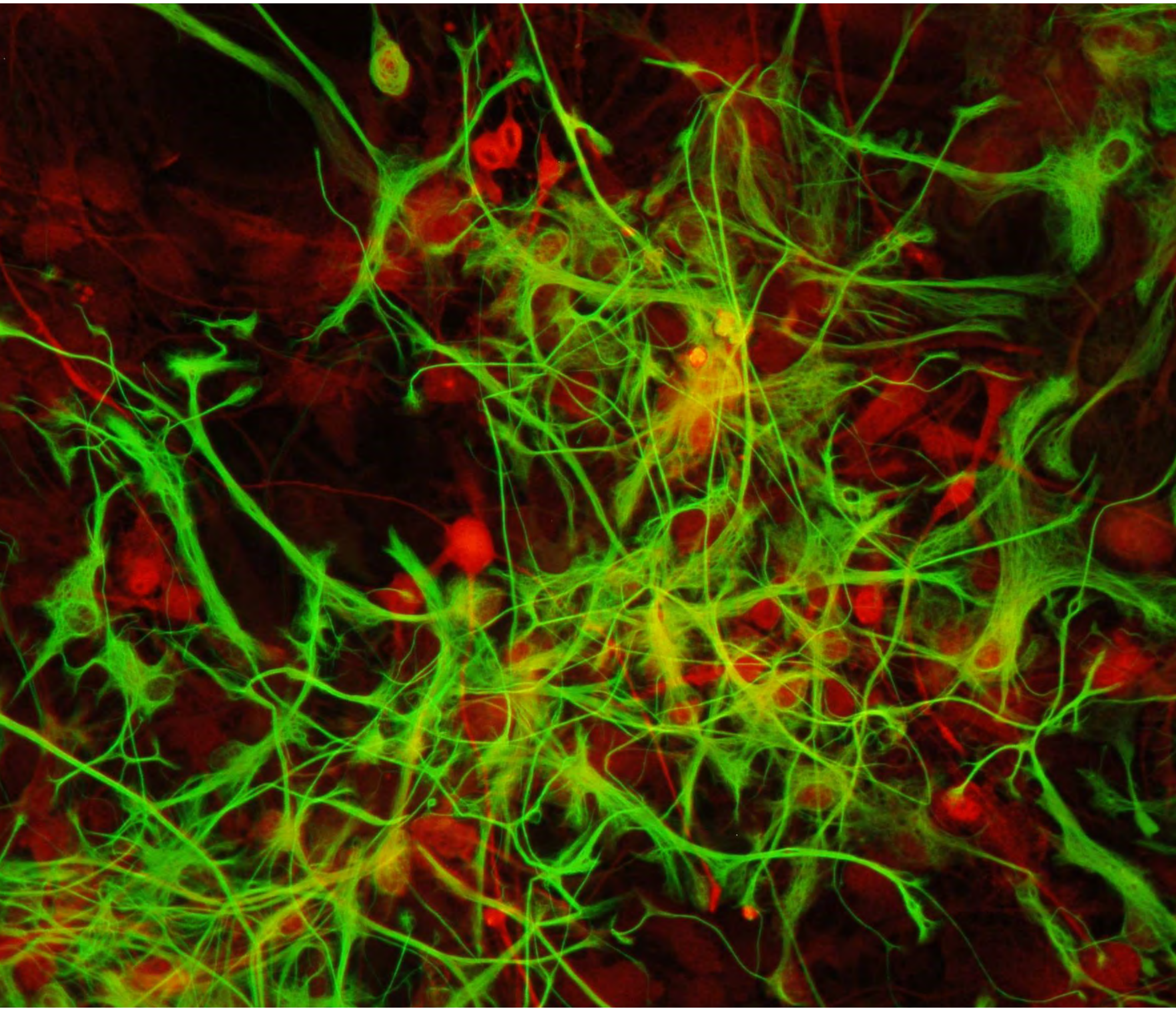
# School of Agriculture, Biomedicine and Environment

*Scientists working across animal, plant and soil science, biochemistry and chemistry, ecology, environment and evolution as well as physiology, anatomy and microbiology.*



latrobe.edu.au/school-agriculture-biomedicine-and-environment

# School of Agriculture, Biomedicine and Environment

This booklet contains ALL of our departments, institutes, research centres and research groups

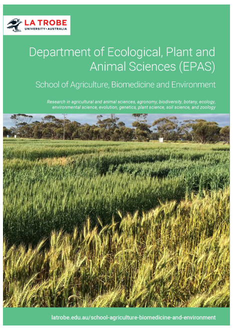

## Baker Department of Cardiovascular Research, Translation and Implementation

*Scientific experts in cardiovascular disease, diabetes and public health research. Together, we are translating our discoveries into practice*

*pp. 4-20*


## Department of Biochemistry and Chemistry

*Scientists at the forefront of knowledge in research areas including synthetic, organic, inorganic and analytical chemistry, molecular, cellular and structural biology, fundamental and applied biochemistry in microbes, plants and animals, as well as biomedical applications in human health and disease*
*pp. 21-57*




## Department of Ecological, Plant and Animal Sciences

*Research in agricultural and animal sciences, agronomy, biodiversity, botany, ecology, environmental science, evolution, genetics, plant science, soil science, and zoology pp. 58-106*


## Department of Microbiology, Anatomy, Physiology and Pharmacology

*Scientists at the forefront of knowledge into how biomolecules, cells, organ systems, disease and the environment interact to form functioning organisms (i.e. viruses, bacteria, animals, humans, etc.)*
*pp. 107-129*

If you are looking for a specific lab and know the lab name/lab head, please see the index at the back of this booklet.

# About the School of Agriculture, Biomedicine and Environment

The School of Agriculture, Biomedicine and Environment is one of the largest in the University, with more than 250 continuing and fixed term staff across multiple campuses. The School has seen significant growth in both research and teaching revenue. Staff in the School currently generate a significant proportion of the University's teaching revenue and research income, and supervise more than 230 higher degree research students. The School is responsible for 7 undergraduate degree courses at the main Bundoora campus in Melbourne, and our regional campus at Albury-Wodonga. It is a leader in teaching innovation and student satisfaction within the university.

The School undertakes teaching and research across a broad range of disciplines, including: Agriculture, Botany, Soil Science, Animal Science, Plant Science, Ecology, Environmental Geoscience, Evolution and Genetics, Conservation Biology, Zoology, Neurobiology, Microbiology, Physiology, Pathophysiology, Pharmacology and Anatomy, Biochemistry, Chemistry and Cardiovascular Physiology.

The 4 departments in the School are:

- Baker Department of Cardiovascular Research, Translation and Implementation
- Biochemistry and Chemistry
- Ecological, Plant and Animal Sciences
- Microbiology, Anatomy, Physiology and Pharmacology

The School of Agriculture, Biomedicine and Environment has recognised research expertise in biological, biomedical, environmental, molecular and chemical sciences. Our outstanding research environment gives academics access to the facilities and infrastructure needed to make significant discoveries.

We work collaboratively with our partners in industry, clinical organisations, philanthropy and government to achieve research outcomes that have a positive impact on the communities we serve.

We bring together the right capabilities, manage projects efficiently, act with integrity, and turn research results into translational outcomes.

Our contribution aligns with La Trobe's research themes: Healthy people, families and communities; Resilient environments and communities; and Understanding and preventing disease.

The School of Agriculture, Biomedicine and Environment research environment is dynamic and growing, and includes these major research centres:

- Centre for Cardiovascular Biology and Disease (collaboration with the Baker Heart and Diabetes Institute)
- Research Centre for Extracellular Vesicles
- Centre Research Biomedical and Environment Sensor Technology (BEST)
- Research Centre for Future Landscapes (collaboration with the Arthur Rylah Institute of DELWP)
- Centre for Freshwater Ecosystems
- Research Centre for Applied Alpine Ecology

Many of our staff are members of one of the University's flagship Institutes:

- La Trobe Institute of Sustainable Agriculture and Food (LISAF)
- La Trobe Institute for Molecular Science (LIMS)

Or research centres:

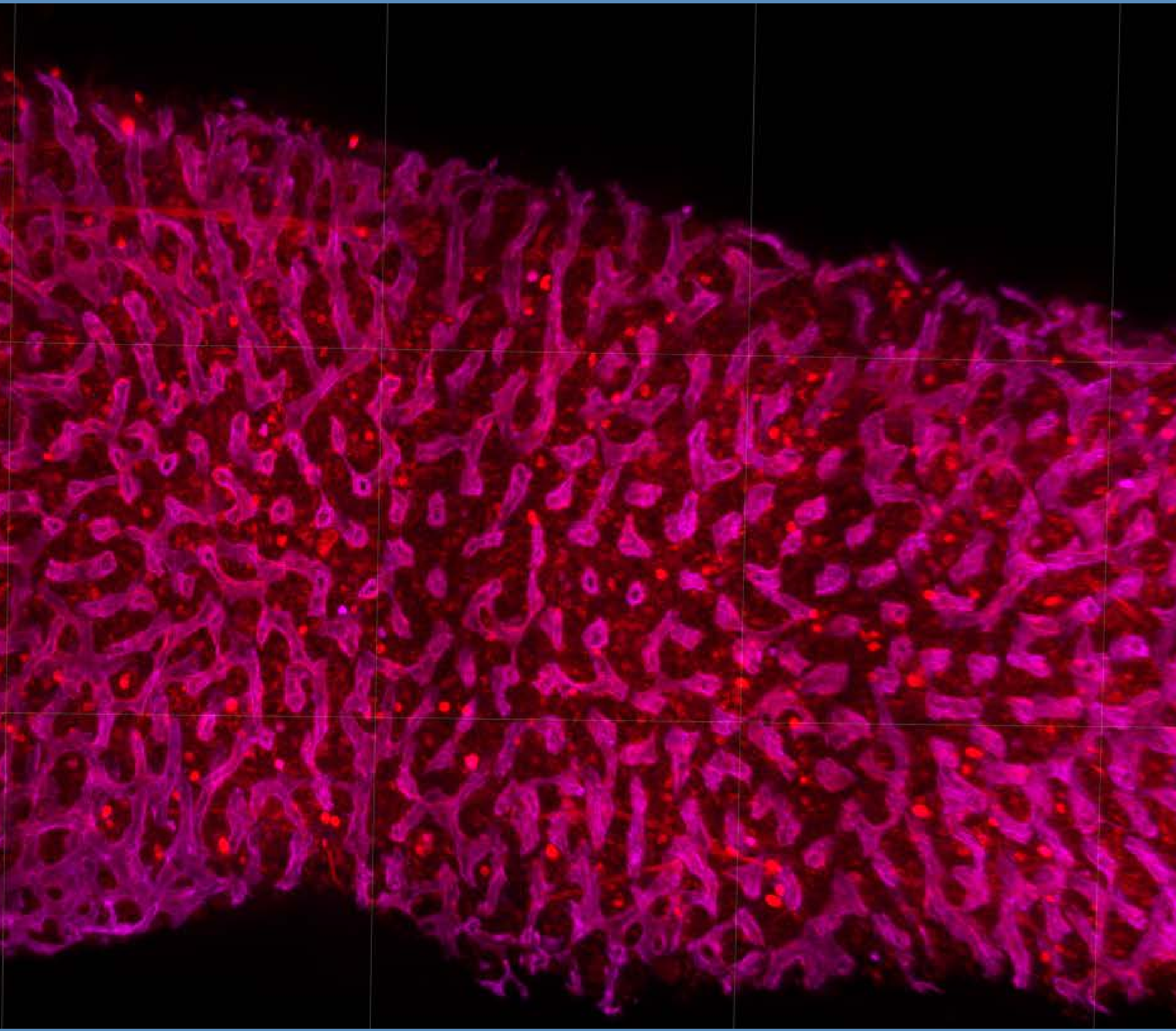
- ARC Centre of Excellence in Plants for Space
- ARC Industrial Transformation Research Hub for Protected Cropping
- Industrial Transformation Research Hub for Molecular Biosensors at Point of Use (MOBIUS).
- Mallee Regional Innovation Centre (MRIC)(a joint venture with The University of Melbourne)

Professor Robyn Murphy
Dean, School of Agriculture, Biomedicine and Environment

# Baker Department of Cardiovascular Research, Translation and Implementation

## School of Agriculture, Biomedicine and Environment

*Scientistific experts in cardiovascular disease, diabetes and public health research. Together, we are translating our discoveries into practice.*



latrobe.edu.au/school-agriculture-biomedicine-and-environment

# Baker CRTI Contents



*Cover Photo:*
*The vascular network of the bone marrow (Photo Credit: Dr Man Kit Sam Lee)*

# Baker Department of Cardiovascular Research, Translation & Implementation

The partnership between the Baker Institute, an independent, internationally renowned medical research facility more than 95 years old, and La Trobe University has led to the establishment of the Baker Department of Cardiovascular Research, Translation and Implementation led by Professor Peter Meikle. Together, we are growing the scope, volume and quality of cardiovascular and diabetes research and are enhancing access to health service and research networks in academia, industry and government, including local and rural collaborations. Our research extends from the laboratory to wide-scale community studies. We focus on diagnosis, prevention and treatment of diabetes, cardiovascular disease and associated metabolic diseases. We offer postgraduate opportunities via our Honours, Masters and PhD programs, in fundamental science using preclinical models, clinical studies and epidemiological and public health studies. Our research aligns with La Trobe's research themes: Understanding and preventing disease and Healthy people, families and communities. Our researchers are experts in cardiovascular disease, diabetes and public health. Together, we are translating our discoveries into practice, policy and education. Our research is grouped into three key areas:

### Clinical Research

We are identifying new and improved ways of preventing, diagnosing and treating heart disease and diabetes, and their complications. The goal is to enhance health, reduce disability, improve quality of life and address health disparities. Our work spans human and clinical research. Our scientists use imaging and other diagnostic tools to better inform our understanding of disease development and treatment. They also conduct clinical trials to evaluate new treatments and undertake health services research to inform how health care can be best delivered. Many of our researchers are also clinicians who work in a clinic or hospital setting. They are predominantly heart and diabetes specialists whose research is informed by the needs of their patients.


### Discovery and Preclinical research

We are designing new diagnostic, preventative and therapeutic strategies to tackle cardiovascular disease, diabetes and its complications. We are working to understand the cellular mechanisms of disease, biomarkers in the progression of disease and the pathways of gene expression. Our work spans the Institute's laboratory-based cellular and molecular biology and preclinical research, with a focus on translating exciting discoveries in the laboratory to clinical care.

### Population Health

We are examining trends in diabetes and obesity prevalence and incidence, risk factors at a population level, and new therapeutic approaches to prevent and treat diabetes, heart disease and obesity. Our research encompasses the Institute's epidemiological and public health groups, spanning clinical diabetes and obesity, physical activity, population health and behavioural epidemiology. Our work is helping to inform policy guidelines, influence chronic disease management, offer new evidence-based therapies for health professionals, and inform government and health authorities about the scale of these health problems. Our graduate researchers learn from world class experts in world class facilities.

### Graduate research

Our Honours, Masters and PhD students work on projects alongside researchers, in scientific laboratories or research units that are closely connected with clinical facilities and focus on the translation of findings into improved health outcomes. They are well supported and recognised by dedicated awards and funding opportunities overseen by the Research Training and Education Committee, all designed to support and enhance the learning experience.

### Partnerships

Together, we are growing the scope, volume, and quality of cardiovascular and diabetes research. We are enhancing access to health service and research networks in academia, government, and industry, including local and rural collaborations already developed by each organization.

### Australian Partnerships:

We have a physical presence at several health care settings – ensuring our education and research programs are contemporary and meet the needs of our communities. This presence also allows us to collaborate with health professionals on innovative teaching and translational research.

### International Partnerships:

We are globally connected through a range of formal partnerships and informal collaborations arrangements that strengthen our research capacity and outcomes. The Baker Heart and Diabetes Institute, for example, has partnered with University of Cambridge to establish the Cambridge Baker Systems Genomics Initiative. This transnational research partnership brings computational biologists together to drive the development of next-generation analytics, game-changing biology, and clinical utility from multi-omic datasets.

# Research Centre

## Centre for Cardiovascular Biology and Disease Research (collaboration with the Baker Heart and Diabetes Institute)

# Centre for Cardiovascular Biology and Disease Research

Cardiovascular disease comprises a class of chronic diseases involving the heart and/or blood vessels, often leading to heart attack, stroke, heart failure and kidney disease. Cardiovascular disease is also a major cause of dementia.

In Australia, 4 million people suffer from cardiovascular disease, costing the economy $5 billion annually. Alarmingly, cardiovascular disease claims more than 40,000 Australian lives per year, with the highest death rates observed amongst Aboriginal and Torres Strait Islander peoples, socioeconomically disadvantaged groups, and those living in remote and regional areas. It is for these reasons that cardiovascular disease is recognised as a National Health Priority area by the Australian Government.

There is an urgent need for more research and greater public awareness to address the enormous health and economic impacts of cardiovascular disease.

Our research spans the spectrum of cardiovascular biology and diseases, encapsulating basic mechanistic research, clinical and allied health research, and epidemiological studies.

Work in our laboratories involves all major technologies of modern biomedical sciences with unique strengths in experimental animal models, mouse genetics, immunology, genomics and drug discovery, enabling translation of our findings into new diagnostics, preventions and treatments for cardiovascular disease. More specifically, the scope of our cross-disciplinary research includes:

- Unravelling the role of inflammation and activation of the immune system in the pathogenesis of hypertension and chronic kidney disease.
- Studying the inflammatory mechanisms occurring in the brain after a stroke or as a result of reduced blood supply due to stenosis of the carotid arteries.


- Examining changes in contractile properties of the heart during disease and how this is affected by sex hormones.
- Characterising the changes in the gut microbiome during hypertension, diabetes and stroke and determining how these changes influence disease progression.
- Investigating the role of foetal programming in the development of cardiovascular disease.
- Determining the functional components of diet that may protect against or increase the risk of developing cardiovascular disease.
- Utilising 'big data' statistical approaches to reveal associations and relationships between experimental variables and disease parameters, as well as risk factors for cardiovascular events from de-identified hospital and clinical data.

We strive for:

- Research Excellence; by integrating a range of disciplines, using cutting-edge multi-disciplinary technologies, and employing best practice in experimental design, to define the causes of cardiovascular disease and stroke.
- Collaboration; with world-leading researchers working in universities, hospitals and medical research institutes around Australia and across the globe.
- Being future-focused; we want to recruit, support and train the next generation of scientists committed to solving the most pressing global health problems.
- Impact; by partnering with government, the pharmaceutical industry and biotech, NGOs, philanthropic organisations, and communities, especially those in the north of Melbourne and regional Victoria, to share new knowledge and ensure it is translated into guidelines, diagnostics and therapies that reduce the socioeconomic burden of cardiovascular disease.

Co-Directors:
Prof Chris Sobey (c.sobey@latrobe.edu.au) and Prof Grant Drummond (g.drummond@latrobe.edu.au).
Group Leaders:
Prof Garrie Arumugam (Vascular Dementia); Dr Alex Pinto (Cardiac Cellular Systems);
Dr Antony Vinh (Immunity and Hypertension);
Dr Helena Kim (Stroke and Brain Inflammation); Dr Maria Jelinic (Obesity and Diabetes);
Dr Michael De Silva (Cerebrovascular Disease).
Strategic Partners:
Australian Cardiovascular Alliance
Baker Heart and Diabetes Institute
Beluga Foundation.

# Research Groups

# Atherothrombosis and Vascular Biology Lab

The Atherothrombosis and Vascular Biology laboratory pursues a broad range of projects that have the common focus on improving diagnosis and therapy of thrombotic and inflammatory diseases such as myocardial infarction and atherosclerosis. A range of biotechnological methods are used, including recombinant protein design/production, generation of functionalised nano-particles/lipsomes/ microbubbles, cell culture, flow cytometry, flow chamber, microfluidics, intravital microscopy, ultrasound, MRI, PET various fluorescence imaging systems and various animal models of thrombosis, atherosclerosis and inflammation.

We have extended our research beyond cardiovascular applications, based on the successful application of our biotechnological tools for the targeting of activated platelets towards diagnosis and therapy of autoimmune diseases, such as multiple sclerosis, and cancer.

Most recently we are using our bio¬techno-logical expertise to develop mRNA therapies.

All of these projects have a strong translational orientation, which is facilitated by several laboratory members (physicians/ cardiologists/haematologists) treating patients with cardiovascular and haematological diseases as well as cancer. Several of the research projects resulted in patents that are currently being further translated to ultimately improve the health of patients.

Work in the laboratory is particularly attractive for students and postdoctoral researchers who are interested in the development of advanced biotechnological tools for molecular imaging and novel therapeutics (e.g., nanoparticles and anti-inflammatory drugs for plaque stabilisation). The translational direction of the laboratory and the inclusion of patients in studies is highly attractive for physician scientists.

Research focus

- Molecular imaging of thrombosis and inflammation using MRI, PET, ultrasound, FLECT, IVIS.
- Novel recombinant therapeutics for thrombotic and inflammatory diseases.
- Microfluidic flow chambers.
- Intravital microscopy.
- Flow cytometry.
- Animal models of thrombosis and inflammation.
- Production of recombinant proteins for diagnosis and therapy.
- Diagnosis and treatment of patients with coronary artery disease and myocardial infarction.
- Development of mRNA therapeutics

Lab Head: Professor Karlheinz Peter (k.peter@latrobe.edu.au)

Lab members:
Dr Sara Baratchi, Ms Viktoria Rose Bongcaron, Dr Yung-Chih (Ben) Chen, Dr Lisa M Domke, Ms Angela Huang, Dr Smriti Krishna, A/Prof James McFadyen, Dr Mitchell Moon, Dr Jonathan Noonan, Ms Prerna Sharma, Dr Anna Watson, Dr Johannes Zeller, Ms Julia Skoraczynski, Dr Nalin Dayawansa, Ms Shengyuan Liu, Ms Shania Anggita Prijaya, Dr Hanna Stevens, Dr Wen-Kai Wong, Mr Aidan Walsh, Ms Runali Patil, Ms Najma Fithri, Dr Abbey Willcox, Ms Samantha Loong, Ms Huiting Niu, Mr Thomas Montibeller, Ms Habiba Danish.

Fields of Study:
Cardiovascular Diseases, Atherothrombosis, cellular mechanisms of coronary artery disease and its consequences, myocardial infarction.

Capabilities and Techniques:
Ultrasound, MRI, PET, MicroCT, fluorescence and photoacoustic imaging; Generation of antibody-drug fusion constructs; mRNA; Cardiovascular murine models.

Translational Opportunities:
Early detection and prevention of CVDs; Targeted drug delivery; Gene therapy. We work closely with biotech companies to translate our research into clinical settings.

# Cardiac Cellular Systems Lab

Heart failure is a leading cause of mortality worldwide.

Resulting from a wide range of aetiologies, heart failure is characterised by deleterious cardiac remodelling and decline in heart function, ultimately leading to organ failure and death.

Currently there are no effective treatments for heart failure, and fundamental questions remain unanswered regarding the ways in which cardiac remodelling occurs and how it may be reversed.

Until recently the cellular composition of the heart was poorly defined.

Using advanced genetic, flow cytometric and single cell transcriptomic approaches, our lab has shed new light on the cellular constituents of the heart by demonstrating that the heart is comprised of a complex and diverse ecosystem of non-myocytes.

Based on these discoveries, new avenues of cardiovascular research involving the targeting and manipulation of specific cell types and networks are now possible.

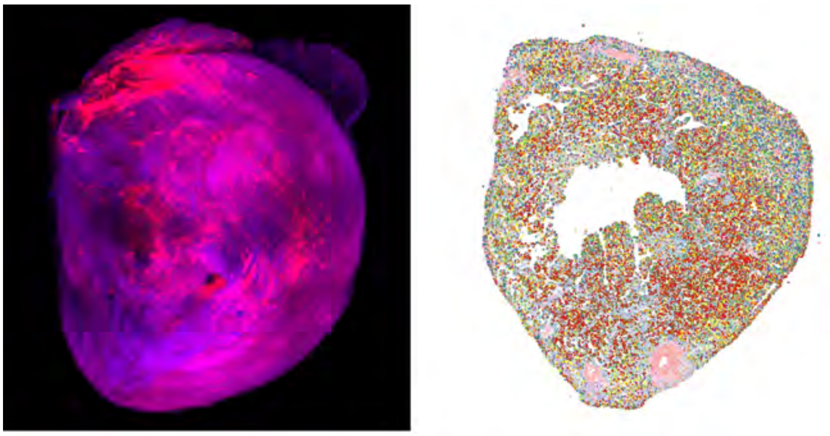
Today, very little is known about how the ecosystem of non-myocytes in the heart operate as a cell network.

Combining advanced single-cell omics, imaging and mouse genetics, our lab aims to study the complex ecosystem of cells that form the heart, to identify novel drivers of cardiac ageing and disease.

### Overarching goals

1. Use single-cell genomics, high-resolution imaging and mouse genetics to map drivers of cardiac pathology.

2. Develop new drugs—nanoparticles and small molecules—to treat cardiac pathology and/or regenerate the heart.



(Left) 3D light-sheet microscopy image of the mouse heart after a heart attack. Red colour indicates nanoparticle-targetted cells. (Right) spatial transcriptomic image of the heart, profiling transcripts corresponding to ~30,000 genes.

### Key areas of ongoing research

1. Determine how cardiovascular stressors such as obesity, hypertension and myocardial infarction impact cardiac cell networks

2. Determine how novel environmental hazards—such as micro- and nano-plastics—impact cardiac cell networks and broader cardiovascular physiology.

3. Development of new drugs to prevent development of cardiac fibrosis.

4. Development of new nanoparticles to target cardiac cells.

5. Development of new drugs and methods to regenerate the heart after myocardial infarction.

6. Determine sex-differences in cardiac development, homeostasis and disease.

7. Development of unique genetic, computational biology, and imaging approaches to precisely study diverse cell populations in of the heart.


### Lab Head:

Associate Professor Alex Pinto
(a.pinto@latrobe.edu.au)
(alex.pinto@baker.edu.au)


### Lab members:

Dr Patrick Lelliott, Dr Rebecca Harper, Dr Malathi Dona, Ms Gabriella Farrugia, Mr Crisdion Krstevski, Mr Thomas Harrison, Mr Ian Hsu.

### Fields of Study:

Cardiac Cell networks; cardiology; heart disease; computational biology; nanochemistry.

### Capabilities and Techniques:

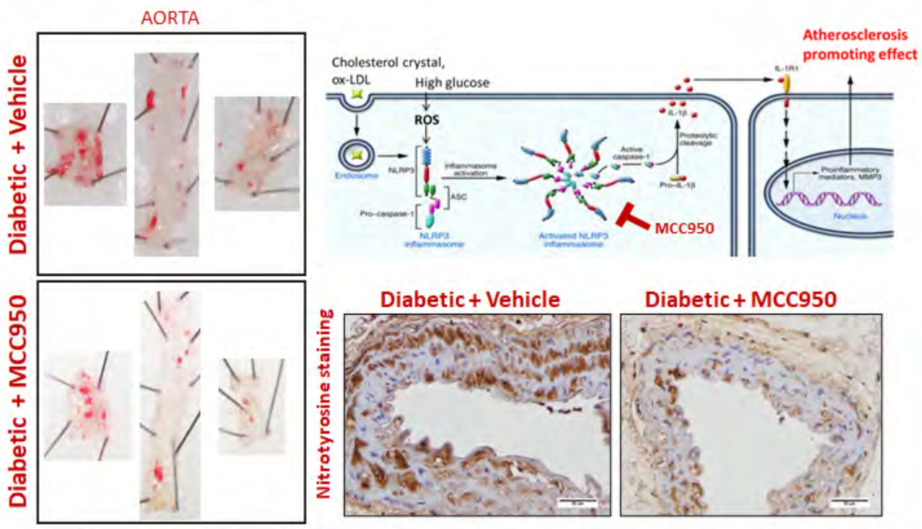
1. Single cell biology — including single-cell RNA sequencing, high-dimensional flow cytometry and image cytometry.
2. Multidimensional imaging — including 3D imaging and spatial mapping of cellular interactions.
3. Mouse genetics — including development of novel cell- and organ-specific genetic tools.
4. Nanochemistry and cellular targeting.

### Translational Opportunities:

Development of new approaches to target molecular and cellular drivers of cardiac pathology. These include pharmacological, gene therapy and cellular approaches to address cardiac fibrosis, vascular dysfunction and inflammation.

# Cardiovascular Inflammation and Redox Biology Lab

Our Laboratory investigates the pathways that drive cardiovascular complications of diabetes. Patients with diabetes are 2-4 times more likely than non-diabetics to experience a heart attack or a stroke, have high blood pressure, and present with vascular disease such as atherosclerosis. Patients with diabetes are also more likely to require balloon-angioplasty and stenting (BAS) to open blocked arteries (restenosis). Diabetes, via disruptions of major metabolic and immunological pathways, results in robust oxidative and inflammatory responses. Despite positive outcomes in preclinical settings, vitamins have not been efficacious in the clinic. Our novel approaches bolster the body's natural antioxidant defenses via compounds that regulate a transcription factor Nrf2, the master regulator of antioxidant and anti-inflammatory responses. We also target the NLRP3-inflammasome, a key cytokine-producing platform as well as downstream of the infammasome at the level of the GasderminD pore. Results from our preclinical mouse models are yielding promising reductions in micro- and macrovascular complications.




Sharma A...de Haan J.B. Specific NLRP3 inhibition protects against diabetes-associated atherosclerosis. ***Diabetes,*** 70:772-787, 2021.

### Nrf2 activators

Our Lab has a strong track record of studying the activators of Nrf2 as a therapeutic strategy to lessen not only oxidative stress, but to additionally dampen diabetes-driven inflammation. Together with our industry partner Reata Pharmaceuticals, and using their tool compound dh404, we have shown significant reductions in diabetes-associated atherosclerosis. This is via reductions in oxidative stress and a direct effect on the NLRP3 inflammasome. Further mechanistic understanding is required to fully validate this new approach to control diabetes-mediated atherosclerosis. Further, how these drugs control restenosis is an ongoing investigation in our laboratory.

### NLRP3 inhibitors

We have investigated a small molecule inhibitor of the NLRP3-inflammasome (MCC950) and its ability to improve diabetic macrovascular complications such as diabetes-associated atherosclerosis. Our extensive programs now allow us to investigate its use in improving other diabetic complications including endothelial dysfunction, restenosis, and post myocardial infarction.

### GasderminD pore

Targeting the key cellular regulator of pyroptosis is a novel approach to limiting the damage that results in diabetic micro- and macrovascular complications. Our results with a known GasderminD inhibitor are showing promising results in bone marrow derived macrophages. We now have a range of untested and prioritized potential inhibitors ready for further testing, designed using the Baker Institute Computational Biology platform. This project will generate new drugs for the treatment of diabetic cardiovascular diseases.

**Lab Head:** Professor Judy de Haan (j.dehaan@latrobe.edu.au)

**Lab members:**
Dr Arpeeta Sharma;
Judy Choi (PhD student);
Nada Stefanovic (Senior Research assistant).

**Fields of Study:**
Diabetes; Atherosclerosis; Stent Biology; Oxidative Stress; Inflammation.

**Capabilities and Techniques:**
Cell culture of mouse and human endothelial, smooth muscle and bone-marrow derived macrophages; Robust animal models of diabetes and atherosclerosis; qRT-PCR; Western blotting; ELISA; histology; immunohistochemistry; immunofluorescence; stent surgeries

**Translational Opportunities:**
New drug discovery based on in-depth understanding of the oxidative and inflammatory mechanisms under-pinning diabetic complications.

# Clinical Diabetes and Epidemiology Lab

The Clinical Diabetes and Epidemiology group has two main focuses. The first is the epidemiology of type 2 diabetes, examining trends in prevalence and incidence of diabetes (predominantly type 2) in Australia and the rest of the world. The work in this area, pioneered by Prof Paul Zimmet, has been instrumental in demonstrating the rapid growth of the emerging global diabetes epidemic. The surveys undertaken for this work also provide rich data for interrogating a range of putative and novel risk factors for diabetes and its complications, of which lifestyle factors have been studied extensively and remain an important target. The second focus capitalises on the large patient population in our Diabetes Clinic. This facilitates examination of novel treatments, and of observational data on real world responses to therapies.

### Diabetes complications cohort study

A cohort study, called PREDICT, focusing on the development of diabetes complications is currently recruiting participants. It will recruit 2000–3000 people with type 2 diabetes, and aims to better understand the causes of the complications of diabetes. This study will examine not only the classic complications of eye, kidney, nerve and cardiovascular disease, but will also examine emerging complications, such as cognitive decline and frailty. Central to the study is the establishment of a biobank of samples that can be interrogated for a variety of novel candidate causes of the complications of diabetes. A sister study, PREDICTION, is currently being initiated. This will focus on the rapidly-developing epidemic of type 2 diabetes in younger adults. Younger-onset type 2 diabetes has been associated with poorer outcomes than diabetes with the more usual onset in middle-age. Like PREDICT, it will be a population-based cohort, and will examine the complications of diabetes. It will also include a cohort of people with adult-onset type 1 diabetes, which is another sub-group in diabetes about which knowledge is very limited.

### Data linkage studies

For the last ten years, we have undertaken large data linkage projects. The NDSS is a register of approximately 80-90% of all people with diabetes in Australia. Although limited data are held in the NDSS, linking it to Medicare prescription databases, the National Death Index, the dialysis and kidney transplant registry and to hospital admission datasets provides a powerful tool for examining the population-level impact of diabetes and its complications. We examine the burden of diabetes complications, trends in diabetes and its complications, disease costs, and the impact of socio-economic status on diabetes and its complications.

### Global diabetes registry analyses

We established and lead the GLOBODIAB collaboration, which brings together national and sub-national diabetes registries from over 20 countries around the world. This powerful set of data, with information on tens of millions of people with diabetes allows comparisons between countries for important aspects of diabetes epidemiology, such as the trends in in the incidence of and mortality in diabetes, the distribution of causes of death, and the risks of developing important complications.

### Australian Diabetes Obesity and Lifestyle Study (AusDiab)

The Australian Diabetes, Obesity and Lifestyle Study (AusDiab) is the largest Australian longitudinal population-based study examining the natural history of diabetes, pre-diabetes (in which glucose metabolism is impaired but not to the level to cause diabetes), heart disease and kidney disease. The 1999/2000 AusDiab study was the first national diabetes prevalence study to be conducted in Australia, and included 11,247 adults from 42 different locations across Australia. The participants were followed up in 2004/2005 and again in 2011/12 to provide the first ever information about the incidence (or development) of diabetes and other non-communicable diseases in Australia over time.

**Lab Head:** Professor Jonathan Shaw, (j.shaw2@latrobe.edu.au), Professor Dianna Magliano (d.magliano@latrobe.edu.au).

**Lab members:** Dr Julian Sacre, Dr Lei Chen, Dr Elizabeth Barr, Dr Anne Reutens; Ms Maria Lawton; Ms Robyn Veljanovski; Mrs Elena Vulikh; Ms Alexandra Eckert; Mr Nicholas Johnson.

**Fields of Study:**
Trends in diabetes prevalence and incidence; type 2 diabetes and its complications at a population level; risk factors for diabetes complications.

**Capabilities and Techniques:** Establishment of population-based cohort studies; data linkage; advanced epidemiological analyses; access to large whole-of-population datasets.

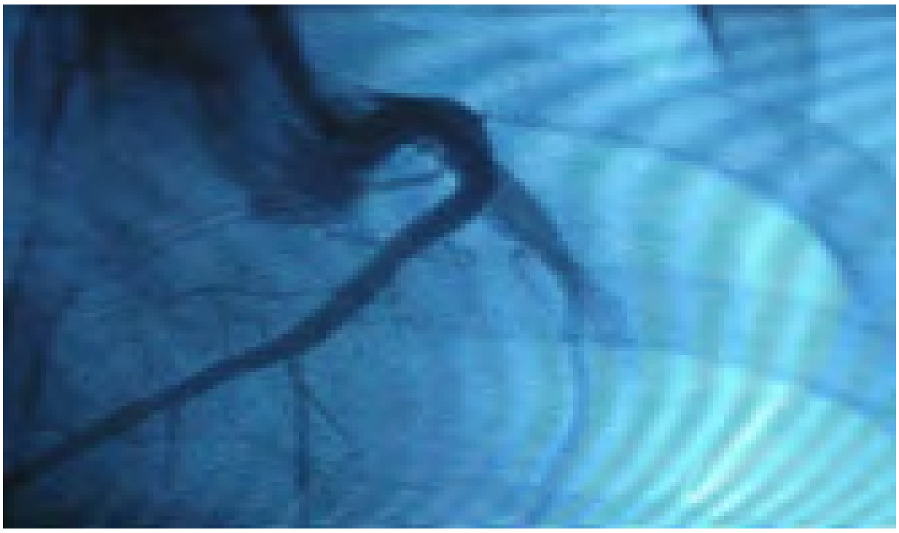
**Translational Opportunities:**
Data from our studies are translated into healthcare planning by providing robust estimates of disease burden.

# Haematopoiesis and Leukocyte Biology Lab

The Haematopoiesis and Leukocyte Biology laboratory focuses on understanding the pathways contributing to enhanced leukocyte production and altered function in the context of (but not limited to) cardiovascular and metabolic diseases. Diets high in calories, saturated fat, and cholesterol combined with a sedentary lifestyle lead to a high prevalence of atherosclerotic cardiovascular disease (CVD). High-circulating blood lipids, including elevated low-density lipoproteins (LDL) and triglyceride-rich lipoproteins, result in increased entry and retention of these particles in the arterial wall, leading to a macrophage-dominated chronic inflammatory process and eventuating in atherosclerotic plaque rupture or erosion, myocardial infarction, or thrombotic stroke. While elevated plasma cholesterol levels have an essential role in atherogenesis, comorbidities such as smoking, hypertension, and diabetes accelerate atherosclerotic CVD.

In addition, chronic kidney disease, recurrent infections, myeloproliferative neoplasms, and autoimmune disease such as rheumatoid arthritis and systemic lupus erythematous also greatly increase the risk of athero- thrombosis. A common theme linking these diseases to athero- thrombosis is an overactive immune system, mediated in part by increased production and activation of innate immune cells. We seek to understand these changes in the immune system from the level of the long-lived haematopoietic stem cells through to the mature effector cells such as monocytes and macrophages.

We study fundamental biological process contributing to the retention and liberation of haematopoietic stem cells (HSCs) within specific bone marrow (BM) niches and how these HSCs and the BM niche become altered in disease. We are interested in how these HSCs traffic to the spleen and initiate extramedullary haematopoiesis. We focus on how inflammatory diseases associated with increased cardiovascular risk influence these pathways, including diabetes, obesity and autoimmune diseases such as rheumatoid arthritis. We explore how these diseases influence the function of circulating cells, (monocytes, neutrophils and platelets). We study the role of plaque macrophages and pathways contributing to foam cell formation. We are also exploring two main outcomes of vascular disease, myocardial infarction and stroke and how these diseases influence the haematopoietic system to promote enhanced myelopoiesis, which is associated with a worse outcome. We focus on exploring the utility or current treatments and developing novel therapies to target the pathways we have identified in our preclinical models that are also detect in patients with these diseases.



Using contrast dye to evaluate coronary blood flow (Photo credit: Colleen Thomas)

Research focus

Fundamental process regulating haematopoiesis.
Exploring how the lipidomes of immune cells regulates their function.
Understand multi-organ communication to stimulate haematopoiesis.
Determining how the body responds to hyperglycaemic spikes.
Exploring if and how inflammatory diseases associated with increased cardiovascular risk impair the regression of atherosclerotic lesions.
Understanding how enhanced reticulated platelets influence accelerated atherosclerosis in diabetes.
Exploring the role of human monocyte subsets in cardiovascular disease.
Investigating pathways contributing to foam cell formation in the atherosclerotic lesion.

Lab Head: Professor Andrew Murphy (a.murphy2@latrobe.edu.au).

Lab members:
Dr Dragana Dragoljievic;
Dr Andrew Fleetwood;
Dr Graeme Lancaster;
Dr Sam Lee;
Dr Pooranee Morgan;
Ms Camilla Bertuzzo Veiga;
Mr Patrick Bell;
Mr Tom Collins;
Mr Simon (Yangsong) Xu;
Ms Zoe (Yiyu) Zhang.

Fields of Study:
Cardiovascular Diseases; Inflammatory chronic metabolic disease; Haematology; diet/dietary lipids; immunometabolism.

Capabilities and Techniques:
Cell Culture; Molecular Biology; Animal Models; Biotechnology; Stem cell and mature effector cell research techniques.

Translational Opportunities:
Inflammatory disease therapies; Atherosclerotic lesion therapies for diabetes and other diseases.

# Inflammation and Cardiovascular Disease Lab

The Inflammation and Cardiovascular Diseases laboratory uses a multi-disciplinary approach to understand how the immune system and inflammation modulate the pathogenesis of cardiovascular diseases.

Inflammation is a protective response triggered by damage to living cells.

This response localises and eliminates the injurious agents, while also removing damaged tissue components so that the body can heal and maintain homeostasis. In cardiovascular diseases, the injury may be caused by internal factors (e.g. myocardial infarction (MI) rather than external factors such as bacteria or viruses).

The immune system is largely responsible for initiating inflammation and untreated acute (subclinical) inflammation leads to chronic inflammation that eventually causes cell damage (e.g arteries).

Our areas of focus are vascular inflammation (atherosclerosis) and cardiac inflammation (cardiomyopathy).

We will decipher how both adaptive and innate systems contribute to inflammation in cardiovascular diseases in animal models.

We aim to translate these findings into practice in both diagnostics for early detection and therapeutics for effective intervention to prevent premature plaque ruptures.

Associate Professor Tin Kyaw

**Current research projects:**
Better understanding and preventing recurrent myocardial infarctions.

CD4+ regulatory T cells and preventing/ reversing the development of vulnerable atherosclerotic plaques associated with unstable angina and MI/stroke.

Understanding how gamma-delta T cells contribute to vulnerable plaque development.

Myocardial inflammation associated with myocardial infarction.

Diffuse interstitial cardiac fibrosis.

**Lab Head:** Associate Professor Tin Kyaw (t.kyaw@latrobe.edu.au)

**Lab members:**
Dr Kurt Brassington;
Mr Peter Kanellakis;
Ms Yi Ee Lye.

**Fields of Study:**
Immune system, inflammatory disease, cardiovascular diseases, stroke.

**Capabilities and Techniques:**
Cell Culture; Molecular Biology; Animal Models; Biotechnology; cell research techniques.

**Translational Opportunities:**
Diagnostics for early detection and therapeutics for effective intervention to prevent premature cardiovascular plaque ruptures.

# Imaging Research Lab

The Imaging Lab is led by Professor Tom Marwick, who is involved in clinical research and research training. As a cardiologist, he has a focus on health outcomes and holds particular expertise in cardiac imaging in heart failure and coronary disease, and the detection of early stages of cardiac dysfunction.

He was one of the initiators of stress echocardiography, and has made contributions to the prognostic evidence underlying cardiovascular imaging. His research interests relate to the detection of early cardiovascular disease and cost-effective application of cardiac imaging techniques for treatment selection and monitoring.

The Imaging Research laboratory is dedicated to developing pathways for better integration of imaging with clinical management — including quality and appropriate use and cost-effectiveness of imaging, risk evaluation and intervention based on detection of early stage cardiovascular disease, heart failure with preserved ejection fraction, and new cardiovascular imaging modalities.

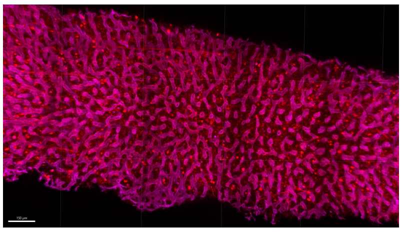
The research focus of the Imaging Lab is

- Risk evaluation and intervention based on detection of early stage cardiovascular disease.
- Heart failure with preserved ejection infarction.
- Quality, appropriate use and cost-effectiveness of imaging.
- New cardiovascular imaging modalities.

In conjunction with research work the lab is heavily focused on these clinical research studies:

CAUGHT-CAD
A multi-centre Australian randomised trial of coronary calcium for risk evaluation and prevention in patients with a family history of coronary artery disease.

Heart failure readmission
This study is based on the ability of echocardiography to assess haemodynamics and myocardial function, we aim to reduce heart failure admissions and costs



SUCCOUR
We aim to show that cardiac imaging surveillance leads to the use of adjunctive cardioprotective therapy that will limit development of reduced ejection fraction at one-year post chemotherapy (primary outcome), and interruptions to planned chemotherapy and the development of heart failure in follow-up (secondary outcomes).

TAS-ELF and VIC-ELF
This study is on Early LV Dysfunction and atrial fibrillation in Tasmania and Victoria. These are an observational dataset (TasELF) and an RCT (VicELF) that seek to provide early diagnosis and treatment to prevent the progression of asymptomatic to symptomatic heart failure.

AGILE
This study is on the use of Artificial Intelligence-Guided Echocardiography to Guide Cardiovascular Management in Rural and Remote Australia.

ARISE-HF study
This study looks at the complications diabetes can cause, including heart damage. It is a multi-centre, randomised placebo-controlled study to evaluate the safety and efficacy of an investigational drug in patients with diabetic cardiomyopathy/Stage B heart failure.

AMEND-CRT trial
This trial aims to improve selection of heart failure patients for this expensive and potentially harmful intervention of Cardiac Resynchronization Therapy (CRT), which is used as a treatment option in addition to standard medical therapy for patients with reduced left ventricular function and a clear conduction delay.

ED-CAD
This study is on the Early detection of coronary artery disease by polygenic and metabolic risk scoring (EDCAD-PMS) aims to identify whether a polygeneic risk score (PRS) can predict the presence of coronary calcium in the arteries, which occurs when plaque is present. We also want to find out whether knowing your PRS or knowing the results of your CT angiogram (a scan of your coronary arteries) is more effective at reducing cardiovascular risk/

PERCEIVE
This study aims to understand whether COVID-19 causes damage to the heart and impacts functional capacity. We also want to know if best practice management (e.g. heart medication or exercise training) can restore function/

RISK-HELP
Risk-guided strategy for reducing readmission for Acute Decompensated Heart Failure (Risk-HELP). We aim to identify whether a targeted management plan focusing on control of the body's fluid volume, phone and personal follow-up, home surveillance through a Heart Failure app on your smart phone and home treatment can reduce repeat hospital admission in heart failure patients.

Lab Head
Prof Tom Marwick (tom.marwick@baker.edu.au).

Lab members:
A/Prof Costan Magnussen, A/Prof Nitesh Nerlekar, Dr Quan Huynh, Dr Mark Nolan, Dr Yusuke Sata, Ms Ashleigh-Georgia Sherriff, Mr Atro Azad, Mr Joel Smith, Ms Kristyn Whitmore, Ms Liz Dewar, Ms Leah Wright.

Fields of Study:
Cardiovascular Disease

Capabilities and Techniques:
Cardiac Imaging

Translational Opportunities:
Detection of early cardiovascular disease and cost-effective application of cardiac imaging techniques for treatment selection and monitoring.

# Metabolomics Lab

Our laboratory applies state of the art lipidomic capabilities to characterise the relationship between lipid metabolism and cardiometabolic disease. Clinical translation of our research will deliver new diagnostic/ risk assessment/monitoring tests and therapeutic interventions for chronic disease. Dysregulation of lipid metabolism underpins multiple diseases including obesity, type 2 diabetes, cardiovascular disease and age-related dementia. We have utilised tandem mass spectrometry to develop the only high throughput lipidomic platform in Australia and have performed some of the largest clinical and population lipidomic studies yet reported.

These have enabled the characterisation of metabolic pathways and identified lipidomic biomarker profiles that are able to better predict disease risk and therapeutic efficacy. Modulation of the same pathways now holds potential as an interventional strategy to prevent, attenuate or treat the major chronic diseases. Our areas of focus are:

- Population metabolism and biomarker discovery
- Lipidomic/Genomic integration to identify causal pathways to metabolic disease
- Preclinical/mechanistic studies in metabolic therapy
- Translational metabolomics — new therapies for metabolic disease
- Development of lipidomic and metabolomic capabilities in Australia

Our research program aims to characterise the environmental and genetic influences on metabolism and provide the fundamental understanding to select the optimal biomarkers for risk assessment and monitoring of therapy and to assist in the development of policy in order to maintain metabolic health in an aging population. Our developing translational pipeline through academic and commercial partners will enable us to realise the clinical translation of these new biomarkers.

### Genetic determinants of lipidomic variation and their role in CVD risk

There is emerging evidence that rare genetic variation is a likely contributor to heritable risk of cardiovascular disease (CVD,) which is the leading cause of death in the world. We utilise large empirically defined Busselton Health Study family lineages to identify rare causal variants for CVD. We hypothesise that genetic analysis of the plasma lipidome in large families enriched for CVD events, with a focus on identifying rare mutations, will identify novel CVD risk factors of large effect. These risk factors will have clinical utility in the diagnosis and prediction of CVD.

### Identifying lipid and genetic signatures of metabolic disease in early childhood

The antenatal period and early childhood offer a critical window of high plasticity and potential for early intervention to prevent the onset of adverse health trajectories. We hypothesise that plasma lipidomic profiles, combined with genomic profiles, will facilitate the identification of those individuals on adverse health trajectories and provide mechanistic insight to guide preventative interventions. Utilising two unique birth cohorts from Singapore and Australia, we aim to identify early childhood markers of metabolic disease which may herald future risk for development of type 2 diabetes and cardiovascular disease. We also aim to elucidate novel molecular mechanisms with the potential to underpin new therapeutic approaches for the prevention and management of metabolic diseases.

### Lipidomic analysis of Alzheimer's disease; biology, risk assessment & early diagnosis

There is currently no cure for Alzheimer's Disease (AD) and treatment options are limited. A key factor in the development and implementation of AD therapies will be the early identification of those affected or of likely to become affected by AD. Studies have identified lipids as putative biomarkers of AD risk. Our research aims to understand the complex relationships between lipid metabolism and dementia to provide new therapeutic targets for early intervention to halt the onset and progression of AD.


**Lab Head:** Professor Peter Meikle (p.meikle@latrobe.edu.au)

**Lab members:** Dr Anjali Bhagwat; Dr Habtamu B Beyene; Dr Satvika Burugupalli; Dr Aleksandar Dakic; Dr Alexandra George; Dr Corey Giles; Dr Kevin Huynh; Dr Thomas Meikle; Dr Sudip Paul; Dr Tingting Wang; Dr Jingqin Wu; Dr Joe Yi.


**Fields of Study:**
Metabolomics; Cardiometabolic disease; Lipid metabolism; Biomarkers.

**Capabilities and Techniques:**
Defining new lipidomic biomarker profiles for chronic disease; identifying genes controlling lipid homeostasis; mapping lipid metabolic pathways involved in chronic disease; identifying regulatory mechanisms (therapeutic targets) . Tandem Mass spectrometry; study design; Lipid extraction; Liquid chromatography mass spectrometry; Data extraction and analysis.

**Translational Opportunities:**
Clinical translation and commercialisation of lipidomic biomarkers as well as nutraceutical and therapeutic products.

# Molecular Imaging and Theranostics Group

Our Group focus is on providing better diagnostic imaging, side-effect free targeted drug/mRNA delivery and theranostic (concurrent therapy and diagnostics) approaches for a range of cardiovascular diseases. The team's research involves:

1) Advanced functional and molecular imaging of cardiovascular diseases using ultrasound, MRI, PET, MicroCT, fluorescence and photoacoustic imaging.
2) Biotechnology for genetic design and engineering of recombinant proteins, as well as antibody-drug fusion therapeutics for cardiovascular diseases.
3) Biomaterials selection, design, functionalisation and generation of innovative nano-/micro-particles for drug/mRNA delivery.
4) Novel conjugations of antibody-particles using biological and/or chemical coupling.

Work in this laboratory is particularly suitable/would be ideal for students and postdoctoral researchers who are interested in the development of advanced biotechnological tools for molecular imaging and novel therapeutics (e.g. nanoparticles). The translational direction of the laboratory and the inclusion of patients in studies is highly attractive for physician-scientists.

### Molecular Imaging

Clinical imaging technologies mainly provide an anatomical readout of the structural changes for diagnosis, usually after irreversible damage has occurred. Our research aims to advance a range of innovative preclinical imaging modalities for more sensitive functional readouts. The technologies employed include ultrasound, MRI, PET, MicroCT, fluorescence and photoacoustic imaging. Novel molecular imaging incorporates a range of techniques (biology, biotechnology, chemistry and physics) to achieve a more comprehensive diagnosis and enable early detection of cardiovascular diseases.

### Targeted drug/RNA delivery

Clot-busting drugs have frequently been associated with side effects of potentially life-threatening bleeding complications, thereby limiting their wider clinical use. Our research focuses on the development of recombinant antibody-drug fusion constructs for targeted drug delivery. This approach directs therapy to the desired site of action, allowing for lower concentrations of effective systemic drugs to be used, thus eliminating the risk of side effects. Therefore, our targeted drug delivery approach has the potential to create a paradigm shift for side-effect free prophylactic and therapeutic use across a variety of CVDs. We also use mRNA therapeutics to stop the progression of chronic inflammation to prevent devastating CVD events from occurring.

### Theranostics

Innovative theranostic strategy involves concurrent diagnosis and therapy. The use of targeted nano-/micro-particles gives us the flexibility to increase the therapeutic payload of drugs, including gene therapy. In our research projects, we design and develop biocompatible particles with improved contrast properties and enhanced loading of therapeutic agents.

**Lab Head:** Professor Xiaowei Wang (xiaowei.wang@baker.edu.au).

**Lab members:**
Dr Jonathon Noonan, Dr Mark Vidallon, Dr Ahmed Refaat, Dr Hung Nguyen, Dr Cuong Phan, Dr Aidan Walsh, Dr Umeka Nayanathara, Haikin Liu, Naomi Philosof, Yuyang Song, Shania Prijaya, Pengkai Shi, Anne Nguyen, Benedict Nathaniel.

**Fields of Study:**
Cardiovascular Diseases, Imaging, Targeted Drug/mRNA, Nanobiotechnology.

**Capabilities and Techniques:**
Ultrasound, MRI, PET, MicroCT, fluorescence and photoacoustic imaging; Generation of antibody-drug fusion constructs; Design and create nanoparticles and mRNA; Cardiovascular murine models.

**Translational Opportunities:**
Early detection and prevention of CVDs; Targeted drug delivery; Gene/mRNA therapy; Theranostics. We work closely with biotech companies to translate our research into clinical settings.

# Molecular Proteomics Group

Our laboratory studies the molecular function of nano-sized biological extracellular vesicles (EVs) to deliver, reprogram and engineer strategies for cell/tissue repair and regeneration. Our advanced nano approaches have identified novel signaling regulators. We utilize advanced quantitative mass spectrometry to study proteome regulation to unravel mechanistic insights, including how EVs mediate their function. Our research has led to important developments in delivery-based therapeutic applications for fatty liver disease, cardiac protection/repair, adopted internationally for clinical trials, multiple international patents, and industry engagement (CSL, Tithon Biotech, VivaZome, Prescient Therapeutics). We also study EV composition and function, EV surface/targeting capacity, and EV utility to design new deliverable therapeutics and nanoparticles for cell-free therapies.

### Mechanisms of cell reprogramming by EVs

EVs intercellular communication influences most cell physiology processes. EV intercellular signaling enables complex instructions (transmitted via bioactive cargo) to be sent to specific recipient cells. However, due to their intricate molecular complexity, quantitative knowledge on their signaling mechanisms is missing, this impedes their biological interpretation and therapeutic application. We focus on studying EV-mediated cell signaling (phosphorylation) mechanisms and how these impact cell reprogramming and function of specific cells and multi-cellular organoid models of cardiac disease.

### Surfaceome and targeted delivery of EVs

The EV surface proteome (surfaceome) is a fundamental signaling gateway that links intra- and extracellular signaling networks and enables EVs to communicate and interact with their environment. We found EV-mediated reprogramming of target cells alter their cellular landscape and surfaceome (surface proteome). Functionalization of EV surface proteins is an effective means to design vehicles that could deliver therapeutic drugs and nanocarriers to target sites. We study EVs as systemic regulators and focus on how they target cells and organs. We use EV surface expression/modification as a new way to target and deliver to the heart.

### Defining circulating EV heterogeneity

Molecular dissection of circulating EVs in human plasma is essential for understanding EV function and disease biomarker discovery. We developed a strategy to purify circulating EVs and comprehensive proteomic and lipidomic characterization from clinically relevant plasma volume important for biomarker discovery, dissecting function and standardization of their protein/lipid landscape. We study the heterogeneity of different circulating EV and non-EV subtypes. We aim to investigate circulating EVs in coronary artery disease and identify how circulating EVs and whole plasma profiling can differentiate development of coronary atherosclerosis.

### Cell-derived nanovesicles delivery platform

Red blood cell (RBC) membranes generate EV mimetics (nanovesicles). Their membrane proteome expresses surface proteins (e.g. CD47) that improve biocompatibility and bioavailability. We have found that RBC-derived nanovesicles are important for paracrine signaling in cell-based therapies and can be used as a drug delivery platform. EVs and nanovesicles from stem/progenitor cell-based models are used as standalone therapies for cardiac repair. We use molecular, cell and protein biology methods, as well as models of cardiac disease/damage to find biological pathways for EVs to deliver cardiac protection and repair therapeutics.

### Spatial proteomics and cardiac remodeling

Mass spectrometry-based spatial proteomics has been used in profiling protein spatial dynamics at an organelle level. Proteins subcellular location impacts their biological functions (i.e. growth and proliferation, structural preservation, signal transduction, and cell movement). Systemic analysis of organelle-specific proteome and phosphoproteome changes reveal key insights in organelle composition and disease progression. We use spatial proteomics to study subcellular proteome and phosphoproteome changes in cardiac cell and tissue remodeling. We develop therapeutic strategies, to understand changes in subcellular dynamics that could complement known mechanisms of actions and reveal organelle cross-talk.

**Lab Head:** Assoc Prof David Greening. (d.greening@latrobe.edu.au)
**Lab members:** Dr Alin Rai; Ms Haoyun Alexandra Fang; Mr Jonathon Cross; Ms Bethany Claridge; Ms Auriane Drack; Mr Jonathan Lozano-Salgado; Ms Qi Hui Poh.

**Fields of Study:**
Proteomics; Cell signaling; Extracellular vesicles; Cardiovascular Disease; Cell Biology; Nanovesicles.

**Capabilities and Techniques:**
Mass spectrometry; quantitative proteomics; phosphoproteomics; functional assays; comprehensive plasma profiling (proteomic); informatics; density fractionation; EV characterization (biochemical and biophysical)

**Translational Opportunities:**
Native/biological EVs properties offer stability and aid crossing biological barriers to deliver molecular cargo to cells, acting as intercellular communication to regulate function and phenotype. We have defined the EV surface, signaling and cell reprogramming molecular mechanisms, and led discoveries on EV heterogeneity in blood. Our EV design advances and engineering methodologies facilitate development of therapeutics for cardiovascular diseases. We translate research discoveries in partnership with biotechnology and preclinical companies.

# Non-Communicable Diseases and Implementation Science

Our laboratory aims to make a meaningful difference to the lives of people living with chronic conditions. We also aim to increase the research capacity and expertise in the prevention and management of non-communicable diseases (NCDs) at the national and international level in both high- and low/middle income countries where we work. Our work generates high quality evidence to inform policy and practice and we develop effective evidence-based solutions that improve health outcomes of people with non-communicable diseases. Our international team, leads and collaborates on a variety of multidisciplinary research, evaluation, quality improvement, and science implementation projects. Our community of professionals in NCD prevention and control consists of researchers, healthcare practitioners, policymakers, and members of the public. Our cutting-edge advantage is we work collaboratively across disciplines, countries, settings, seniority levels to implement interventions, programs and policy changes that improve health in Australia and beyond. We are passionate about effective, cost-effective, and equitable health improvement at the population level. We strive to implement evidence-based health solutions across contexts and settings.


### Long-term effects of a structured lifestyle intervention on cardiometabolic risk

The Kerala Diabetes Prevention Program is a cluster-randomized controlled trial of 1007 individuals conducted Kerala state, India. We aim to examine the effects of a lifestyle intervention on blood pressure, blood glucose, obesity, and cholesterol levels using data on sociodemographic characteristics, behavioral/lifestyle factors, medical history, family history of disease, health service utilization, psychosocial variables, anthropometric and biomedical measures. Data were collected at baseline, 12 months (at completion of intervention), and 24 months. Data collection for the 8th year follow-up will be completed in 2022.

### Scaling up structured lifestyle interventions to improve hypertension & diabetes control

In partnership with the governments of Kerala and Tamil Nadu and leveraging India's national NCD program, this NHMRC-GACD funded project's implementation stage is being undertaken by the National Institute of Epidemiology (Tamil Nadu), Sree Chitra Tirunal Institute for Medical Sciences and Technology (Kerala), in collaboration with the Baker Heart and Diabetes Institute. This project aims to find evidence-based research on the scale up of lifestyle modification interventions to control Type 2 diabetes and hypertension.

### Codesigning adaptations to digital healthcare delivery for people with acute coronary syndrome: Smart-CR

This proof-of-concept program involves a large interdisciplinary research team that disseminates findings through seminars and publications. The research program provides urgently needed cost-effective, convenient, accessible, sustainable, and scalable virtual delivery of healthcare service at home. Our unique technology-enabled healthcare delivery platform will provide a digital ecosystem of individually tailored support and healthcare services delivery to people with chronic and complex medical conditions and/or disabilities.

### Implementation research capacity strengthening

Our NCD and Implementation Science laboratory conducts capacity-building programs to strengthen implementation research and includes technical assistance and consultancy. Our resources include:

*Implementation research e-Hub*
With GACD support, we developed an online implementation research science e-Hub focused on chronic and complex NCDs. This online learning space for gaining new knowledge and building on skill development has been instrumental in conducting implementation research training and development;

*Implementation Science School*
Our team co-leads the annual Implementation Science School with GACD. Up to fifty early- and mid-career researchers, practitioners and policy makers attend the school;

*Implementation Research Workshops*
We run workshops and short courses in collaboration with other leading academic and research institutions in low and middle-income countries, including the Institute for Health System Research (Malaysia) and the University of Philippines.

### Connected Health NHMRC Centre of Research Excellence

Prof Oldenburg is the PI/Director of this CRE which aims to develop and implement technology to improve health care delivery and health outcomes for people with long term chronic conditions. Our team participates in this Centre's Career Development Program which involves research and health service collaborators worldwide.

**Lab Head:** Professor Brian Oldenburg (b.oldenburg@latrobe.edu.au)
**Lab members:** Dr Dominika Kwasnicka; Dr Yingting Cao; Dr Tilahun Haregu; Dr Radhika Arunkumar; Dr Lu Yang; Mr Kevin Mao; Mr Nick Kashyap; Mr George Zsis.

**Fields of Study:**
Non-communicable diseases; Chronic disease management: Digital Health; Health Behaviour.

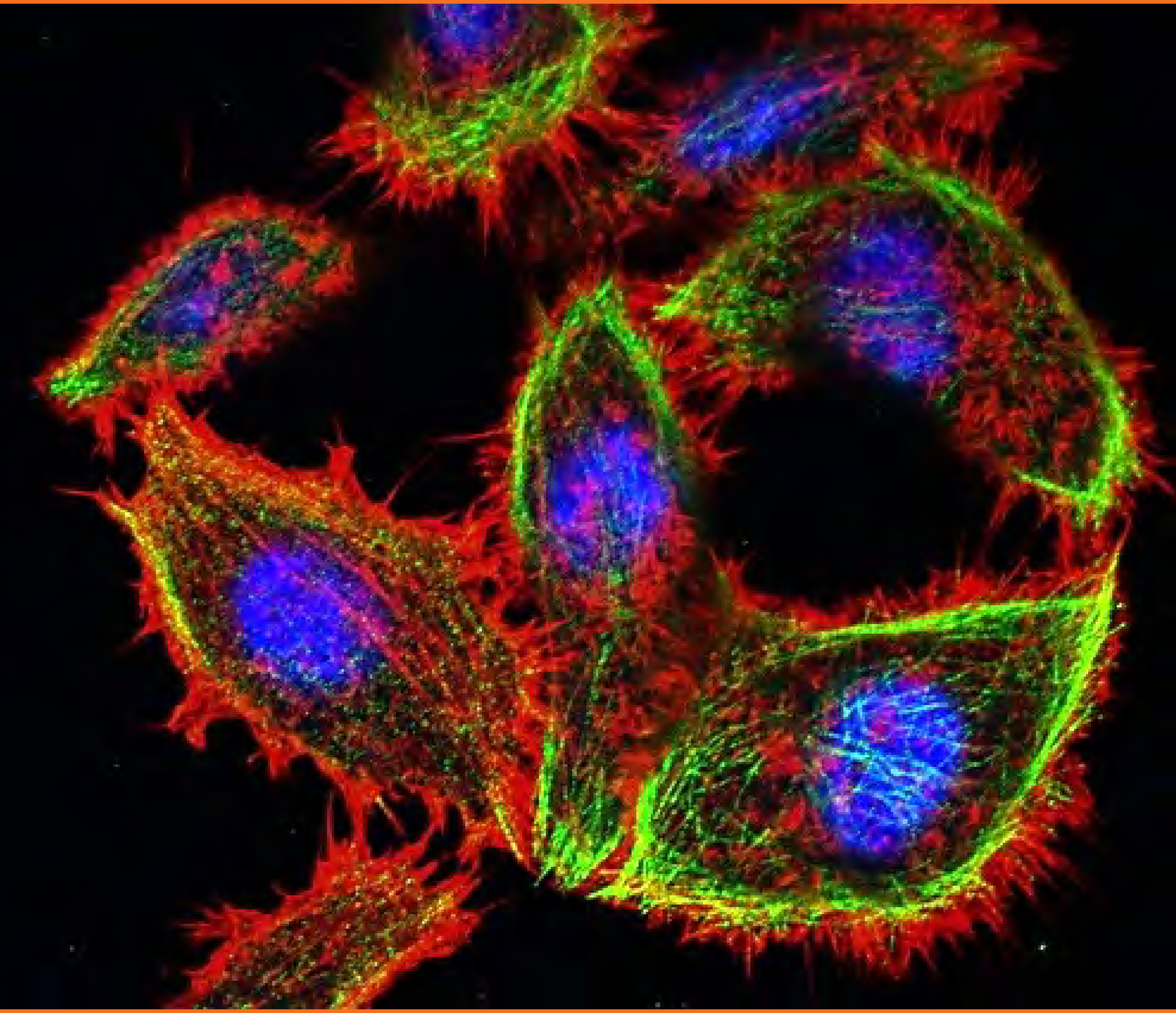
**Capabilities and Techniques:**
Implementation science

**Translational Opportunities:**
Digital chronic disease management.

# Department of Biochemistry and Chemistry

## School of Agriculture, Biomedicine and Environment

*Scientists at the forefront of knowledge in research areas including synthetic, organic, inorganic and analytical chemistry, molecular, cellular and structural biology, fundamental and applied biochemistry in microbes, plants and animals, as well as biomedical applications in human health and disease*



latrobe.edu.au/school-agriculture-biomedicine-and-environment

# BC Contents



Cover Photo: Immunofluorescence microscopy of the cytoskeletal network in human PC3 prostate cancer cells. Photo credit: Guneet Bindra, PhD student Hulett lab

# Department of Biochemistry and Chemistry

The Department of Biochemistry and Chemistry consists of more than 75 continuing and fixed-term academic staff, including six NHMRC Investigators (1x L2, 1x L1, 4 x EL1), two ARC Future Fellows, two ARC DECRA Fellows, one Moderna, one Victorian Cancer Agency Research Fellow, and one National Heart Foundation Fellow.

We teach over 2000 students enrolled across undergraduate and master's subjects. We take great pride in providing a friendly and supportive environment, taking particular care to ensure a positive experience for our students. We oversee La Trobe's courses in undergraduate Biomedicine, Masters in Biochemistry and Biotechnology, and Masters in Biotechnology Management, as well as teach in to La Trobe's undergraduate Science course and offer fully online subjects through Open Universities Australia. A number of our teaching staff have been recognized as Fellows of the UK's Higher Education Academy and have received university and national awards for innovation and excellence in curriculum design and delivery.

Our department trains graduates who are ready to take up a diverse range of job opportunities, with potential careers in research institutes, manufacturing and chemical industries, pharmaceutical and biotech companies, government departments and agencies, as well as pathology laboratories and hospitals.

The Department has a dynamic Higher Degree by Research (HDR) program that reflects the multidisciplinary interests of the staff. We are currently training 80 PhD and Masters students and 20 Honours students from Australia and overseas.

Research carried out in the Department is world leading and focusses on some of today's biggest challenges in biomedicine and biotechnology. Staff and postgraduate students research molecular structure and design, the molecular basis of human health and disease, and have a strong focus on translating our fundamental discoveries into new diagnostics and treatments. Indeed, over the past few decades our department has several embedded biotech companies including Hexima Ltd, Adalta Ltd, VivaZome Therapeutics Ltd, and Immunexus Therapeutics Ltd.

Our breadth of expertise and co-location in the world-class facility of the La Trobe Institute for Molecular Science (LIMS) creates opportunities for new discoveries in molecular science and the important health challenges of cancer, neurodegenerative diseases, infection and immunity, cardiovascular disease, and rare diseases. Through this research, members of the Department are key contributors to La Trobe's new Research Theme Understanding and preventing disease.

The Department's research activities also underpin La Trobe Universities rating of '5-well above world standard' in latest round of Excellence in Research Australian (ERA) in the broad areas of Chemistry and Biology, and in the discipline areas of Analytical Chemistry, Biochemistry and Cell Biology, Medicinal and Biomolecular Chemistry. The department has also contributed to similarly high ratings in are areas of Microbiology and Neuroscience.

The Department's research environment is dynamic and multidisciplinary and includes strong collaborative ties with world-renowned medical research institutes such as The Olivia Newton John Cancer Wellbeing Centre, and The Baker Heart and Diabetes Institute, as well as facilities such as the Australian Synchrotron. We are home to these major research centres:

- Research Centre for Extracellular Vesicles
- Centre Research Biomedical and Environment Sensor Technology (BEST)

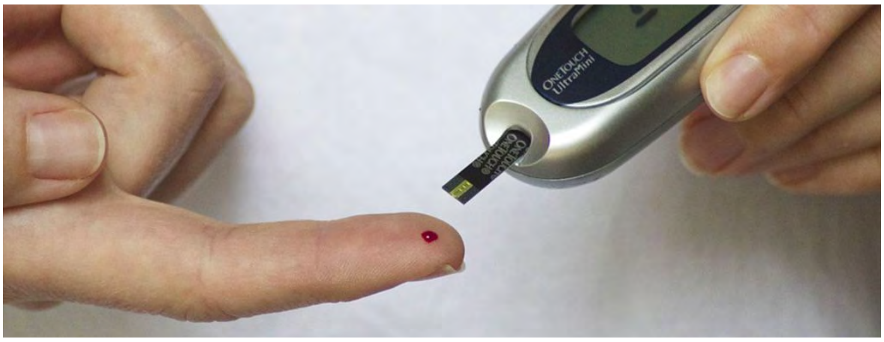
We are also the founding department for LIMS (the La Trobe Institute for Molecular Science).

# Research Centres

- Biomedical and Environment Sensor Technology (BEST) Research Centre
- Research Centre for Extracellular Vesicles

# Biomedical and Environment Sensor Technology (BEST) Research Centre

The Biomedical and Environmental Sensor Technology (BEST) Research Centre holds a goal of improving the quality of life for people within our society. We aim to do this by developing new and better sensor technology. Sensor technology is an important research field. Chemical sensors and biosensors provide essential information about our chemical and biological environment. In doing so, they enable better quality of life through accurate and personalized medical diagnoses, efficient energy use, better industrial processes, safer and more ethical food, and a cleaner environment. Because sensor technology is a very broad topic, we have brought together a range of varied expertise from academia and industry. Through collaboration, we can create better sensors, and improve quality of life. The BEST Centre is focused on developing the next generation of sensor technology. Our research covers a broad range of areas from health and disease diagnosis to sensing for transport and energy networks.




### Nanofabricated molecular imaging devices for disease diagnostics and environmental monitoring

Development of nanostructured microscope slides to detect the presence of diseased or abnormal cells (e.g. cancer or MS) and also to monitor changes in chemical composition at the nanoscale through combination with microfluidics.

### Optical nanoscopy of lipid membranes

Using the newly developed La Trobe near-surface optical microscope we will continue to develop quantitative optical microscopy methods for characterising the composition and topography of cell membranes.

### Fluorescent reporters for sensing and imaging proteostasis dysfunction

Developing novel fluorescent probes to quantify proteostasis, which ensures proper protein folding and function, and prevents accumulation of unfolded and misfolded proteins. Methods to quantify proteostasis capacity and the impact on individual proteins on a global scale in cell are currently lacking. Therefore, we are developing novel fluorescent probes which are being tested by collaborators in the Royal Melbourne Hospital, and the Nationwide Children's Hospital, Ohio, USA.

### Nanoscale phase contrast imaging combined with metal-conjugated antibody detection

X-ray fluorescence measurements conducted at the Australian synchrotron using metal-conjugated antibodies permit molecular tracking with a much larger parameter space than current optical approaches. When combined with ultrasensitive phase contrast mapping (ptychography) this project will deliver a new X-ray based technique for molecular imaging in-situ which simultaneously characterises the tissue microstructure.

### Functional heterobimetallic probes for sensing sugars

Development of new molecular organometallic probes for sensing biologically important carbohydrates and glycalated proteins. This project will result in improved methods for diagnosis and management of diseases associated with these markers such as diabetes and Alzheimer's disease.

### Innovative approaches to sensing based on synthetic biology

The rapid detection of contaminants at low concentrations is essential to prevent the spread of nefarious substances through the environment. Sensitivity and specificity of detection is vital to prevent environmental and economic damage. Synthetic biology provides a systematic approach to rationalising molecular pathways within microbes allowing the programming desired outputs from specific inputs such as heavy metals.

### New miniaturised instruments for point-of-care immunodiagnostic applications

This project epitomizes in many ways the principles of BEST. A collaboration which seeks to translate some of the high impact fundamental science emerging from the chemistry discipline in recent years, by leveraging expertise in the physics discipline in instrument development; and the largely untapped resource comprising the electronics and product design capabilities of the School of Molecular Sciences workshop. Underpinned by solid market research, this project will provide a new platform to showcase next generation diagnostics.

### Mobile phone-based based point-of-care diagnostics

Detection of Sepsis and Malaria biomarkers utilising only a cheap disposable sensor strip and the built-in audio and camera of a mobile phone to carry out sophisticated electrochemical and luminescence-based analyses. More broadly, making inexpensive, quantitative sensors for medical sensing applications to make chemical and biochemical analysis, usually confined to the lab, widely available through similar "instrument free" analysis.

### New Electrochemiluminescence based detection strategies

Develop novel supramolecular assemblies that exhibit electrochemically-sensitized luminescence (ESL) by coupling metal complex donors to either luminescent nanoparticles or fluorescent proteins. These assemblies are predicted to have unique sensing properties using simple analytes and bio-markers.

Director:
Dr Saimon Moraes Silva
(S.MoraesSilva@latrobe.edu.au)

# Research Centre for Extracellular Vesicles

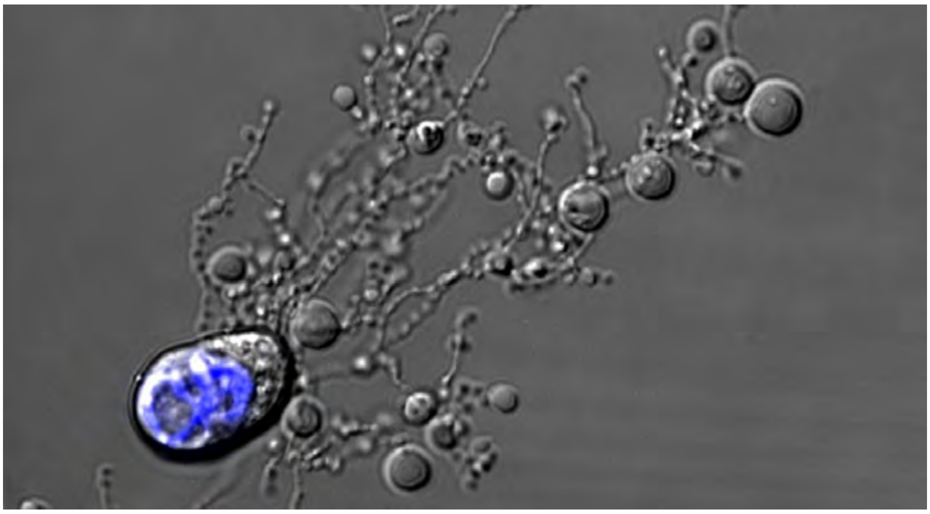
The La Trobe Research Centre for Extracellular Vesicles (RCEV) integrates a diverse group of internationally recognised researchers sharing a major interest in the study of extracellular vesicles (EVs). Our team explores EVs and their critical role in cell and tissue communication. We are based in the School of Agriculture, Biomedicine and Environment. Our team has expertise in the isolation and analysis of extracellular vesicles from cells, biofluids and tissues and next generation deep sequencing of EV cargo (especially small RNAseq and available workflow/technology).

We provide our national and international collaborators and industry partners a unique hub, for research, learning and engagement. Our objective as a research centre is to work with national and international groups to study how and why EVs mediate cell-cell communication. We hope to explore ways of harnessing this power.

We do this by:

- building an Australian Research Centre encompassing academic researchers, industry partners and educational activities to gain knowledge about EVs in intercellular communication.
- spearheading a multidisciplinary, collaborative program of research to understand, monitor and exploit EVs in the normal and disease processes of all organisms, from plants to humans.

We are studying EVs to advance our understanding of their novel role in the fundamental cellular processes of cell to cell communication and potential biological applications. In the future, we will translate results from these basic biological studies to outcomes with real world impact. Our ultimate aim is to develop methodologies to use EVs for diagnostic purposes in medicine and agriculture and as tools to deliver therapeutics in humans, animals and plants.



White blood cell (monocyte) undergoing programmed cell death (apoptosis). Photo credit: Georgia Atkin-Smith and Ivan Poon

### New methodologies

We are developing new, rapid and rigorous methodologies for EV isolation and characterisation. This enables extraction and functional analysis of distinct EV subtypes from biofluids and clinical samples, quantification of the biophysical, genetic, protein, and lipid makeup and how this exerts functional changes in target tissues.

### Vesicle biogenesis

Our researchers are also dissecting vesicle biogenesis - the cellular pathways that regulate how different EVs, called exosomes, microvesicles and apoptotic vesicles are formed and released by cells. Once we understand this, it may be possible to manipulate different stages in a targeted way and control cell to cell communication.

### Biomarkers

EVs represent a reservoir of new biomarkers for pathogenesis and susceptibility to disease and as drug delivery vehicles for novel therapeutics. We are studying novel and specific disease associated biomarkers in EVs isolated from clinical samples, including cancer, neurodegenerative diseases and the early stage of pregnancy.

### Host-pathogen communication

We are also studying the role of EVs in host-pathogen communication during fungal and bacterial pathogenesis and in the transfer of antibiotic resistance.

**Director:** Professor Ivan Poon (I.Poon@latrobe.edu.au)

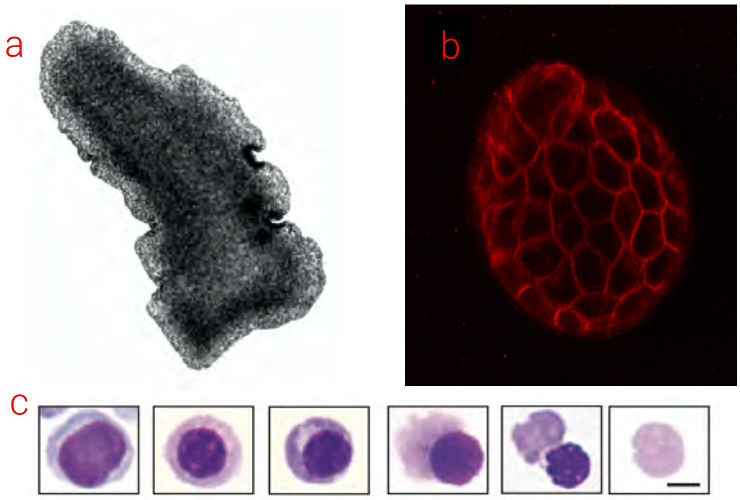
**Deputy Directors:**
Dr Lesley Cheng; Dr Pamali Fonseka.

**Strategic Partners:**
The University of Adelaide
Baker Heart and Diabetes Institute
Curtin University
The Florey Institute of Neuroscience & Mental Health
Garvan Institute of Medical Research
Hudson Institute of Medical Research
The University of Melbourne
Monash University
Murdoch Children's Research Institute
University of Sydney
QIMR Berghofer Medical Research Institute University of Queensland
University of Technology Sydney
Walter and Eliza Hall Institute of Medical Research
University of Western Australia
Aalborg University, Denmark
University of Auckland, NZ
Beijing Genomics Institute, China
University College London, UK
University of Gothenburg, Sweden
Hallym University, South Korea
University of Hohenheim, Germany
Kings College London, UK
University of Oxford, UK
Institute for Systems Biology, Seattle, USA University of Texas, USA
University of Virginia, USA
University of Utrecht, Netherlands

# Research Groups

# Cancer Biology, Cell Polarity, and Tissue Architecture Group

Cell polarity, or asymmetry, a basic property of all cells, is encoded by an evolutionarily conserved genetic program that coordinates the differential division of stem cells, the positioning of cells within an organ, and the precise architecture of the organ. Disruption of this genetic program leads to tissue disorganisation and can promote the first steps of cancer. Our laboratory studies how cell asymmetry and tissue organisation can regulate cancer initiation, progression and metastasis. We aim to devise therapeutics to help tumours to “reorganise” themselves, thereby stopping the cancer’s growth and spread. We also study how the cell polarity genetic program's involvement in tissue regeneration on earth and in space, as well as in developmental processes (e.g. blood cell production and function). Our multi-disciplinary approach encompasses state of the art imaging, genetically engineered mouse models, and the use of powerful genetic and chemical screens. We work closely with cancer clinicians and pathologists.




a), Trichoplax adherens, one of the simplest and most ancient animals; b), Expression of cell polarity protein Scribble (Red) in 3D MDCK cell cultures; c), enucleation of a mouse red blood cell

### “Re-organising” early breast and prostate cancer as a preventative approach

Loss of the proper orientation of cells within a tissue, known as cell polarity, is one of the hallmarks of breast and prostate cancer and is correlated with more aggressive and invasive cancers. How loss of cell polarity occurs and how it contributes at the molecular level to tumour formation remains unknown. Using approaches including RNAi screening, we identified genes that mediate the tumour suppressive functions of cell polarity. We use this new molecular information to re-establish normal tissue architecture through clinically approved drugs and aim to stop early tumour growth.

### The evolutionary origin of cancer

How did cancer begin? The advent of the first multicellular animals from single cells required new molecular mechanisms that allowed cooperation between cells and suppressed any conflicts that enhanced the individual fitness of any one cell, stopping them from “cheating” to the detriment of the organism. We study these very first cancer protective mechanisms in one of the oldest and simplest animals on earth, *Trichoplax*. Most human disease genes including cancer suppressing genes are found in this organism. By studying how it escapes cancer, we hope to gain insights into the origins of cancer that will be translated to humans.

### The role of gravity in tissue organisation and regeneration

Since life began on Earth four billion years ago, gravity has been the only constant environmental factor accompanying the evolution of life. The role gravity has played with respect to the establishment and maintenance of tissue organisation in multicellular organisms is unknown. Physiological effects resulting from hypergravity or microgravity (weightlessness) have been noted with detrimental effects on bone and muscle turnover, and wound healing in humans. This is a crucial factor for international space programs which aim at a long-term stay of humans and bioregenerative life support systems in space. Through our close connection with the German Aerospace Centre (DLR), and in partnership with TiHo, Hannover, we are testing for the first time how altered gravity may affect the development of tissue architecture and regenerative programs in the simplest and most ancient animal, *Trichoplax*. We use short-term space flights in sounding rockets and ground-based microgravity simulators to provide new insights into how all animal tissues are organised and regenerated.

### How did the red blood cell lose its nucleus?

Red blood cell enucleation (extrusion of the nucleus) is a feature of mammalian blood required for proper circulation of red blood cells (RBCs) through the microvasculature and increased haemoglobin concentration in blood. A major challenge for transfusion medicine is the difficulty obtaining sufficient supplies of specific RBC subtypes. Despite advances in *in vitro* production of human RBCs from hematopoietic, embryonic, and induced pluripotent stem cells, the reduced ability of these cultured cells to fully enucleate remains a major hurdle. We study the molecular mechanisms regulating the enucleation process to provide improved strategies for the efficient and rapid production of RBCs for self-generated patient transfusion.


**Lab Head:** Professor Patrick Humbert (P.Humbert@latrobe.edu.au)
**Lab members:** Ms Bree Mellberg; Mr Lucas Newton; Ms Yuliya Stepkina

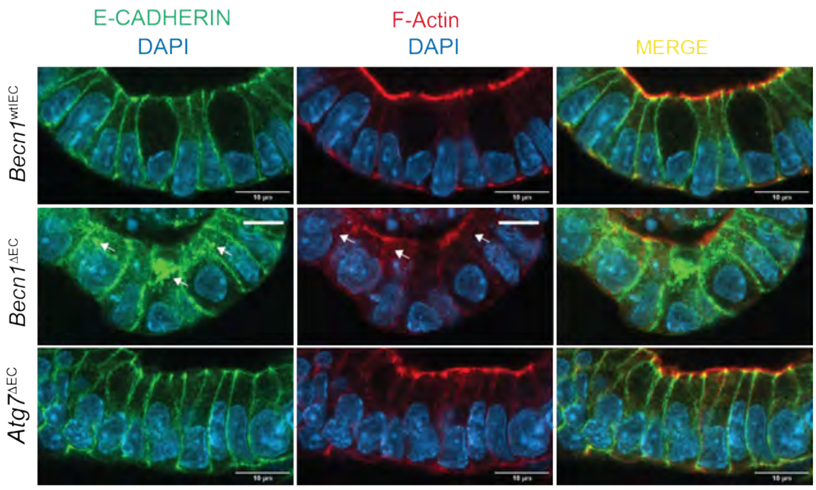

**Fields of Study:**
Cell development, proliferation and death; Cellular interactions; Cancer cell biology; Space Sciences; Cell Polarity; Erythropoiesis

**Capabilities and Techniques:**
3D cell cultures; Animal models of disease; Functional screening; CRISPR-Cas9 gene editing; Microscopy – electron, confocal, light; Flow cytometry; Protein biochemistry; Microgravity simulation; Real microgravity experimentation, sounding rockets

**Translational Opportunities:**
Human patient-derived 3D organoid cultures; Pre-clinical animal models of cancer for drug screening.

# Cell Death and Survival Group

Our group is uniquely positioned at the cross-roads of SABE and the School of Cancer Medicine (Olivia Newton-John Cancer Research Institute). Our research investigates how our cells determine their fate. In particular, we aim to understand what goes wrong in this decision-making process in disease and to then utilize this knowledge for therapeutic intervention. Using a combinatorial approach based on biochemistry, cell biology, and animal-based techniques, we seek to decipher the molecular mechanisms regulating cell fate decisions. Our research focuses on the pathways of cell death known as apoptosis, and of cell survival known as autophagy. Deregulation of these processes have been implicated in diseases such as cancer and inflammatory bowel disease.




Gastrointestinal organoids stained for critical cellular markers
Photo credit Doug Fairlie and Erinna Lee.

### Targeting apoptosis for cancer treatment

Our Group has a long and productive track record in the study of the intrinsic apoptotic pathway regulated by the BCL-2 family of proteins. Deregulation of this pathway can result in insufficient cell death and is a hallmark of cancer. Over the years, we have made significant contributions to how this pathway is regulated and to international collaborations that have led to the development of clinically approved drugs targeting it. Our current program investigates the clinical application of drugs that induce apoptosis in incurable and aggressive solid cancers with low overall survival rates. As part of this program, we collaborate with pharmaceutical companies such as AstraZeneca.

### Novel regulators of intestinal homeostasis

We also have a research program that focuses on the cell survival pathway of autophagy. This evolutionarily conserved process of cell recycling enables unwanted cellular material to be degraded by the lysosome and is critical for maintaining a healthy cell. Mutations in the pathway have been strongly associated with inflammatory bowel disease. We are currently investigating how well-established regulators of autophagy regulate intestinal homeostasis at a molecular level. Our studies have yielded unexpected but exciting results showing that a key autophagy regulator also has a moonlighting role in another pathway that is critical for maintaining a healthy gut.

### Identifying novel immune-oncology regulators

Many of the latest approaches to cancer treatment involve harnessing the immune system to kill rouge tumour cells. Whilst this process is well understood, all of the molecular players that dictate responsiveness have yet to be identified. We recently entered a collaboration with the Molecular Immunology Laboratory, headed by Conor Kearney at ONJCRI, to use CRISPR/Cas9-based screening approaches targeting boutique libraries of genes involved in cell death and survival, as well as membrane trafficking. We expect to uncover critical new regulators of this process that could serve as future targets in efforts to improve immune-oncology outcomes.

### Drug screening

A recent successful grant application has enabled the ONJCRI to purchase a liquid handling robot. Our lab has now established an efficient experimental pipeline using this robot that allows for the screening of drug libraries on cancer cells. We now plan to initiate a new screening platform that enables researchers to collaborate with us on projects that facilitate the discovery of new strategies for targeting cancer cells.

Lab Heads:
Associate Professor Doug Fairlie (D.Fairlie@latrobe.edu.au) and
Associate Professor Erinna Lee (Erinna.Lee@latrobe.edu.au)

Lab members:
Ms Umairah Binte Abdul Khalid;
Ms Julie Juliani;
Ms Tiffany Harris;
Mr Kristian Caracciolo;
Ms Nina Rogers.

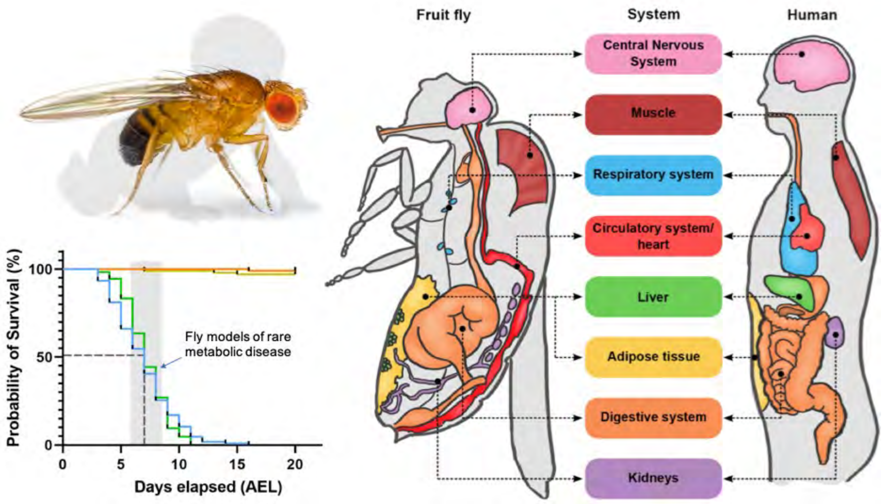
Fields of Study:
Apoptosis;
Autophagy;
Cell Biology;
Cancer;
Gastrointestinal Biology and disease.

Capabilities and Techniques:
Cell survival and death assays; high throughput drug screening; genetic editing of apoptosis and autophagy pathways; genetic mouse models of disease.

Translational Opportunities:
Drug screening;
Mechanism of action studies;
Drug validation.

# Cell Signalling and Rare Metabolic Disease Group

Our Group investigates the complex interplay between cells and their environment to better understand processes that underpin animal development and health. Our work takes us from the molecular scale, understanding how proteins control cell-to-cell communication, through to body tissues and whole organism scales where we look at physiology in disease. Our animal of choice is the fruit fly Drosophila melanogaster, which has a fast life cycle, can be easily manipulated at the genetic level, and has many similarities with humans, from its genes to entire body system processes. We aim to use Drosophila as a biomedical research tool to reveal new mechanisms of cell signalling control, as well as learn how disease affects the body for targeted therapy development. The research is highly collaborative and involves local, national and international partners.




We use Drosophila melanogaster to model rare human inherited metabolic diseases. (Image credit: Sarah Mele)

## Models of rare inherited disorders

There are more than 1,000 inherited metabolic disorders (IMDs) known which collectively affect approximately 1 in 800 births. Tragically, IMD often cause rapid neurological decline and death during infancy, and due to their rarity and large overall number, IMD remain a major challenge for treatment development. Our Group is addressing this by generating fly models of IMDs for the purpose of understanding these diseases and finding new treatments. IMDs are unique amongst inherited disorders because they are often very responsive to dietary changes. As Drosophila has a fully customizable diet available, we are performing large-scale nutrient screens on our fly IMD models to identify dietary compositions that restore health parameters. The goal of this work is to translate our findings to mammalian models and into the clinic to reduce the suffering of those with IMDs.

## Understanding blood cell biology

Our work on cell signalling control has led us to study the macrophage: a highly versatile blood cell responsible for a plethora of activities that support organismal health. Despite having been studied for more than a century, we still know very little about how their numbers and distribution around the body are controlled. In Drosophila more than 95% of the blood cells are macrophages, making them ideal for such studies.

We have developed a suite of sophisticated genetic and imaging tools for their study. We currently have a number of projects focused on macrophage biology including: identifying cell signalling pathways that control macrophage number, and applying new approaches to study their response to environmental and genetic perturbations.

## Mechanisms of cell signalling

A major focus of our research concerns cell signalling at the earliest stages of animal development - in the embryo. Here we study a receptor pathway that is activated in a unique spatial manner for a critical developmental process, the control mechanism of which is poorly understood. We are applying biochemical and structural biology approaches in concert with in vivo developmental biology techniques to reveal how signalling is controlled at the molecular level. Interestingly, a key player in this mechanism is related to bacterial toxins and vertebrate immunity effectors usually associated with cell killing. Unravelling how such a molecule functions in the early embryo to control receptor activity may therefore shed light on several areas of biology, as well as have implications in the development of therapeutics for developmental disorders and cancer.


Lab Head: Dr Travis Johnson
(T.Johnson@latrobe.edu.au)


**Lab members:**
Dr Sarah Mele;
Dr Jemma Gasperoni;
Ms Grace Jefferies;
Ms Emily Kerton;
Ms April Lewis;
Ms Sabah Jbara;
Ms Zoriana Novosiadla.

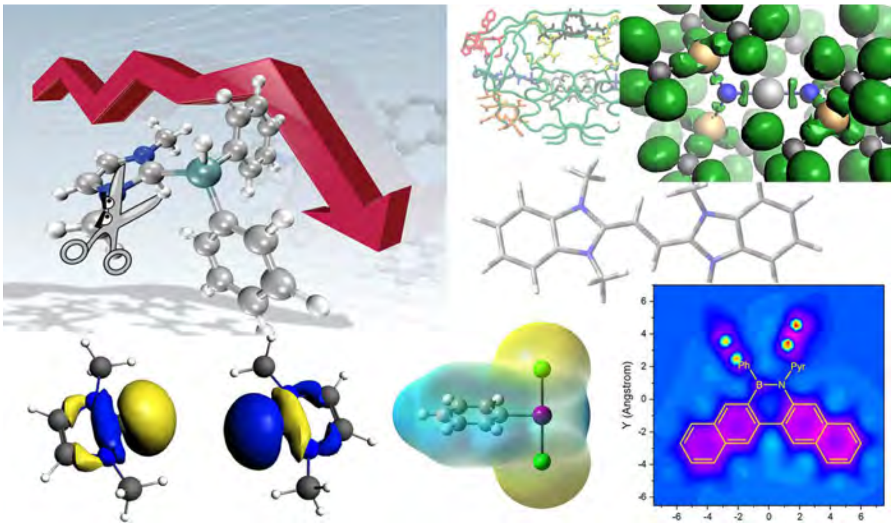
**Fields of Study:**
Genetics; Molecular Biology; Cell Biology; Developmental Biology; Disease models.

**Capabilities and Techniques:**
Confocal microscopy; Gene-editing; Transgenesis; Genetic analysis; Nutrigenomics.

**Translational Opportunities:**
Rare inherited disease therapeutics; Precision diet screening; imaging devices.

# Computational Chemistry Group

Our group does chemistry by computer to better understand the structures and properties of molecules and how they react. Our research is highly interdisciplinary and lies at the interface of materials, biology, physics, and chemistry. The goal of our research is to develop quantum chemical tools to calculate accurate chemical properties and then apply these tools to problems of chemical structure, mechanism, and design. We employ a range of computational techniques including empirical force fields, density functional theory, and ab initio quantum chemical methods. Our applied studies range from optical materials design to medicinal drug design, including the computational design of optical materials for use as LEDs, new materials for hydrogen storage, efficient catalysts, and accurate modelling of biological molecules. The research is collaborative and involves local, national, and international partners.



Various molecular chemistry structures

## Designing new chemistry

Chemistry is in an age where our ability to rationally design and tailor new molecular systems has led to remarkable developments in materials science, drug design, catalysis, and green chemistry. The capacity to engineer new molecules for specific roles is in large part underpinned by advancements in computational chemistry, which is now able to reliably predict the structures and function of molecular systems. Our group has a strong track record in predicting new chemistry and designing molecules for specific use as chemical reagents, medicines, and materials. In collaboration with Professor Jason Dutton and Professor Robert Gilliard, we are demonstrating the remarkable benefits that arise from the synergy of computational chemistry together with advanced synthetic chemistry that provides the capacity for molecular engineering.

## Understanding Chemical Reactivity

Optimization of chemical processes is enhanced by an understanding of the mechanism of reaction; it is difficult to optimize an industrial process if the mechanism is not known, if the reacting species in the flask are ill-defined, or do not even exist. Our group has significant expertise and experience in probing chemically important reactions. Current projects include the mechanism of reaction of halogenation reactions with iodine reagents. Techniques to introduce halogen atoms into organic molecules are of fundamental importance to industry because of the ubiquity of these atoms in useful molecules such as medicines, agricultural chemicals, materials, and specialty chemicals.

## Light-emitting materials

Our group is focused on the design and understanding of optical properties of molecular systems, including boron-doped organic molecules and metal-based (ruthenium, iridium) complexes. These are projects are often carried out in collaboration with experimental scientists. One current focus is the Incorporation of boron into polycyclic aromatic hydrocarbons (PAH), which has become a key strategy in the search for new molecular materials such as LEDs. Our research seeks to harness the potential of boron, which is increasingly occupying a prominent position in both molecular optoelectronic materials and medicinal drug discovery due to its 'magic' qualities of its ability to form a variety of bonds and capacity to mimic metal properties.

## Molecular Shape

Our research is driven by a curiosity of molecular structure and chemical bonding. Molecular science is underpinned by a fundamental relationship between structure and function; understanding the function of molecules as medicines, industrial chemicals, and useful materials, requires a fundamental understanding of molecular structure and shape. We apply the full array of computational chemistry tools to probe the shape and structure of molecules of importance to biochemistry, astrochemistry, optoelectronics and sensing, and materials chemistry.

**Lab Head:** Associate Professor David Wilson (David.Wilson@latrobe.edu.au)

**Lab members:** Mr Andrew Molino; Ms Aishvaryadeep Kaur; Mr Johnny Agugiaro; Ms Ishara Peiris; Mr Matt Gosch.

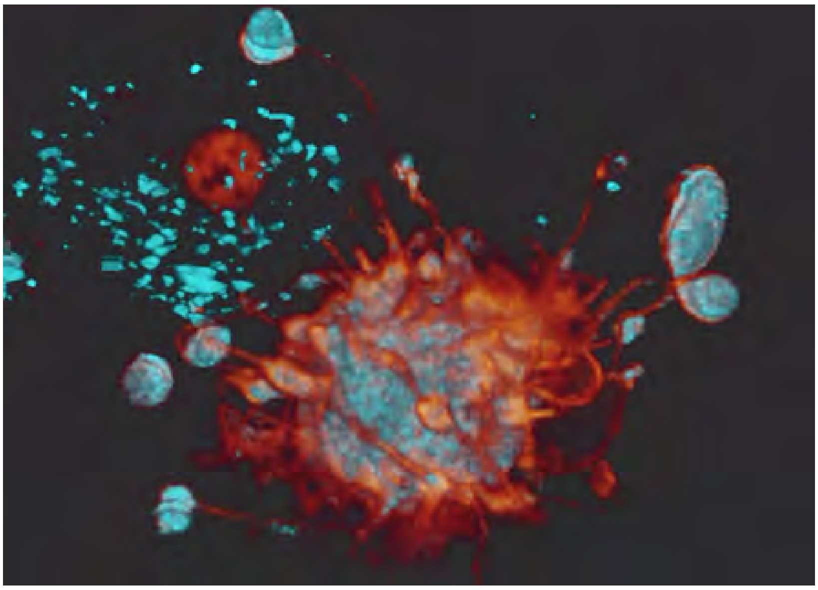
**Fields of Study:**
Theoretical and Computational Chemistry.

**Capabilities and Techniques:**
Computational chemistry; molecular structure analysis; reaction mechanism.

**Translational Opportunities:**
Reaction design and optimisation; optoelectronic materials design.

# Dead Cell Clearance and Infection Group

Apoptosis, a type of a programmed cell death, is a key host defence that destroys pathogenic niches in infected cells, kills infectious agents and initiates adaptive immunity. Dying cells have an active role in alerting the immune system, by attracting phagocytes (e.g., dendritic cells, macrophages). Furthermore, dying cells often break into 'bite-sized' membrane-bound fragments called 'apoptotic bodies' (ApoBDs) to enhance corpse engulfment and removal by phagocytes (a process known as 'efferocytosis'). In turn, the phagocytes process the ApoBD contents and activate their own signalling programs, specific to the type of molecular messages that they have recognised. Our group aims to advance current understanding of the dynamic host-pathogen interaction along apoptosis–efferocytosis axis and to develop novel therapeutics for respiratory infections, the leading pathogenic causes of global morbidity and mortality.



ApoBD formation in an apoptotic Jurkat T cell, captured by lattice light-sheet microscopy.

### Efferocytosis-mediated viral entry and inflammation

Severe SARS-CoV-2 infection is typified by an exacerbated pro-inflammatory 'cytokine storm', which develops after peak viral titre. Macrophages, rapid cytokine producers upon pathogen infection, are a major driver of COVID-19-associated hyperinflammation. Hitherto, it remains unclear how SARS-CoV-2 gains entry into macrophages, which lack canonical receptor required for viral entry, and triggers hyperinflammation. We recently discovered that SARS-CoV2-induced ApoBDs mediate a novel viral uptake pathway, by primary human macrophages and other phagocytes. Of great clinical significance, SARS-CoV-2-ApoBD-engulfing macrophages, secreted markedly high levels of cytokines. We thus aim to uncover the novel mechanism of infection-derived ApoBDs in facilitating viral uptake and driving inflammation, and develosp novel ApoBD-targeting therapeutics to tackle other apoptosis-inducing newly emerging virals. threats.

### Anti-mycobacterial immunotherapy

Mtb and many intracellular bacteria have evolved to prevent host apoptosis to escape host immunity and enhance their growth in infected cells. Hence, therapeutic induction of infected cell apoptosis and promotion of ApoBD formation may reinstate host anti-infective responses through ApoBD-mediated T cell activation. We will conduct world-first groundwork for the therapeutic enhancement of ApoBD formation to promote host-mediated clearance of Mtb infection by combining MAIT cells (for specific apoptosis induction of infected cells) and pharmacologically inhibiting ApoBD formation.

### Novel regulators of ApoBD formation and efferocytosis

Apoptotic cell death underpins many critical physiological and pathological processes, not only infection but also cellular homeostasis, development, ageing and immunity. The communication between dying cells and healthy cells can be relayed by ApoBDs. In addition, the fragmentation of apoptotic cells into "bite-sized" ApoBDs mediate the rapid and efficient debris removal via efferocytosis. However, the molecular basis of ApoBD formation and efferocytosis remains poorly understood. We seek to identify novel regulators of ApoBD formation using proteomics and CRISPR/Cas9 screening.

### Drug screening and development

As ApoBD formation and efferocytosis play important roles in many critical cellular processes and diseases, we aim to perform multiple drug library screening as well as rationalised drug designs to identify ApoBD-targeting small molecules as novel therapeutics.

Lab Head: Dr Kha Phan
(Thanh.Phan@latrobe.edu.au)

Lab members:
Ms Bo Shi; Ms Dilara Ozkocak; Mr Omar Audi.

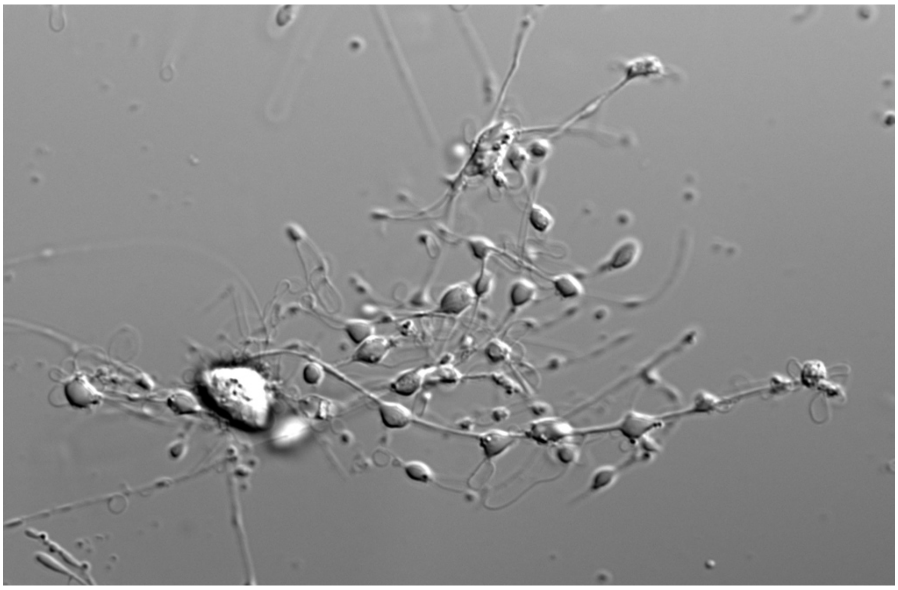
Fields of Study:
Cell Biology; Microbiology; Innate Immunology.

Capabilities and Techniques:
Advanced imaging; Multicolour flow cytometry and sorting; PC3 pathogen handling; CRISPR/Cas9 gene editing.

Translational Opportunities:
Drug development; Disease diagnostics.

# Dying Cell Clearance and Disassembly Group

Billions of cells die daily as part of normal turnover in various organs. It is vital that dying cells are rapidly removed as their accumulation has been linked to inflammation, autoimmunity, cancer and infection. To aid efficient removal of dead cells, dying cells often disassemble into smaller fragments for neighbouring cells to engulf. Certain cellular components can be packaged selectively into these fragments to regulate tissue repair and immunity. We aim to understand the machinery that controls how dying cells can disassemble into smaller pieces, the importance of cell disassembly in disease settings (e.g. influenza A infection and atherosclerosis), and identify new drugs to control this process.



Dying cancer cell undergoing disassembly. (Photo credit: Stephanie Rutter)

### Mechanism of dying (apoptotic) cell disassembly

Apoptosis (programmed cell death) occurs in all tissues as part of development, homeostasis, and pathogenic processes including infection and cardiovascular disorders. Apoptotic cells often disassemble into smaller membrane-bound extracellular vesicles called apoptotic bodies. We have demonstrated that the formation of apoptotic bodies is a highly regulated process in T lymphocytes and monocytes. We discovered a new type of membrane protrusion (coined "apoptopodia") that facilitates the separation of membrane blebs during apoptosis to generate individual apoptotic bodies. The molecular machinery that controls the formation of apoptopodia is undefined. We aim to determine the molecular machineries required for the formation of apoptopodia.

### Function of apoptotic cell disassembly in pathophysiological settings

Extracellular vesicles including apoptotic bodies have been implicated to regulate physiological and pathological processes via the molecules they carry inside or exposed on their surface. The importance of generating apoptotic bodies during apoptosis in pathophysiological settings is poorly understood. We study the role of apoptotic cell disassembly in the context of viral infection. During viral infection, infected cells often undergo apoptosis to shutdown cellular machinery as a defence mechanism to limit viral replication. Phagocytic removal of infected apoptotic cells/ fragments may also facilitate the spread of infection, and the phagocyte could become infected following the engulfment of apoptotic cells/fragments containing viral particles. Viral proteins have been suggested to accumulate in apoptotic bodies during apoptosis, but the role of apoptotic cell disassembly in the context of viral infection is underexplored. We study apoptotic body formation in influenza A and SARS-CoV-2 infection.

### Discovery of novel drugs to modulate the apoptotic cell disassembly process

Apoptotic body formation is a key cellular process for efficient removal of apoptotic debris and intercellular communication in certain disease settings. There is a lack of drugs to target this process so identifying drugs that could modulate apoptotic cell disassembly is important. Using a novel flow cytometry-based drug screen approach, we have identified a number of drugs that can inhibit or enhance the formation of apoptotic bodies without having an impact on the level of apoptosis. Some of these drugs are FDA approved and are currently being used clinically. We aim to characterise these novel inhibitors and enhancers of apoptotic cell disassembly in detail, in particular how these compounds could modulate the morphological steps of apoptotic body formation as well as the activities of known molecular regulators of apoptotic cell disassembly (e.g. ROCK1 kinase and pannexin 1 channel). Furthermore, whether these drugs can be used to control the apoptotic cell disassembly process in disease settings will also be examined.

Lab Head: Professor Ivan Poon (I.Poon@latrobe.edu.au)

Lab members:
Dr Amy Baxter; Dr Donia Abied; Ms Caitlin Vella; Ms Gemma Ryan; Ms Amy Hodge; Ms Bo Shi; Ms Jascinta Santavanond; Ms Dilara Ozkocak; Ms Stephanie Rutter; Mr Omar Audi.

Fields of Study:
Cell Biology; Cell Death; Cell Clearance; Extracellular Vesicles.

Capabilities and Techniques:
Time-lapse microscopy; flow cytometry; cell death analysis; drug screening.

Translational Opportunities:
Treatment and diagnostics for infection, cardiovascular and autoimmune diseases.

# Electrochemical Sensing Group

Our group conducts a range of both fundamental and applied multidisciplinary research focused on expanding the bounds of Analytical Science. We pursue the development of new chemistries and new technologies which will result in exquisitely low detection limits and enhanced selectivity. Building on breakthrough fundamental science, we seek to develop novel sensing technologies and miniaturised instruments for use outside the laboratory setting. For example, we hold several patents in the use of personal electronic devices such as mobile phones for sensing applications from environmental analysis to medical diagnostics. We also have on-going collaborations with a range of industries and government bodies around sensor development. Working at the interface of electrochemistry and photochemistry, we have pioneered several new approaches to detection science.  Our group is 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.

### Photophysics and electrochemistry of highly luminescent transition metal complexes

We are interested in developing and investigating materials which are electroactive, materials which are luminescent and in particular, materials which exhibit both of these properties simultaneously. One area in which we are are very active, is in the applications of highly luminescent Iridium, platinum and ruthenium complexes. We explore the use of such molecules (with Dr Peter Barnard and others) for applications in ultra-sensitive medical diagnostic and health testing applications.

### Ultra-sensitive Electrochemiluminescence (ECL) sensing

Electrochemiluminescence, (ECL) facilitates extremely low (sub-femtomolar) detection limits for bioanalytical measurement, often outstripping fluorescence by several orders of magnitude; but current ECL detection technology consists of large laboratory instruments.  We are developing new minimally invasive diagnostic technologies based on electrochemiluminescence (ECL)  detection chemistry. This will provide superior detection limits ultimately enabling the detection of biomarkers in saliva.

### Android Voltammetry: A simple but powerful smartphone-based biosensing platform

The development of simple, inexpensive (yet quantitative and sensitive) sensors for environmental, medical and other sensing applications is an extremely important emerging area because it has the potential to make chemical and biochemical analysis, usually confined to the lab, more widely available. Such technology can be transformational, particularly in remote areas and in the developing world, where levels of health expenditure are low. Our patented sensing technology called Android voltammetry, developed in the Hogan lab eliminates the requirement for an instrument and harnesses the e xisting audio capabilities of mobile phones to facilitate electrochemical detection. Our first application for this platform (the "ElecTrobe") is set to save millions of dollars for the Australian wine industry each year. By using the audio jack to provide electrochemical stimulation we have replicated what is usually done using  expensive laboratory instruments to  perform "instrument free" analysis. As the data and associated metadata can be readily shared, this opens up a range of exciting possibilities for e-Health, telemedicine and "crowd sourced sensing". See http://youtu.be/X6zSgFEhFd4 and https://youtu.be/XUXvdd5nMcM. We are currently developing a range of exciting new applications for this platform in the fields of environmental analysis and medical diagnostics.

### Design and printing of disposable sensors for electrochemical and ECL detection

Our laboratory hosts a Diamatix materials inkjet printer, a state-of-the-art technology for the production of bespoke printed sensors in significant quantities.

Mobile phone based wine analysis using Fourier Transform AC voltammetry

The materials printer affords unprecedented scope for printing novel sensor designs. We use it to explore the influence of novel sensor geometries on sensitivity in electrochemical and ECL sensing.

**Lab Head:** Professor Conor Hogan (C.Hogan@latrobe.edu.au)
**Lab members:** Dr Mohammad Reza Moghaddam;  Dr Robert Sikos; Ms Laena D'Alton; Ms Samridhi Bajaj; Ms Helmini D G Dona; Mr David Macedo.

**Fields of Study:**
Chemistry; Analytical Chemistry; Electrochemistry; Luminescence, Biosensors.

**Capabilities and Techniques:**
Unique combination of expertise in electrochemistry, photophysics and sensor technology; Proven ability to translate / commercialise basic science for real-world sensor technology applications.

**Translational Opportunities:**
Proven ability to translate / commercialise basic science for real-world chemical and biosensor technology applications.
Follow us on Twitter @hogansheroeslab and Facebook.

# Exosomes, secretome and systems biology

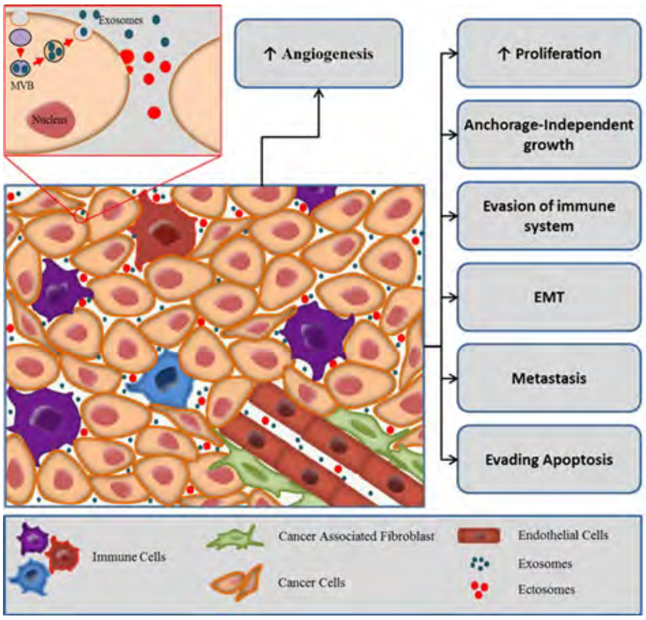
Our major research interests are in exploring the role of extracellular matrix components (soluble secreted proteins and extracellular vesicles) in cancer and intercellular communication. Our lab integrates proteomic, genomic and bioinformatics methodologies to study cancer progression. In addition to medical research, we are also interested in basic science projects including the biogenesis of exosomes and the role of exosomes in intercellular communication.

## Exosomes in the tumor microenvironment

Exosomes are 40-100 nm diameter membrane enclosed extracellular vesicles released by various cell types, including cancer cells. For tumors to progress, bidirectional crosstalk between different cells occurs within the tumor and its surrounding supporting tissue. A tumor can be considered as a complex tissue or organ with abnormal cells harboring genetic mutations, typically referred to as tumor or cancer cells, enmeshed within the surrounding and interwoven stroma, the epithelial parenchyma, which provides the connective tissue of the tumor. Stromal elements include the extracellular matrix as well as other cell types that are activated and/or recruited to the tumor microenvironment such as fibroblasts, immune and inflammatory cells, fat cells and endothelial cells of the blood and lymphatic circulation. Recent literature indicated that all aspects of cellular tumorigenicity are profoundly influenced by reciprocal interactions between responding normal cells, their mediators, structural components of the extracellular matrix, and genetically altered neoplastic cells. Exosomes have recently been recognized as important mediators of the cross-talk in the tumor microenvironment. Exosomes derived from tumor cells have been shown to have both pro- and anti-tumorigenic properties. Our lab is interested in studying the role of exosomes in the tumor microenvironment.

## Proteogenomics analysis of exosomes and extracellular vesicles

Recent studies have highlighted the secretion of oncoproteins including mutant proteins via exosomes. However, a prior knowledge of the mutant protein is a prerequisite in all of the published studies.




Exosomes role in tumor microenvironment. (Picture credit: Gangoda et al. 2015, Proteomics)

A global approach to systematically identify mutant proteins secreted through exosomes will aid in elucidating the functional roles of exosomes. In order to identify the mutant proteins that are secreted by a cell via exosomes, we use global proteogenomics approach. In addition to functional implications, as exosomes may contain disease causing proteins including mutant proteins/RNA, assaying for mutant or disease-causing proteins/RNA as disease biomarkers may provide the required specificity for a biomarker test.

## Systems biology - exosomes and colorectal cancer

Constant dynamic interactions between a cell and its surrounding tissue microenvironment are important in maintaining the differentiated state of a cell. While such organised intercellular signalling cascades are pivotal in cellular proliferation, sustained disruption of key signalling events render the cells susceptible to malignancy. Our group uses systems biology or bioinformatics approaches to study the molecular mechanisms of colorectal cancer. We use proteomic and genomic technologies to study colorectal cancer cells and integrate bioinformatics methods to make biological sense of the obtained data. With the explosion of datasets from high-throughput techniques, systems biology approaches hold immense promise to investigate such data and present them at the context of the disease. It has to be noted that high-throughput data should be dealt carefully owing to the noise and systemic pitfalls. Our group develops computational tools to analyze such datasets and integrate them with heterogeneous datasets obtained from similar biological experiments using statistics and computation.


Lab Head: Professor Suresh Mathivanan
(S.Mathivanan@latrobe.edu.au)
Lab members: Dr Pamali Fonseka;
Dr Christina Nedeva; Dr Sarah Stewart;
Mr Sai Chitti; Mr Sanjay Shahi;
Mr Taeyoung Kang; Mr Rahul Sanwlani;
Ms Akbar Marzan; Mr Kyle Bramich.

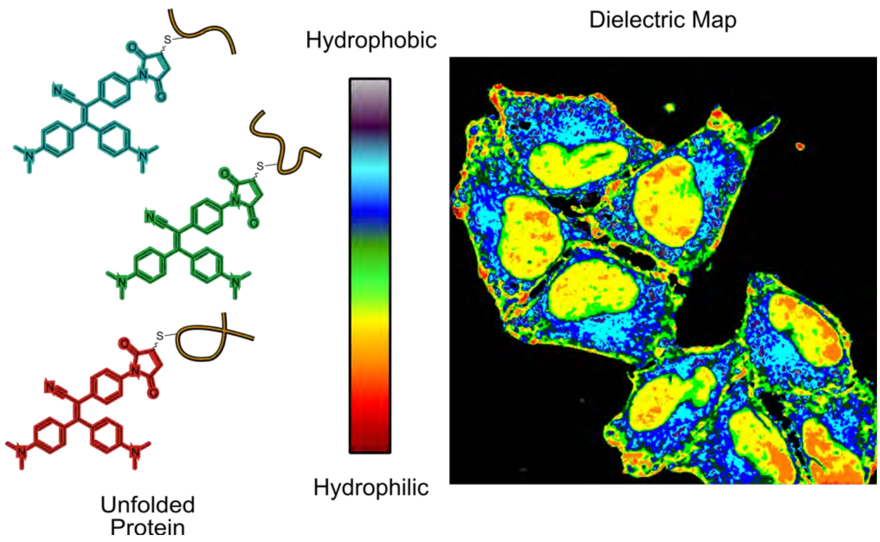
Fields of Study:
Exosomes; Cancer; Extracellular Vesicles; Proteomics; Bioinformatics

Capabilities and Techniques: Extracellular vesicles isolation and characterization; Mass spectrometry; IVIS imaging; Confocal microscopy.

Translational Opportunities:
Treatment for cancer; Therapies to block metastasis; Treatment for cancer cachexia; Cancer prevention.

# Fluorescence Chemical Biology Group

Our group develops novel fluorescent probes for understanding and manipulating fundamental biological processes regulating cell fitness and their association with aging and diseases. Our goal is to generate molecular tools that can report on changes such as protein folding, modification and degradation in a native environment such as in live cells and organisms to reveal hidden molecular level mechanisms for the understanding, diagnosis, and potentially treatment of diseases in particular neurodegenerative diseases. The group's work combines multidisciplinary approaches, ranging from synthetic and analytical chemistry, bioconjugation chemistry, molecular and cell biology to bioinformatics, and involves collaborations with local, national, and international partners working on Parkinson's, Huntington's, Motor Neuron Diseases (MND), leukemia and rare diseases.




Mapping Unfolded Proteome (Image credit: Tze Cin Owyong)

### Protein Damage in Neurodegeneration

Neurons are postmitotic long-lived cells. Over time, with the accumulated exposure to stress (from ROS production, DNA damage, infection, etc.), the protein quality control system becomes less efficient, leading to accumulation of protein damage and eventually neuron death. Our Group has developed unique chemical tools that can tag on damaged proteins, including those cannot fold properly (e.g. unfolded, misfolded, or aggregated) or undergo aberrant modifications. These tools can selectively tag on damaged proteins, turn on their fluorescence, allowing us to quantify the level of damaged proteins as a measure of proteostasis capacity, imaging unfolded and aggregated protein in cells, mapping subcellular polarity changes in response to protein unfolding, as well as identify those proteins to study protein stability in cells. These tools have been used in the study of Huntington's, Parkinson's, MND, virus infection and antimalaria drugs.

### Tracking and Measuring Autophagy

Autophagy ("self-eating") is a cellular housekeeping process in which unwanted components are identified, degraded, and recycled, greatly contributing to cell homeostasis and development, but also the prevention of various diseases. Autophagy is a multi-step, dynamic process. Dysregulation of autophagy has been linked to many diseases, such as neurodegeneration, cancers, cardiovascular and infectious diseases, with different steps of the pathway being impaired. Current tools to study autophagy rely on antibodies or fluorescent protein-based sensors, both of which require modification of the cells prior to the study. Our group develop fluorescent chemical probes that are highly specific to autophagy, which allow us to follow the dynamic process of autophagy and quantify its activity in situ and in a high throughput manner without the prerequisite of genetically modifying the cells. We use these probes in a range of cell models including those derived from Parkinson's patients and model organisms like zebrafish and demonstrate their applications for drug screening, understanding disease mechanisms, as well as studying fundamental biological processes.

### Using Luminescence to Fight Antimicrobial Resistance

Antimicrobial resistance (AMR) is a growing health issue recognised by the World Health Organisation (WHO), which has listed AMR as one of the top 10 global public health threats. For example, as a consequence of antibiotic misuse in dental practice, AMR in oral pathogens is becoming more and more prevalent. We develop novel fluorescence for visualizing and inhibiting bacteria growth including those resistant to conventional antibiotics. Some of these molecules also present photodynamic therapy activities, which provide the possibility of using light to kill bacteria in a selective area in a controllable way.

**Lab Head:** Associate Professor Yuning Hong (Y.Hong@latrobe.edu.au)
**Lab members:** Dr Bicheng Yao; Dr Siyang Ding; Dr Xavier Zhang; Mr Timothy Gialeris; Ms Soheila Sabouri; Mr Tze Cin Owyong; Ms Karren Jiamin Zhao; Mr Liang Tan; Mr Jack Spencer.

**Fields of Study:**
Analytical Biochemistry; Bioassays; Biologically Active Molecules

**Capabilities and Techniques:**
We specialize in fluorescent probe design and synthesis and have developed novel fluorescence probes for protein oligomers, for unfolded protein response, for targeting and imaging organelles, for enzyme activity, for autophagy activity, etc.

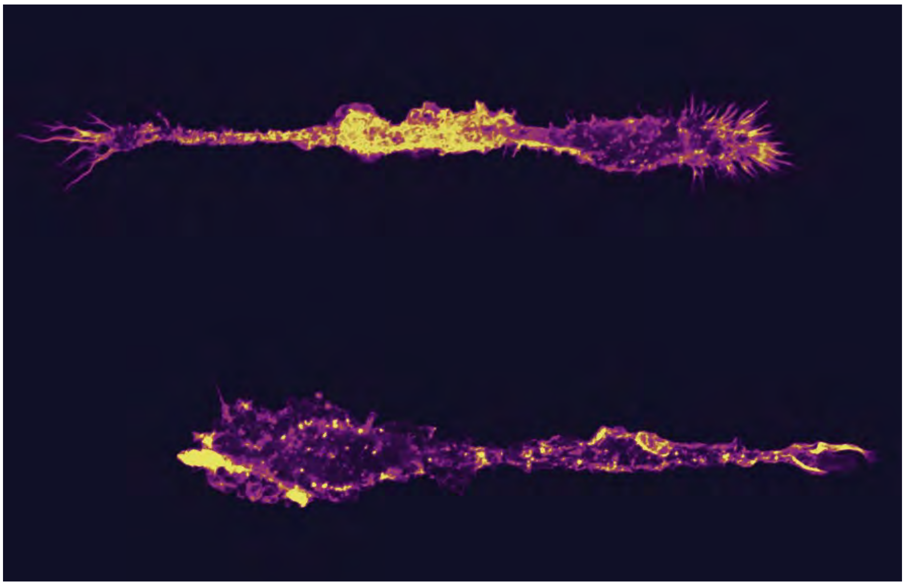
**Translational Opportunities:**
Material transfer; Early detection of neurodegenerative diseases; Disease treatment evaluation; Assay kits/device development based on our materials.

# Immunometabolism and Macrophage Biology Group

Every cell in our body requires energy to perform their specific functions. Generally, this is a well-controlled and ordered process. However, in some settings, the ways in which cells obtain this energy is altered and has important functional consequences.

We are now learning that the metabolism of immune cells is intricately linked to their function, where distinct metabolic configurations are ascribed to different phenotypes.

Our research aims to understand the link between what immune cells 'eat' in our tissues and how this is connected to their normal biology, response to infections, and inflammatory diseases such as high blood pressure and diabetes.



Confocal microscopy image of murine macrophages. (Photo credit: Katrina Binger)

### Macrophages go 3D

The cell type we focus on are macrophages, innate immune cells that acquire specialised pro- or anti-inflammatory functions upon responding to stimulatory cues (e.g. toll-like receptor agonists and cytokines) in their local tissue environment. Macrophages therefore have a variety of responsibilities including protecting us from invading pathogens (bacteria, viruses, and parasites), promoting inflammation and tissue repair. Macrophages are also unique in that they are the only immune cells derived from two developmental origins: from progenitors, which seed all tissues during embryonic development, and on command from haematopoietic stem cells, which give rise to circulating precursors that infiltrate tissues throughout adulthood (Wright & Binger. Pflugers Arch 2017).

As the tissue environment is a major controller of macrophage function, understanding their function with classical 2D in vitro culture systems is impossible. The aim of this project is to develop 3D systems that better recapitulate the tissue microenvironment and support TRM function. We are interested in developing in vitro models that better mimic tissue environments. Using 3D printing, macrophages are suspended into different environments and the effect of this on their function is measured. We are particularly interested in modeling tissues like the lung microenvironment to better understand how macrophage function occurs in this specialised environment during infection with respiratory viruses such as Sars-CoV-2, influenza and others.

### Mechanosensing metabolism

Our recent data shows that the interaction of macrophages with the extracellular matrix (ECM) is important for their function (McGowan et al iScience 2022). We think that this 'mechanosensing' is a critical, but underappreciated modulator of macrophage biology. In this project students will employ proteomics to identify proteins that regulate macrophage interaction with the ECM, and investigate their role in metabolism.

### Dietary salt

It has recently emerged that small molecules, such as metabolites and electrolytes, have significant effects on macrophage phenotypes via 'reprogramming' their cellular metabolism; involving the activation of signalling pathways, expression of metabolic enzymes and proteins, increased uptake and storage of nutrients, and physical remodelling of mitochondria. We previously reported that high dietary salt increased sodium (Na+) in tissues that subsequently modulated macrophage phenotypes: increasing pro-inflammatory responses and glycolytic metabolism, while inhibiting protective anti-inflammatory functions and mitochondrial respiration (Binger et al., J Clin Invest 2015; Jantsch et al., Cell Metab 2015). The aim of this project is to understand how sodium reprograms macrophage metabolism.

**Lab Head:** Dr Katrina Binger (K.Binger@latrobe.edu.au)

**Lab members:**
Mr Sean Cutter; Ms Kaitlyn Ritchie; Ms Emily Field; Ms Jennessa Ng.

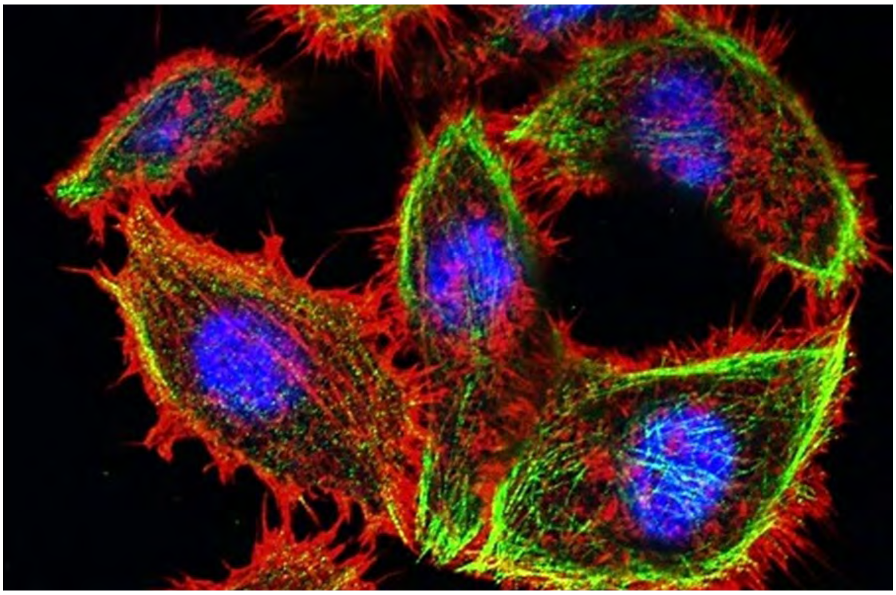
**Fields of Study:**
Cardiovascular disease; Immunology; Inflammation; Fibrosis; Cell Biology; Metabolism; Biochemistry; Molecular Biology.

**Capabilities and Techniques:**
3D primary cell culture; gene and protein expression assays; animal models of disease; microscopy; metabolism analyses.

**Translational Opportunities:**
Biomedical therapies for fibrotic control and inflammatory diseases.

# Inflammation and tumour progression group

Our research aims to understand the structure and function of key molecules in innate immunity and tumour progression and to harness this information for the development of novel therapeutics to treat infectious disease, inflammatory disease and cancer. In particular, we aim to precisely define and translate the unique molecular mechanisms of innate defense peptides and the heparan sulphate (HS)-degrading enzyme heparanase in immunity and tumour progression. Towards this aim, our interests are focused on two main research themes, to define (i) the role of heparanase and investigate its drug targeting in the disease settings of cancer and inflammatory disease, including the important cardiovascular disease atherosclerosis, and (ii) the molecular basis of membrane-targeting by defensins, its importance in innate defense, and to use this information to develop novel antimicrobial and anticancer molecules.



Cytoskeletal proteins in human cancer cells (Photo credit: Guneet Bindra)

### Heparanase function and drug targeting in inflammatory disease

Cell migration is critical in the initiation of inflammation and to combat infection. The HS-degrading enzyme heparanase plays a key role in these processes by facilitating the migration of immune cells. As such, heparanase can also promote chronic inflammation that underpins various inflammatory diseases and therefore is an attractive anti-inflammatory drug target. Atherosclerosis is a chronic inflammatory process that is a major contributor to myocardial infarction and stroke – key sources of morbidity and mortality. We have defined heparanase as an important driver of atherosclerosis and are now assessing heparanase inhibitors as novel anti-atherogenic drugs to prevent and treat these cardiovascular diseases.

### Heparanase function and drug targeting in tumour progression

The ability of malignant tumour cells to escape from primary tumour sites and spread through the circulation to other sites in the body is what makes cancer such a deadly disease. Essential in these processes of tumour growth and spread, are metastasis - where tumour cells move into and out of tissues and the vasculature, and angiogenesis – where new blood or lymphatic vessels are formed in and around a solid tumour. Heparanase has been linked to promoting tumour metastasis and angiogenesis and therefore represents an attractive anti-cancer target. Our lab has generated unique heparanase knockout mice that we are using to define the precise role and contribution of heparanase to tumour progression in the settings of breast, colon and prostate cancer, towards determining the appropriate application of heparanase inhibitors for treatment.

### Antimicrobial and Anticancer Defensins

Antimicrobial peptides such as defensins are natural innate immunity molecules found throughout the plant and animal kingdoms and are attracting clinical interest for their unique antimicrobial properties against bacterial, fungal and viral pathogens, as well as their ability to target and kill cancer cells. We defined a key mechanism of action of defensins involving the specific recognition of membrane phospholipids that results in permeabilisation and death of target and anticancer therapeutics. cells. We focus on defining the precise molecular basis of the specific membrane-targeting activity of defensins to develop new potent antimicrobial and anticancer therapeutics.

**Lab Head:** Professor Mark Hulett (M.Hulett@latrobe.edu.au)
**Lab members:** Dr Fung Lay; Ms Gemma Ryan; Dr Tien Nguyen; Mr Matt Hein; Ms Zoe Day; Ms Serenay Demir; Mr Nick Bronchinetti; Mr Gavan Frances, Ms Chloe Bourchier.

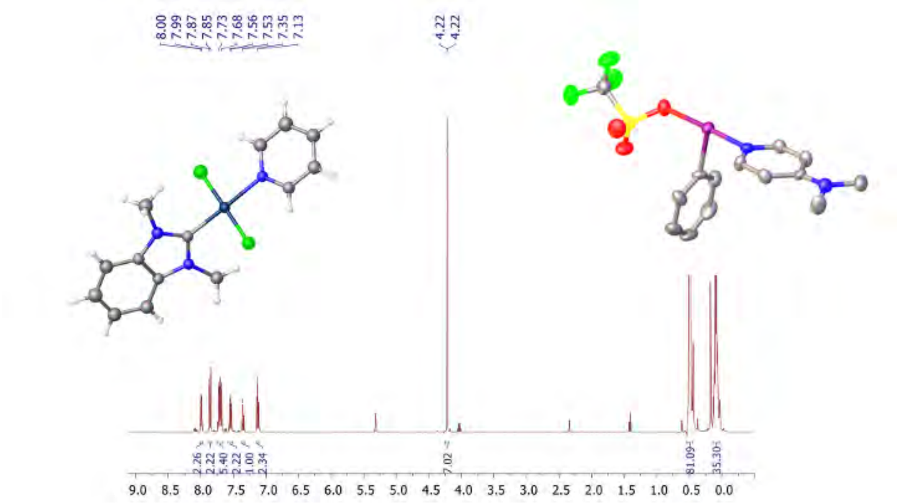
**Fields of Study:**
Biochemistry; Cell biology; Innate immunity; Inflammation; Cancer biology; Cardiovascular disease.

**Capabilities and Techniques:**
Molecular biology; gene expression analysis; protein expression, purification & quality control; protein-protein & protein-lipid interaction; mammalian cell culture; live cell electron microscopy; cell viability & drug testing; flow cytometry; mechanistic cell death assays; immunohistochemistry; heparanase activity; inflammation/cytokine profiling; in vivo mouse models of tumour progression, inflammatory disease; heparanase conditional gene knockout mouse models.

**Translational Opportunities:**
In vitro mechanistic & in vivo functional studies for infection, inflammatory disease & tumour progression; peptide & small drug therapeutics development & preclinical testing. Track record of translating research discoveries in partnership with biotech companies e.g. Progen Industries, Hexima Ltd, Wintermute Biomedical.

# Inventing Chemistry Group

Our Group seeks to invent new chemistry with a broad philosophy of achieving this by making molecules as uncomfortable as possible. Electrons dominate the properties of molecules and in projects spanning the periodic table we consider molecules that either have too many or too few electrons. These new molecules are typically highly reactive and often result in the discovery of completely new reactions. We use a combined effort to interrogate molecules and reactions involving synthesis, spectroscopy, structural characterization and finally theoretical studies. In the latter area we undertake both predictive theoretical studies, especially in the area of chemical compounds that are too toxic or reactive to handle, and also to rationalize observations that are made by our group and others. Overall the goal of the group is to increase understanding in what is possible in chemical synthesis.




Structural characterization and spectroscopy of a small molecule

### Discovering Organic Chemistry with an Inorganic Touch

Carbon has a privileged place in. chemistry, and the entire field of organic chemistry is built around it. We however don't view carbon as distinct from any other chemical element and treat it as just another metal. Using this philosophy we have discovered a number of molecule classes and reactions that are very simple, but were completely unexplored simply because a classically trained organic chemist wouldn't think that way. For example in metal chemistry one can generate a molecule by taking away electrons from the metal and replacing them with ligands, or conversely adding electrons and removing ligands. It turns out carbon can behave exactly the same way, which in turn gives carbon based species that are extremely reactive in classic organic chemical transformations.

### Super Charged Halogenation Reagents

Halogenation, the addition of fluorine, chlorine, bromine or iodine to simple organic feedstocks are some of the most important transformations in chemistry, occurring on a multi-million ton scale. Elemental halogens (e.g. Cl2) are efficient at this, but are ferociously difficult to handle on a small scale. We are developing improved halogenation reagents based on I-X (X = F, Cl, Br) bonds in extremely electron poor environments that are more reactive than elemental halogens, but offer a vastly improved safety and handling profile. We have also found that organic chemists are frequently wrong in invoking how iodine reagents work and are carrying out a campaign to correct the literature.

### Gold Chemistry for Organofluorine Synthesis

Fluorine holds a special place in medicinal chemistry, with half of top selling drugs containing a C-F bond. However, it is difficult to controllably change C-H into C-F. We have discovered that Au-F compounds are effective for performing this transformation. In this project we are using simple and cheap fluoride sources, combined with electrochemistry to generate extremely electron poor and thus reactive Au-F molecules that can catalytically effect the transformation of C-H info C-F bonds without degrading other parts of the druggable molecule of interest. In perusing this goal we have also uncovered a raft of other interesting reactivity surrounding the Au-F bond, which is generally unexplored due to its unstable nature.

### Predictive Theoretical Chemistry

Sometimes one has good ideas that for a reason or another can't be actioned. In concert with the Wilson group we have an ongoing program in predictive theoretical chemistry. One of the main focusses is Beryllium chemistry. Beryllium has a very rich reactivity but is hardly explored due to its extreme toxicity. We predict what might be possible in the computer, and international groups with the appropriate skills test our predictions in their labs.

**Lab Head:** ProfessorJason Dutton (J.Dutton@latrobe.edu.au)
**Lab members:** Mr Lachlan Sharp-Bucknall; Ms Tania; Mr Lachlan Barwise; Ms Biljana Vujci; Ms Aseel Bakro; Mr Jason Benetts; Mr Benjamin Davis; Mr Luke Vincent-Blood.

**Fields of Study:**
Inorganic chemistry; Organic Chemistry; Theoretical Chemistry.

**Capabilities and Techniques:**
Complex chemical synthesis; Characterization of small molecules by spectroscopy; X-ray crystallography; theoretical calculations.

**Translational Opportunities:**
Chemical analysis; Prediction of chemical properties; Reaction planning and synthesis.

# La Sense Group

Our research group is highly interdisciplinary and strongly focuses on translational research. We build new smart materials and interfaces for application in point-of-use sensors and biosensors to detect molecules of biological, medical, and environmental interest. Some of our activities involve the design, engineering, and characterization of new electrochemical sensor materials. A major goal is to develop biosensors that can detect multiple biomolecules simultaneously directly on-the-spot, where the measurement needs to be done, without sample pretreatment. Currently, a variety of projects are underway that focus on the development of biomolecular sensors for disease diagnostics. We also work closely with key industry partners in the biosensors and diagnostic fields, creating hence a pathway to the translation of new technologies.

### Point-of-care biosensors for cancer diagnostics and monitoring

Blood-based cancer biomarkers represent a range of promising diagnostic analytes for the early detection and surveillance of cancer. Current detection approaches involving serology protein-based assays and circulating tumour DNA tests rely upon an intravenous blood draw, sample processing, and testing requiring a specialized laboratory setting. This project aims to advance the development of next-generation cancer biomarker detection for on-spot detection of cancer analytes using rapid and inexpensive portable electrochemical biosensors. This is expected to provide significant benefits for cancer patients, especially in remote locations, where surveillance methods can be limited and expensive for early detection of cancer and monitoring of disease recurrence during treatment.

### Chemical contaminated water: biosensors for rapid, on-the-spot detection

This project aims to develop a versatile biosensor system for rapid on-site detection and monitoring of toxic per- and poly-fluoroalkyl substances (PFAS) in contaminated waterways. PFAS are also known as the 'forever chemicals' and have become a major environmental pollutant that threatens human and ecological health; in Australia PFAS contamination is prevalent in both urban and rural areas, and all Australians are expected to have detectable levels of toxic PFAS in their blood. Current conventional PFAS detection methods rely on sample collection and transport to a centralized laboratory, which is expensive and time-consuming. Thus, there is a need for low-cost portable sensors for the on-spot monitoring of PFAS. In order to achieve specific molecular recognition for PFAS detection, this project will employ protein-based surface chemistries, where fatty-acid binding proteins will be used as the PFAS recognition elements. The produced electrode surfaces will be fully characterized and analytically challenged in 'real-world' contaminated water samples.

### Multiplexed sensors

The ability to simultaneously and precisely detect multiple target analytes in biological samples is a high-reward goal of analytical sensors. Multiplexing capability is necessary for improving diagnostic effectiveness, improving the diagnostic precision for given diseases, and lowering associated costs with diagnoses and disease management.For example, in the case of cancer, most cancers present biomarkers in common with other cancers, thus detection of multiple biomarkers is required for the precise distinction of cancer types and/or location. Therefore, this project seeks to develop new electrochemical sensing platforms for the direct and simultaneous detection of multiple disease biomarkers in high-fouling biological media, for example, blood plasma or whole blood.

### Detection of salivary biomarkers in cardiovascular disease

Cardiovascular diseases are the leading cause of mortality globally. In acute cardiovascular conditions, time is critical for the outcomes of disease management. Provided the ease and noninvasiveness nature of obtaining saliva, salivary biomarkers can offer a rapid and efficient diagnosis of cardiovascular diseases. This project will look into identifying key cardiovascular disease biomarkers present in saliva as well as developing and fully characterizing new electrochemical sensing interfaces for the detection of such biomarkers.

A point-of-use biosensor where the teststrips strips can be manufactured in a large scale.

**Lab Head:** Dr Saimon Moraes Silva (S.MoraesSilva@latrobe.edu.au)

**Lab members:** Currently recruiting PhD and Masters students.

**Fields of Study:**
Biosensors, Point-of-use diagnostics, Electrochemistry, Analytical Chemistry, Synthesis of Biomaterials and Nanomaterials.

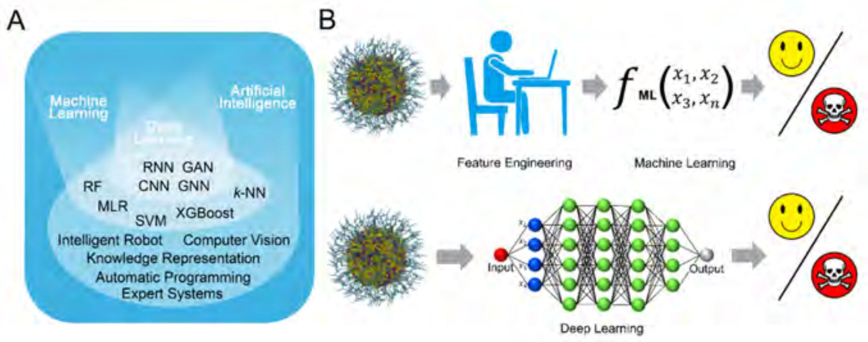
**Capabilities and Techniques:**
We have expertise in electrochemistry, biomaterials, nanomaterials, and surface modification with a strong focus on interfacing materials with biological systems.

**Translational Opportunities:**
We work together with our industry partners to translate and commercialize the next-generation biosensors for medical and environmental applications.

**Twitter:** @moras_saimon

# Materials design using AI and machine learning

Computation is the third arm of research, after theory and experiment. Computational modelling and simulation of molecular systems are becoming indispensable for 21st-century science. However, the size, scale and complexity of realistic materials-biology interactions preclude the application of rigorous, physics-based computational methods like molecular dynamics and quantum chemistry. AI and machine learning are making spectacular inroads into solving these very complex problems. We use a wide range of computational chemistry and AI-based methods to model complex systems and predict their properties. These provide insight into how molecules interact with biology at the molecular level. As these are broadly applicable platform methods, we collaborate with experimental scientists across a wide range of projects, unravelling structure-property relationships problems in materials.




*Machine learning and deep learning.*
*(A) Relationships between AI, ML, and deep learning. ML and deep learning are subsets of AI, and the main approaches to realize AI at present.*
*(B) Main differences between traditional ML and deep learning. Traditional ML needs to generate diverse features before constructing predictive models, while deep learning can directly extract features from raw data. RNN, Recurrent Neural Networks; GAN, Generative Adversarial Networks; CNN, Convolutional Neural Networks; GNN, Graph Neural Networks; RF, Random Forest; MLR, Multiple Linear Regression; SVM, Support Vector Machine; XGBoost, eXtreme Gradient Boosting; kNN, k-Nearest Neighbors*
Photo credit: CC BY-SA 4.0 from Yan, Yue, Winkler, Yin, Zhu, Jiang, and Yan, Chem. Rev. 2023, 123, 13, 8575–8637.

### Machine learning for materials and surface science
In collaboration with colleagues from La Trobe we apply advanced informatics and machine learning methods to extract new knowledge from surface analysis methods. We are applying these methods to tissue profiling or tumour samples and to libraries of polymers that are candidate coatings for implantable and indwelling medical devices. In collaboration with colleagues from La Trobe, RMIT, the GetCO2 CRC and Izmir Institute of Technology, we design catalysts and photo-catalysts for CO2 reduction, and water splitting photovoltaic and electroactive polymers and perovskites for environment and energy applications and nanomaterials for medical applications.

### Next-generation biomaterials
We collaborate on a large University of Nottingham EPSRC project designing new materials for medical applications. We use data from high throughput experiments to build models describing how the chemistry and microtopography of polymeric materials affect cell responses.

### Biomarker discovery
We work with colleagues at Sydney and Monash Universities to find biomarkers for colorectal cancer using sparse feature selection and machine learning and to understand how cytokines and essential amino acids drive stem cell fate.

### Materials for batteries and corrosion control
Working with collaborators from CSIRO, HZG Hamburg, and RMIT (DP240100753, A$530k), we use AI and machine learning to design safe organic corrosion inhibitors to address the >$1Tn market for corrosion control.

### International consortium projects
We were part of two EU Horizon 2020 projects on safety by design of nanomaterials: SABYDOMA, (€6M.1) and (NanoSolveIT (€6M) and a Marie Skłodowska-Curie project on the use of AI in drug discovery (AIDD, €3.93 M). We have recently joined a new EU H2020 project INSIGHT (Models for the Development and Assessment of High Impact Chemicals and Materials, €4.13 M).

Lab Head: Professor Dave Winkler (D.Winkler@latrobe.edu.au)
Research Fellow: Dr Jimiama Mosima Mafeni Mase (Nottingham).

### Collaborators:
Prof Morgan Alexander; Dr Grazziela Figeiredo; Prof Ricky Wildman (Nottingham); Prof Alex Tropsha (UNC Chapel Hill); Prof Nikolai Petrovsky, Dr Sakshi Piplani (Vaxine Pty Ltd, Flinders); Dr Tim Würger; Dr Sviatlana Lamaka; Dr Christian Feiler (Herzberg Institute Hamburg); Dr Ceyda Oksel, (Izmir Institute of Technology); Dr Tu Le; Dr Nas Meftahi; Prof Andrew Christofferson; Prof Rachel Caruso (RMIT); Dr Tony Hughes (CSIRO); Prof Ivan Cole (RMIT); Prof Nico Voelcker; Dr David Rudd (Monash); Prof Michael Morris (Sydney); EU H2020 consortia.

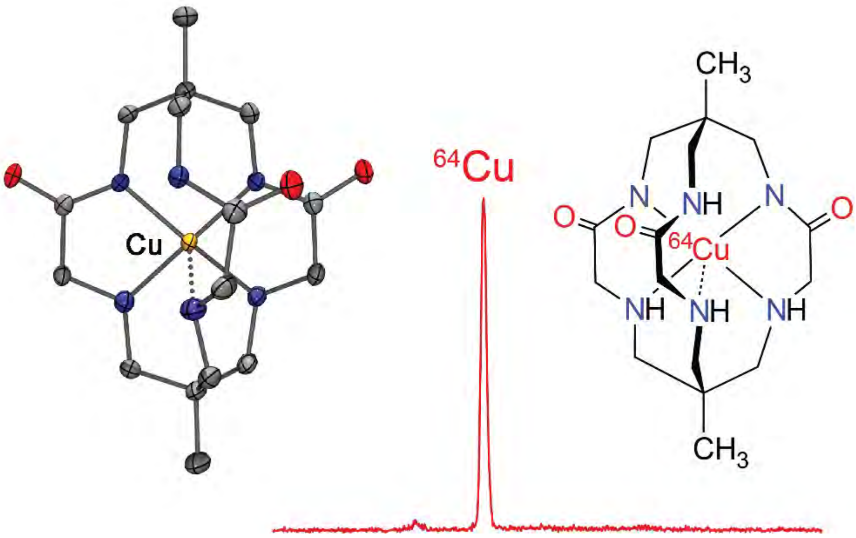
### Fields of Study:
Computational chemistry; drug design; AI and machine learning; materials design; complex systems.

**Capabilities and Techniques:** Mathematical analysis; visualization; and interpretation of complex data.

### Translational Opportunities:
Cancer drugs; biomarkers; materials.

# Medicinal Inorganic Chemistry and Luminescent Sensors

We use chemical synthesis to prepare new organic and inorganic molecules for medicinal and biological imaging applications. Organic synthetic chemistry is used to prepare ligands for the formation of metal-based coordination compounds with properties optimized for use as medicines, imaging agents, and chemical sensors. Our lab has two main areas of research focus, the first is the development of antibacterial silver and gold-based compounds, which are active against multi-drug resistant bacterial strains. The second research area is the preparation of luminescent and radiolabeled molecules for potential chemical sensor and biological imaging applications. To allow for the selective sensing of carbohydrates, boronic acid-based luminophores have been developed as part of a collaborative project with the Australian fine chemical company Boron Molecular.



Triamine cryptate ligand labelled with the positron emitting radionuclide copper-64.

### Silver and gold-based antibacterial agents

Medicinal inorganic chemistry is the development of metal-based compounds as potential medicines. We are working on gold- and silver-based complexes of N-heterocyclic carbene ligands as new antibacterial agents. A series of compounds have been prepared that show excellent activity against both Gram-positive and Gram-negative bacteria and significantly also multi-drug resistant bacterial strains. A noteworthy feature of these compounds is that antibacterial resistance does not develop, whilst resistance is developed against the widely used broad-spectrum antibiotic ciprofloxacin in the same bacterial strains. Current work is focused on evaluating the mechanisms by which these compounds are active and the preparation of targeted gold and silver metallodrugs.

### Synthesis and Studies of Luminescent and Electrochemiluminescent Metal Complexes

We are developing luminescent and electrochemiluminescent coordination compounds of, iridium, gold, ruthenium and the lanthanide metals. These compounds are of interest as biological imaging agents and as luminescent chemical sensors. A particular focus is electrochemiluminescence where the luminescent emission is stimulated using electrochemical processes. Current efforts are directed toward tuning the luminescent properties of d-f heterobimetallic arrays (containing d-block and f-block metals) to provide molecules that are emissive in the infrared region. We are also interested in developing new compounds that can detect and monitor simple sugars and more complex carbohydrates. To achieve this luminescent boronic acid-based molecules that sense carbohydrates have been prepared as part of a collaborative project with the Australian fine chemical company Boron Molecular.

### Radiopharmaceutical Imaging Agents for Disease Diagnosis

In this collaborative project with the Australian Nuclear Science and Technology Organization (ANSTO) we are developing new ligands for radiopharmaceutical imaging applications. A range of ligand systems are being used in combination with metallic radionuclides such as technetium-99m and copper-64. Technetium-99m is the most widely used radionuclide in medical imaging and many technetium-99m labelled compounds are currently used to image a range of disease states. As all isotopes of technetium are radioactive, we develop new chemistry using the metal rhenium and an array of rhenium complexes of N-heterocyclic car bene ligands have been prepared. Significantly, our laboratory was the first to successfully label a N-heterocyclic carbene ligand with technetium-99m.

### Synthesis of amide-based cryptate and cage molecules

The amide or peptide functional group is critical to life as it provides the linkage between adjacent amino acid residues in proteins. Amides also display interesting coordination chemistry and we have utilized the amide linkage to synthesize new cryptate ligand systems. In this work, a range of cryptate and cage ligand systems incorporating amide groups have been prepared (for example the triamidetriamine cryptate ligand shown in the picture).


**Lab Head:** Associate Professor Peter Barnard (P.Barnard@latrobe.edu.au)
**Lab members:** Mr Michael Dewar-Oldis, Mr Quoc Dat Duong, Mr Rahad Rahman, Ms Neha Jangra and Mr Liam Barron.

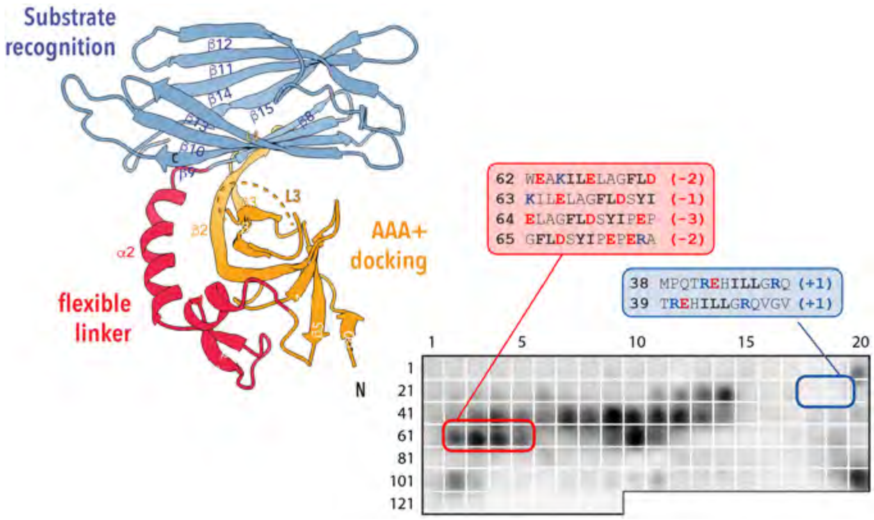

**Fields of Study:**
Medicinal Inorganic chemistry; Organic Chemistry; chemical luminescence.

**Capabilities and Techniques:**
Organic and inorganic chemical synthesis; Medicinal inorganic chemistry; Molecular structural characterization by NMR spectroscopy, mass spectrometry X-ray crystallography.

**Translational Opportunities:**
Chemical synthesis; peptide synthesis; radiochemistry.

# Mitochondrial Proteostasis Lab

Mitochondria are critically important organelles that contribute to a wide range of cellular functions. Unsurprisingly, impaired mitochondrial function is linked to many different diseases including cardiovascular disorders, neurodegeneration and cancer. As mitochondrial proteins and protein complexes are separated from other cellular compartments by a double membrane, specific mechanisms are required for the biogenesis, surveillance, and maintenance of the mitochondrial proteome termed protein homeostasis (proteostasis). A key part of this maintenance is performed by ATP-dependent machines and assembly factors which help protect the organism from disease. Our research focuses on the molecular details of substrate recognition by these machines, from how they recognize protein substrates directly, to how these machines are regulated by specialized components, known as adaptor proteins. Our goal is to conduct fundamental research that improves our understanding of mitochondrial proteostasis in human health and disease.




Structure of human POLDIP2, a novel adaptor protein for the mitochondrial AAA+ protease CLPXP. Peptide array illustrating the features of substrate recognition by human CLPX (Photo credit: David Dougan)

### Complex II assembly

The mitochondrial oxidative phosphorylation (OXPHOS) system fuels the energy demands of most eukaryotes through the generation of the majority of cellular ATP. The OXPHOS system comprises five multi-subunit protein complexes in the mitochondrial inner membrane, termed Complexes I to V. These multi-subunit complexes are composed of redox active cofactors including flavins, iron-sulfur clusters, copper and heme. Assembly of each complex requires assembly factor proteins, which act at several steps, including membrane insertion, subunit association and cofactor incorporation. Mutations in, or the absence of, these assembly factors lead to assembly defects of the various Complexes resulting in mitochondrial dysfunction.
Complex II is composed of four subunits (SDHA, B, C and D). Assembly of these subunits into the final complex requires four dedicated assembly factors (SDHAF1, 2, 3 and 4). Mutations in SDHAF2 affects Complex II assembly, triggering mitochondrial dysfunction and causing cancer. The molecular details and dynamics of Complex II assembly pathway, however, remain unclear. Notably, our unpublished data has identified several uncharacterized assembly intermediates. This project will determine the composition of these intermediates and the precise role of the assembly factors within these intermediates.

### Molecular dissection of protein degradation pathways in mammalian mitochondria

Our group has a strong track record in the study of regulated protein degradation in various model systems from bacteria to mammalian mitochondria. We have made several ground-breaking findings in the field, including the structural and functional dissection of several essential protein degradation components. We previously identified that the AAA+ (ATPases associated with a variety of cellular activity) protease, LONM, is responsible for the turnover of the Complex II assembly factor, SDHAF2, which forms an intermediate complex with SDHA, *en route* to the final functional complex. Importantly, our unpublished data suggest that the turnover of SDHAF2 is facilitated by a short N-terminal degradation (N-degron) tag composed of two elements one of which is occluded in the SDHA-SDHAF2 assembly intermediate. This project will dissect the significance of the N-degron, and the mechanism that triggers release of this degron for progression of SDHA into the final complex.


**Lab Head:** Dr Kaye Truscott (K.Truscott@latrobe.edu.au)
**Lab members:** Dr David Dougan
**International collaborators:**
Prof. Kornelius Zeth (Roskilde University, Denmark); Prof. Kürşad Turgay (MPI, Berlin, Germany)

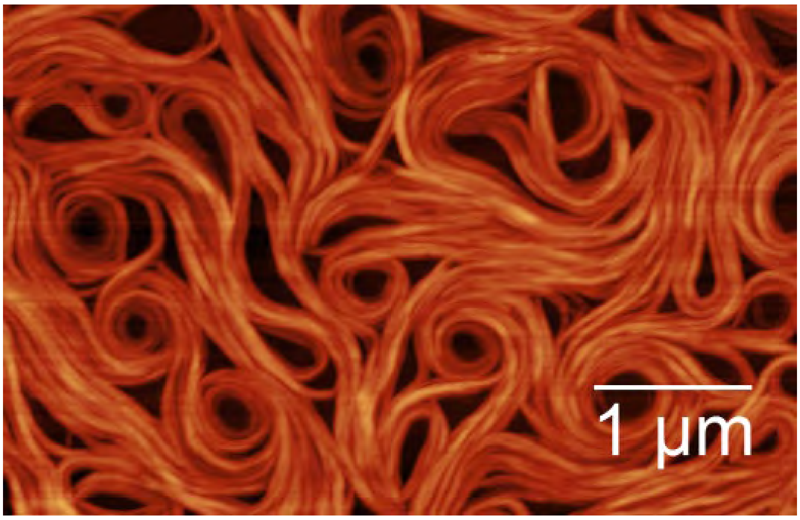

**Fields of Study:**
Biochemistry; Mitochondrial Biology; Microbiology, Cell Biology.

**Capabilities and Techniques:** Biochemistry (protein chemistry, protein structure-function analysis Protein array interactions); Mitochondrial assays, Blue Native PAGE; Bacterial/eukaryotic cell culture.

**Translational Opportunities:**
Our research is fundamental however it will lead to a better understanding of how chaperones, proteases and assembly factors regulate mitochondrial proteostasis and thus may reveal opportunities for small molecule interventions to prevent late onset mitochondrial diseases.

# Molecular Self-Assembly and Nanoarchitecture Group

Our Group studies natural self-assembling systems and uses self-assembly principles to design complex nanostructures. Self-assembly is nature's way of building complex structures from molecular building blocks. Cell membranes, silk fibres and proteins are examples of this process where final structure is the product of a multitude of second order interactions – individually weak, non-covalent bonds between adjacent molecules, the collective effect of which is a strong, stable superstructure. Adapting the self-assembly process to the design of complex nanomaterials from unnatural building blocks requires the study of the natural processes and establishing design rules. This will eventually lead to the development of a "molecular lego" toolbox where the chemical building blocks can be selected to create complex nanostructures.



Self-assembling oligoamides form nano-micro scale hierarchical structures

## Phospholipid Self-Assembly

Self-assembled phospholipid bilayers provide the core structure of cell membranes – the physical boundaries of cells and sub-cellular structures that preserve cell integrity while also serving as a platform for life functions related to metabolism, sensing and intercellular communication. Phospholipids, organised into a two-dimensional bilayer, provide the primary membrane structure. We study the formation and physicochemical properties of phospholipid bilayers of various composition, with microscopic and microspectroscopic methods. Our aim is to describe the structural and chemical characteristics of such biomimetic membranes that are deterministic of their collective properties: phase transitions, tension, bending rigidity, as a function of composition and environmental factors. We create artificial biomimetic membranes on arbitrary surfaces to mimic the physiological environment of living cells, for applications in biophysics, while also furthering the fundamental understanding of lipid self-assembly.

## Peptide-membraneinteractions

Disrupting integrity of cellular membranes underpins many biophysical processes in biology, from immunity to apoptosis and plays many roles in nature, however the mechanism of membrane disruption is not fully understood. We study membrane disruption by antimicrobial peptides which provide innate immunity against pathogens in most living organisms. They disrupt the cytoplasmic membrane of pathogens, facilitate the efflux of essential ions, and thus disrupt ionic homeostasis. We study the molecular mechanism of these interactions, focusing on identifying the factors contributing to the specificity and selectivity of these peptides towards pathogenic membranes. By studying the role of lipid composition, peptide sequence, the physiological environment and temperature at various stages of the interaction, and the role these factors play in switching between disruptive and non-disruptive interaction pathways, we aim to develop novel peptide-based broad spectrum antibiotics for last resort applications in the clinical setting.

## Oligoamide based hierarchical nanosystems and metallosupramolecular frameworks

We developed a unique β3 oligoamide based self-assembling platform that forms fibrous nanomaterials from helical units, like a molecular LEGO set. These molecules fold into highly stable helices with a pitch of 3.0-3.1 amino acids, hence the side chains align in the larger oligomers. The helical form is stable for short sequences and for a wide variation of amino acid side chain geometries and chemistries. Metal coordination crosslinking of these molecular fibres creates a unique metallosupramolecular framework, a platform for development into functional nanomaterials. We study the factors affecting the self-assembly of these molecules, working towards implementing multiple self-assembly motifs and chemical "switches" to create either self-spun fibres, two dimensional arrays, or three dimensional metamaterials. The accessible sidechains offer easy pathways of chemical modification of these oligoamides, which we utilize to implement controlled complexity and physicochemical properties.

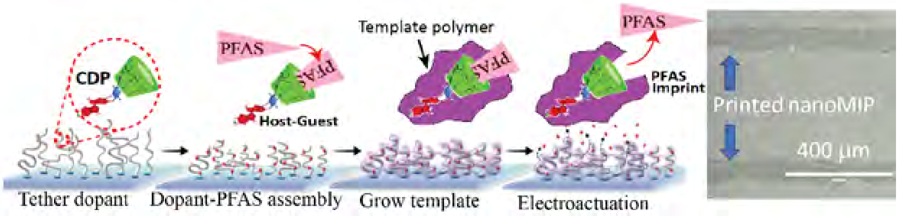
Lab Head: Professor Adam Mechler, FRSC (A.Mechler@latrobe.edu.au)

**Lab members:**
Mr Jose Vilareal-Diaz; Mr Yifan Wang; Ms Zahra Saadatmand; Mr Norton West; Mr Abdalwahab Alshammari.

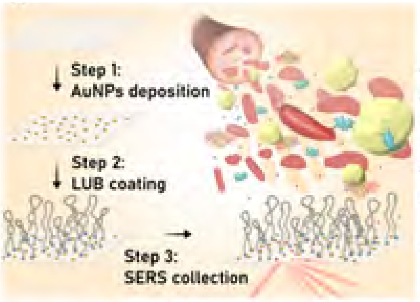
**Fields of Study:**
Physical Chemistry; Lipid Self-Assembly; Antimicrobial Peptides; Hierarchical Nanostructured Materials; Surface Chemistry.

**Capabilities and Techniques:**
Biomimetic solutions for biomedicine; Delivery and effectiveness of antimicrobial peptides and nanoscales.

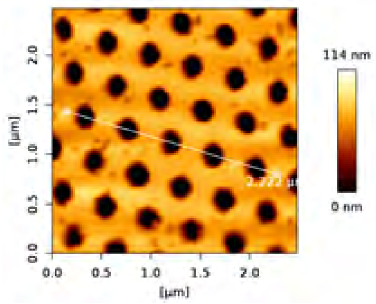
# Multifunctional and Advanced Interfaces Group




Schematic of nanoscale molecularly imprinted conductive polymers




Schematic of non-fouling optical




Nanoimprinted hole array in glass created using pressure solution

Our lab utilizes the physical chemistry of interfaces to engineer innovative materials and surfaces that exhibit multifunctional and responsive properties. Utilizing a multidisciplinary approach which draws on principles from biology, electrochemistry, inorganic chemistry, and geology, we control intermolecular and interfacial interactions and interfacial electric fields to create biosensors, drug delivery, bionic, and nanofabrication technologies. Some of the research activities of the lab include:

## Non-fouling optical sensing interfaces

Surface-Enhanced Ramam scattering (SERS) is perhaps one of the most versatile transduction mechanisms, with sensitivity to a wide range of analytes and potential for single molecule detection. However, this extreme sensitivity makes the technique exceptionally prone to fouling as signals from any non-specifically adsorbed molecules may also be strongly amplified. Taking advantage of the size selective transport properties of an antiadhesive protein called 'lubricin,' non-fouling, molecular sieving interfaces have been created that can separate small molecule analytes from highly fouling biological fluids (e.g., blood). Using these molecular sieving interfaces, highly sensitive SERS-based optical sensing can be carried out directly in highly fouling media with minimal to no sample processing (extraction, separation, dilution, as is standard practice).

## Nanoscale molecularly imprinted conductive polymers

Molecularly imprinted polymers (MIPs) are synthetic polymers with antibody-like binding selectivity to a given molecular target/analyte. Although MIPs have become a powerful tool in preparative/analytical chemistry and sensing, they fall short of their potential due to the high susceptibility to non-specific binding and fouling that currently can only be overcome by extensive sample treatment and processing. This project combines the anti-adhesive protein lubricin with a newly invented 'surface-tethered dopant templating' technique for growing ultra-thin (i.e., < 10 nm), electrically conductive, and optically transparent nanoscale MIPs which exhibit high target binding selectivity. These non-fouling nanoscale MIPs' can be utilized in highly fouling biological fluids or wastewater to selectively capture target molecules in electrochemical/optical sensor systems or solid-phase extraction applications

## Geologically inspired nanofabrication

This project is inspired by 'pressure solution' (PS); a fundamental 'deformation' and mass transfer mechanism in Geology. At its heart, PS describes the enhanced dissolution rate observed when two minerals are pressed together at high pressure in an electrolyte. My lab has recently discovered the electrochemical origins of PS in which an interfacial electric field created when two dissimilarly charged surfaces are pressed together can significantly accelerate the rates of dissolution of certain inorganic materials (e.g., silica, alumina, calcite, etc.) by as much as 1,000,000 (106) times. Because PS only occurs where two surfaces are in 'contact,' PS can be used to selective remove material underneath a patterned surface or a sharp AFM tip to etch nanostructures using only water and ambient temperatures. PS enables powerful nanofabrication tools like nanoimprinting and direct write lithography, currently only able to pattern 'soft' polymer substrates, to directly pattern hard and functional inorganic substrate

Lab Head: Associate Professor Wren Greene (W.Greene@latrobe.edu.au)

Lab members:
Ms Luiza Nasciomento
Mr Rahiel Rasool,
Mr Williams Kwaku
Ms Oshin Misquita

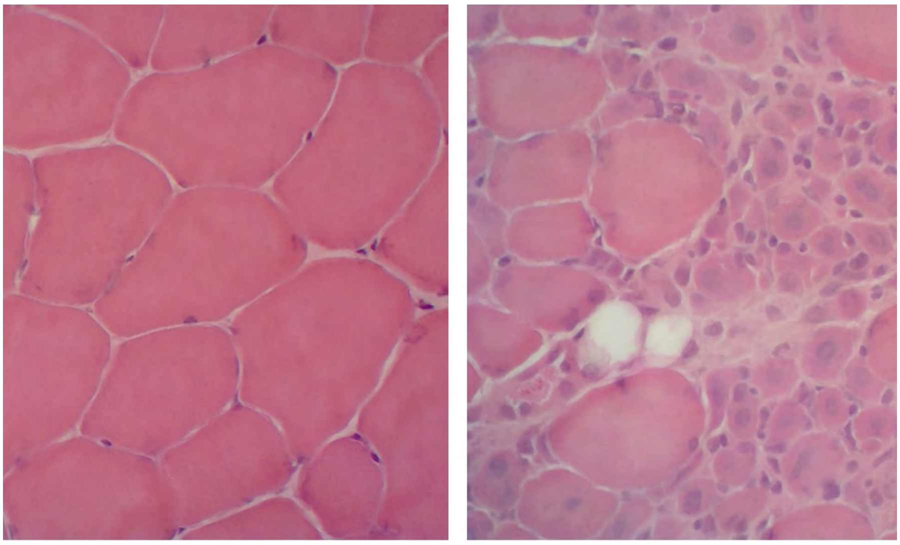
Fields of Study:
Physical Chemistry, Electrochemistry, Materials chemistry, Soft Matter, Interfacial Science.

Capabilities and Techniques: Electrochemical methods, Optical Spectroscopy, Atomic Force Microscopy, Surface and Interfacial chemical modification and characterization.

Translational Opportunities:
Sensor and Diagnostics technology, nanofabrication methods.

# Muscle Biochemistry Group

The Muscle Biochemistry Laboratory focuses on understanding aspects of muscle function and biochemistry in both health and disease. The laboratory is situated in the LIMS1 building, with full access to all biochemistry facilities. The overall research interest of the laboratory is in the area of skeletal muscle in health and disease. The laboratory focuses on various aspects of skeletal muscle biochemistry, using exercise and disease models in humans, as well as animal models. In particular, the laboratory pioneered and optimised the measurement of proteins in very small samples sizes. This allows proteins to be measured in small segments of individual muscle fibres allowing issues with the heterogeneity of skeletal muscle to be overcome. We also examine movement of proteins following micro-dissection of fibres, allowing quantitative assessment of the redistribution of proteins following various interventions, in particular exercise.



H&E staining: healthy (left) & damaged (right) skeletal muscle (Photo credit: Robert Barker)

### Calpains and MMPs

Calcium dependent proteases calpains, and metallomatrix proteinases (MMPs) have been touted as playing similar roles in muscle. To understand their potential, improving our understanding of their regulation and functional properties in the physiological milieu is crucial. If an individual has an absent or non-functional muscle specific calpain-3, they develop a type of muscular dystrophy (LGMD2A). We have identified that calpain-3 likely plays a role in muscle repair. MMPs play a diverse role in the body, with MMP2 and MMP9 linked to muscle degenerative processes. We use exercise as a manipulation to alter intracellular calcium levels and to investigate how lengthening, or eccentric contractions can affect the activation of calpains and/or MMPS, and to identify their in vivo cellular targets.

### Glycogen related proteins

By removing the surface membrane of a skeletal muscle fibre by microdissection, we can quantitatively assess crude localisation of proteins in muscle. Our research has revealed that glycogen related proteins are differentially associated with the glycogen granule in vivo and also that the important energy sensing molecule, AMPK, along with the glucose transporting protein, GLTU4, are not associated with the glycogen granule. These findings debunk the theory that glycogen utilisation directly affects their function. We continue to explore how these proteins, are involved in skeletal muscle function, in particular in response to exercise and diseases such as type 2 diabetes. Importantly, we are trying to understand what the mechanisms are that result in an improvement in this metabolic disease following exercise interventions.

### Mitochondrial dynamics

Mitochondrial content has been described as being reduced with aging, however using our quantitative approaches to protein assessment, we have shown in healthy older adults there is no loss of mitochondrial content or in the ability of mitochondria to adapt to exercise. We identified that an increase in mitochondrial dynamics may be in some way protective to the muscle and overall function.

**Lab Head:** Professor Robyn M. Murphy (R.Murphy@latrobe.edu.au)

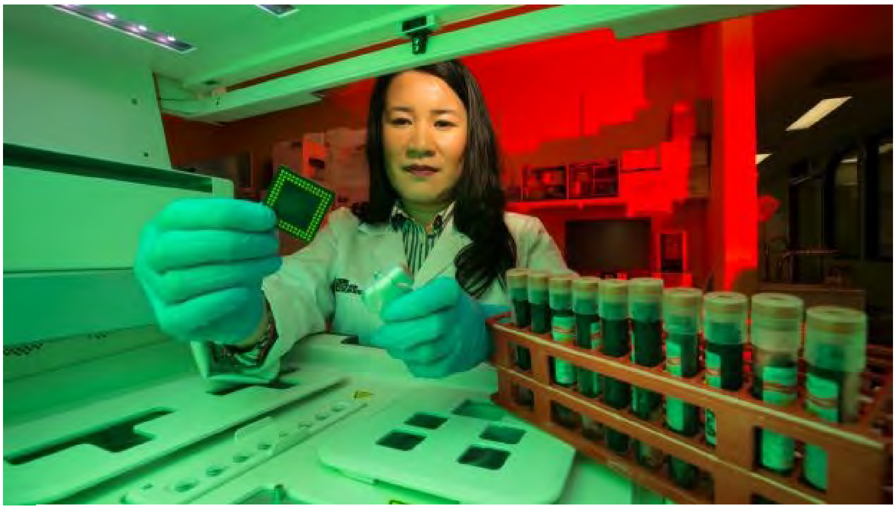
**Lab members:**
Dr Noni Frankenberg; Dr Barney Frankish; Dr Stefan Wette; Dr Robert Barker; Ms Heidy Flores; Ms Amy Pascoe; Ms Oliva Timson Smith.

**Fields of Study:**
Biology with Physiology (cellular, animal and biochemistry); Medical Physiology; Human Movement and Sports Science.

**Capabilities and Techniques:**
Chemidoc imaging (fluorescent, chemiluminescence & UV lights); Leica semi-automated crysostat, LabConco freeze-dryer; Polytron homogenisor for small volumes; Eppendorf refrigerated benchtop microfuge centrifuge; Ultra-sensitive, low volume western blotting.

**Translational Opportunities:**
Muscle disease diagnostics; exercise physiology; exercise interventions for aged individuals.

# Neurodegeneration EV Biology and Biomarker Group



Testing blood samples for neurodegenerative diseases (Photo credit: James South)

Neurodegenerative diseases, such as Alzheimer's disease (AD) is one of the leading causes of death world-wide. At the early stages of AD, neurons that control memory and thinking are attacked by toxic proteins that causes pre-mature neuronal death. Brain tissue becomes damaged, and patients begin to experience symptoms such as dementia related memory and cognitive impairment – a stage of disease when it is difficult to repair with disease-modifying drugs. Currently, the diagnosis process involves invasive procedures such as brain imaging and cerebrospinal fluid testing but is often performed at the symptomatic stage when damage to the brain has begun. Hence, there is currently an unmet need for an early, convenient, low-invasive blood-based test to diagnose AD. Our group focuses on developing diagnostic tests for neurodegenerative diseases such as Alzheimer's and Parkinson's disease but, also other similar dementia disorders to allow for differential diagnosis.

## It's in the blood – Extracellular Vesicles

Exosomes are extracellular vesicles (EVs) that are secreted from cells and tissues where they can then be found circulating throughout the body. They can carry protein and genetic material which have been shown to reflect the host cell. EVs can be isolated from blood making them a potential source of disease biomarkers. Our hypothesis is that EVs secreted from neurons within brain tissue can migrate through the blood brain barrier (BBB) into the blood whereby brain biomarkers are readily detected and reflective of disease occurring the brain, equivalent to a 'liquid biopsy' of the brain. We utilise 'Next-Generation' deep sequencing to identify all the RNA species, in particular microRNA, in EVs isolated from human post-mortem brain tissue and blood of patients with neurodegenerative diseases.

## Brain-derived EVs

Historically, it has been challenging to develop biomarkers for brain diseases as neurological biomarkers do not cross the BBB so sampling peripheral whole blood is not reflective of the brain. However, brain-derived EVs (BDEVs) can cross the BBB through specialised transport channels that allow BDEVs to pass the BBB. Our research group has the capability to isolate BDEVs from human brain tissues, a complete game-changer from using cell culture models. We can now investigate the contents and role of EVs isolated from the brain of patients diagnosed with a neurodegenerative disease from an entirely new perspective.

## The role of EVs in neurodegeneration

We use genomics and proteomics to profile the contents of BDEVs in search for proteins and RNA associated with neurodegenerative diseases. Those we identify are used as potential disease biomarkers but are also further studied in cellular and mice models to understand their role in the pathology of neurodegenerative diseases. We use an array of molecular, cell and protein biology methods to discover biological pathways that are implicated in neurodegenerative diseases and determine whether EVs assist and/or accelerate the disease process.

## EV biogenesis of the BBB

Our group seeks to understand the endosomal and non-endosomal pathways of EV biogenesis and release from human brain endothelial cells of the BBB. We will use cellular models of the BBB together with super-resolution microscopy to visualise EVs within endosomal structures and track their movement across the BBB to the periphery. Unravelling the biogenesis pathways of EVs at the BBB will allow us to manipulate these pathways to deliver therapeutic EVs to the brain to treat neurodegenerative diseases.

Lab Head: Dr Lesley Cheng
(L.Cheng@latrobe.edu.au)
Lab members: Ms Robyn Sharples; Mr Mitch Shambrook; Mr William Phillips; Mr Christopher Reimann, Mr Priyank Gaijar; Mr Mihim Fernando.

## Fields of Study:

Neurodegeneration, biomarkers, genomics, diagnostics and extracellular vesicles

## Capabilities and Techniques:

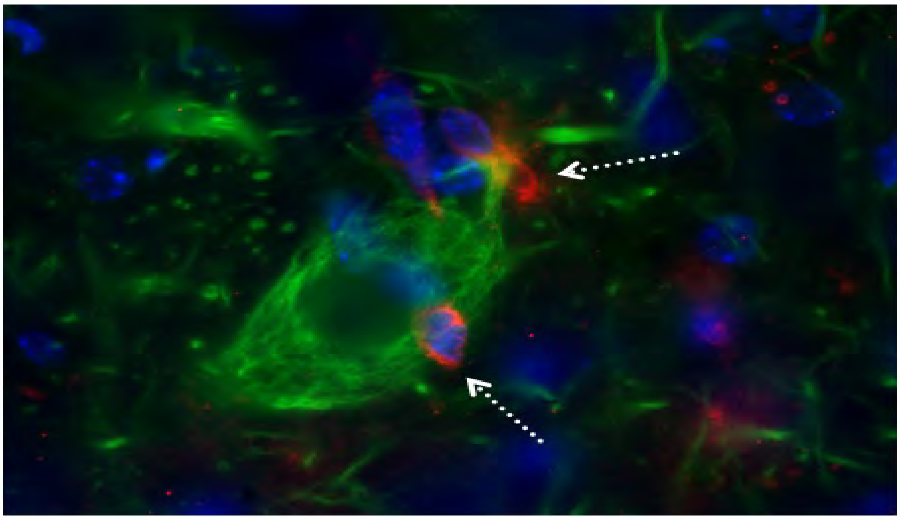
Cellular, tissue and biological fluid extracellular vesicle purification and characterisation, Molecular diagnostics, Genomic sequencing, proteomics, qRT-PCR/ Digital PCR, automated laboratory instruments, cell culture, cellular imaging

## Translational Opportunities:

This research will develop a diagnostic blood test capable of specifically detecting brain-specific disease indicators associated with neuropathological changes in the brain. This would also allow for monitoring decline or improvements during therapeutic treatment. We are currently working with several industry partners within the R&D sector to investigate the use of EVs in therapeutics and diagnostics.

# Neurodegeneration and Neurorepair Group

Our laboratory focuses on multiple sclerosis (MS), an autoimmune and neurodegenerative disorder of the central nervous system (CNS). The cause of MS is unknown, but incidence and prevalence of this disease is rising worldwide. Treatment options are unsatisfactory, because of poor understanding of mechanisms underlying tissue destruction, or of the relationship between evolution of these mechanisms and clinical progression. Our goal is to clarify the pathological processes of tissue destruction and the accumulation of neurodegeneration, from the pre-clinical stage. We have developed multiple animal models that mimic facets of MS, as well as approaches including standard histopathological, advanced imaging and molecular techniques. Our long-term aim is to identify primary and targetable mechanisms for early intervention and prevent irreversible neurodegeneration.



Neuron stained with antibody to neurofilament protein (green) targeted by $CD3^{+}$ T cells (red) during the acute phase of EAE. Nuclei are stained with DAPI (blue). (Photo credit: Anton Ramp)

### Modelling MS

There is no accurate MS model. Instead, experimental paradigms have been developed to study various facets of MS, including virally-induced CNS inflammation (Theiler's murine encephalomyelitis virus model), chemically-induced demyelination (cuprizone, lysophosphatidylcholine) and autoimmune-mediated demyelination (experimental autoimmune encephalomyelitis [EAE]). The EAE model is preferred because it exhibits both inflammation and demyelination. We have developed EAE variants using defined combinations of neuroantigen: mouse strain. This results in clinical progression exhibiting chronic-progressive, chronic-relapsing, or monophasic disease, which can be T cell or B cell-driven. Clinical progression and pathological hallmarks over the disease trajectory have been mapped. We have investigated the earliest timing and mechanisms of neuronal loss and evaluate drug efficacy. Future developments include chemically-induced demyelination models to investigate remyelination strategies.

### Mechanisms of neuronal loss

MS inflammation is relatively well understood and treatable with immunomodulatory drugs. However, neurodegeneration is poorly addressed. Existing MS therapeutics improve quality of life, but do not arrest the neurodegenerative process or actively promote remyelination. Our lab identified an early and critical role for platelets in neurodegeneration in EAE. We identified platelets in the CNS from the pre-onset stage, throughout the whole CNS and specific platelet targeting of neurons. We also demonstrated platelet targeting of myelin. Behavoiural studies have revealed neuropsychological symptoms prior to disease onset. We propose that platelets are the substrate of neurodegeneration and that platelet targeting is a novel strategy for early intervention in MS.

### Targeting neuroinflammation

Historically, the inflammatory component of MS has been the focus of drug development, via T and B cell targeting. With respect to T cell targeting, we have demonstrated the efficacy of the S1P analog FTY720 in reducing disease severity. Our studies have revealed high-level complexity responses by the S1P receptor family, whereby each of the receptors expressed in the CNS exhibits differential dose-related and region-specific changes in response to treatment. Using a B cell driven EAE variant, we mapped B cell compartmentalization and showed efficacy of anti-CD20 drugs in disease attenuation. Immunomodulation does not ameliorate neuropsychological symptoms, suggesting that immunomodulation is not neuroprotective.

### Platelet targeting in neuroinflammation

In view of the evidence of the early and driving role of platelets in neuroinflammation and the inefficacy of immunomodulatory drugs in promoting neuroprotection, we further investigated the potential of platelet-targeting. Current evidence shows that blocking platelet reactivity is associated with both inhibition of inflammation and restoration of myelination and function. Future studies will elucidate mechanisms underlying the multi-faceted consequences of platelet targeting.

**Lab Head:** Dr Jacqueline M Orian (J.Orian@latrobe.edu.au)
**Lab members:** Ms Jing Ting Vernise Lim (PhD student); Mr Hussam Al-Saraji (Honours Student); Ms Xiaoya Li (Master's student); Ms Sivar Sanjana Iyengar (Master's student).

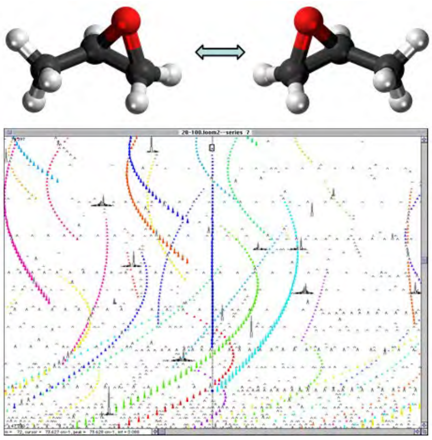
**Fields of Study:**
EAE models, multiple sclerosis, myelin biology, neuroimmunology, platelets.

**Capabilities and Techniques:**
Generation of B and T cell driven EAE variants; Neuroanatomy; Histology; Brightfield and confocal microscopy; Unbiased counting techniques.

**Translational Opportunities:**
Pre-clinical evaluation of candidate multiple sclerosis and remyelination therapeutics.

# Optical Spectroscopy of Atmospheric, Astrochemical and Biological molecules

There is more to light than meets the eye. Light with wavelengths invisible to human sight but detected by sophisticated instruments called spectrometers provide us with a detailed view of the "nanoscopic" molecular world that underpins daily life. We exploit powerful light sources such as infrared, visible and ultraviolet lasers, or the Australian Synchrotron's infrared beamline to study molecules relevant to pharmaceutics, atmospheres and astrochemistry. For example, this type of molecular sensing can reveal the shape of neurotransmitter molecules that act as the 'key' in receptor 'locks' involved with signaling in the brain, the details of how much radiant heat is absorbed by greenhouse gases, the size and temperature of ice nanoparticles like those in high altitude clouds, or the spectral fingerprint patterns that allow molecules in space to be identified through radioastronomy.



Left and right-handed forms of propylene oxide form patterns of spectral lines like those observed by radio astronomy

## Molecules in Space

Life on earth is intrinsically chiral. In the building block molecules such as proteins and sugars, "left-handed" or "right-handed" forms are possible, but only one one type is found and the reason for this choice remains unclear. Astrochemistry may well play a role and yet amongst the 200 molecules detected in the interstellar medium outside our solar system to date, propylene oxide is the only one that is chiral. We are undertaking work to increase understanding of its' spectral properties in the crucial microwave region used for detection. Other work is aimed at finding other chiral molecules in space and identifying the molecules responsible for thousands of unidentified absorption lines measured by radioastronomy.

## Atmospheric molecules and their greenhouse absorptions

The absorption of infrared radiation by greenhouse gases in the atmosphere is at the heart of human induced climate change. Some of our research into fluorocarbons has revealed the fine details that may be used to efficiently model the complex pattern of IR absorption within the atmospheric greenhouse window. One of our targets has been dichlorodifluoromethane, commonly known as CFC-12 or refrigerant R12, which despite being present in concentrations of less than one part in a billion has a warming contribution exceeded only by carbon dioxide, methane, and nitrous oxide. Aerosols also play a key role in our atmosphere, affecting the climate both directly through absorption and reflection of light, and indirectly by hosting chemical reactions and influencing cloud formation. Research to investigate the formation, composition and behaviour of aerosols is critical to improve the climate models. A specialised cooling cell with unique capabilities at the Australian synchrotron's IR beamline enabled us to measure the first far IR spectra of water ice nanoparticles. Such particles as are found in cirrus and mesospheric clouds on earth, and in non-terrestrial environments such as Mars, Titan and the interstellar medium.

## Conformational shape of biomolecules

The conformational shape of biological molecules, and their interactions with the surrounding environment including water molecules are critical to their functioning. Laser-based gas phase spectroscopy combined with appropriate computer modelling generates precise structural information on molecules such as neurotransmitters that provide a rigorous platform for understanding their behaviour and ultimately, rationalizing drug design. The resonant two photon ionisation technique allows electronic and IR spectra to be measured for molecules cooled to a few Kelvin. This results in beautiful, simplified spectra that can be interpreted to reveal the preferred shapes of molecules and how strongly they interact via hydrogen bonding with water.

Lab Head:
Associate Professor Evan Robertson
(E.Robertson@latrobe.edu.au)

Lab members:
Mr Luigi Villani,
Mrs Ishara Peiris,
Mr Kaidan Rolfe.

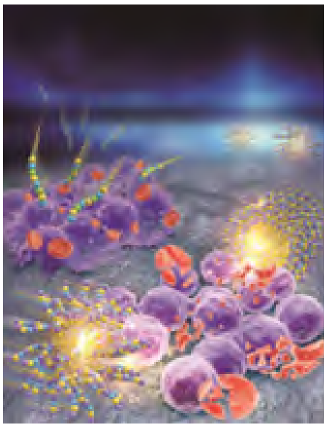
Fields of Study:
Atmospheres, Astrochemistry, Molecular spectroscopy, Vibrational spectroscopy

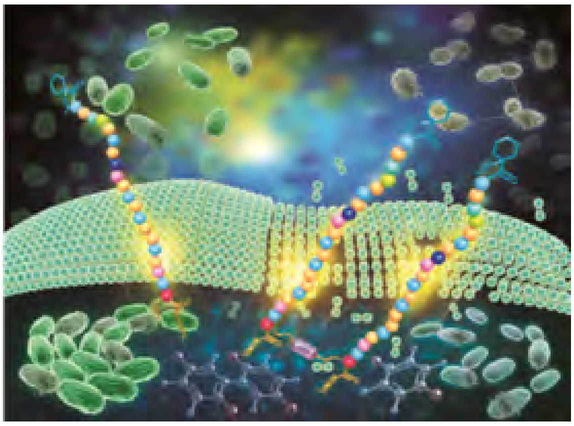
Capabilities and Techniques:
Infrared and Raman Spectroscopy, pulsed ns laser systems, ab initio quantum chemistry, rovibrational analysis.

Translational Opportunities:
Gas sensing, applications of Raman spectroscopy extending into many fields.

# Peptide Chemical Biology Group

The healthcare costs of antimicrobial resistance (AMR) in Australia are estimated at over $1 billion a year. Globally, the World Health Organisation predicts that AMR will cost the world up to 100 trillion USD in 2050. Given the emergence and spread of AMR, alternatives to antibiotic drugs are urgently needed. Antimicrobial peptides (AMPs), which form part of a native host defence system, could be a promising solution to this problem. They can have potent and broad-spectrum antimicrobial activity with a reduced tendency to induce resistance. To develop novel alternative antibiotics, our group's research focuses on chemical modifications to enhance their effectiveness and result in significant conformational changes, such as multimerization, bioconjugation and lipidation.





Membrane active peptides targeting bacteria and red blood cells. (Cover designs from our recent publications )

### Antimicrobial peptide-antibiotic conjugates

One solution for contending with multi-drug resistant (MDR) bacteria is the use of combinations of conventional antibiotics. The use of antimicrobial peptides (AMPs) in combination with, or covalently conjugated to, inexpensive antibiotics such as cephalosporin, may provide important specific antibiotics. However, this approach has met with little success due to the difficulties associated with chemically linking dissimilar compounds, particularly the small molecule antibiotics which have limited non-active site availability of functional groups for anchoring. Covalent conjugation of a conventional antibiotic or small molecules to a peptide can be achieved by either total solid phase synthesis using suitably protected and derivatized antibiotic or in solution via a variety of bimolecular reactions. Therefore, in this project, we aim to apply different linker and conjugation approaches to enhance the bioactivity of AMPs and investigate their mode of action.

### Antimicrobial peptide multimerization

This project involves the multimerization of AMPs to confer improved properties on other AMPs by enhancing their cationic charge and improving their interaction with bacterial membranes. The research team has developed a series of new dimeric AMPs to target WHO priority critical Gram-negative bacterial pathogens, such as *A. baumannii* and its multi-drug-resistant strain. They plan to prepare analogues of selected peptides and screen several bifunctional linkers to determine the general applicability of this method.

### Dual-function molecules

Chronic wound infections are major complications of Diabetes mellitus and are responsible for significant morbidity and mortality. Over 50% of diabetes patients with Diabetic foot ulcers (DFUs) are estimated to develop diabetic foot infections by a polymicrobial community of microorganisms with wound chronicity. The increasing resistance of pathogens to antibiotics causes a huge clinical burden that places great demands on academic researchers and the pharmaceutical industry for resolution. Previously, we identified two leading AMPs, Pardaxin (1-22) and MSI-78 (4–20) (Clinical Trial Pexiganan derivative), that possess effective antibacterial activity against bacteria, including *Escherichia coli* and *S. aureus*. More recently, our recent study showed that the lipidated chemical modification enhanced their antibacterial activity against pathogens, but also increased their cytotoxicity. In this project, we will develop novel potent AMPs against DFI pathogens with wound healing properties on innovative chronic wound models.

**Lab Head:** Dr Wenyi Li
(Wenyi.Li@latrobe.edu.au)

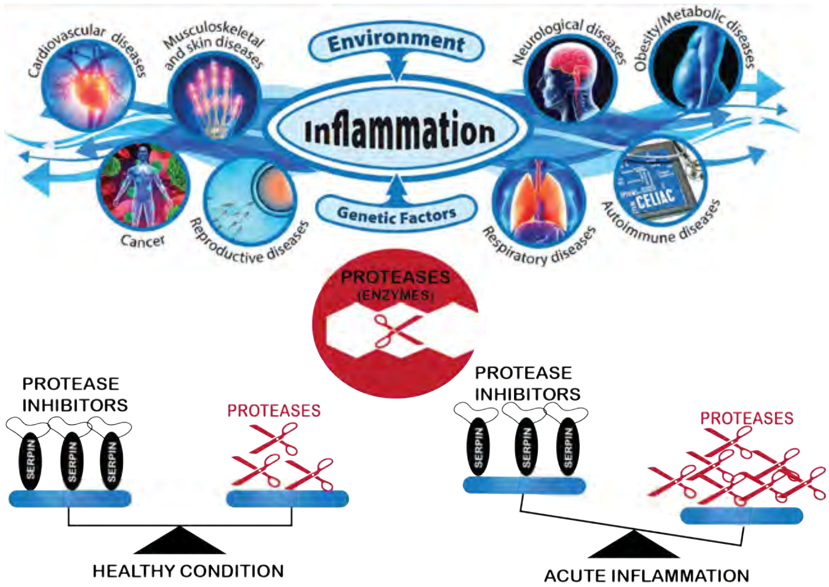
**Lab members:**
Dr Praveen Praveen;
Ms Claire Lai.

**Fields of Study:**
Chemical Biology; Peptide chemistry; Antibiotics; Antimicrobial resistance; mode of actions.

**Capabilities and Techniques:**
Chemical synthesis for various bioactive peptides, including membrane active peptides and posttranslational modifications; Bioassays for antimicrobial determination in vitro and in vivo of Galleria Mellonella infectious model.

**Translational Opportunities:**
Antibiotics; infectious diseases; drug delivery; diagnosis.

# Protease Biology Group




Proteases are involved in multiple biological processes, including the regulation of inflammation. They have been shown to initiate and terminate proinflammatory or anti-inflammatory responses. The dichotomy in the biological roles that proteases exert is essential to drive acute inflammation toward the resolution phase to later return to homeostasis. However, when left unchecked, proteases can also promote inflammatory diseases. Importantly, proteases play both protective and detrimental roles in inflammatory diseases. Therefore, a greater understanding of proteases coupled with development of strategies to monitor and inhibit their activity is likely to have significant positive impact on human health conditions such as thrombosis, cancer, haemophilia, inflammation, and viral diseases.We are a protein biochemistry laboratory using techniques in molecular biology, protein biochemistry and enzymology to understand how the human body responds to infection and disease by dissecting the activity of enzymes called proteases. We use this mechanistic information to study a crucial part of our immune defenses, the Complement system as well as strategies developed by bacterial pathogens and viruses use in order to avoid killing by complement, which results in infections and disease. In the words of Professor Piet Gros, "The challenge lies in understanding the greater picture. It's about understanding the way in which different molecules work together in a process where everything must happen at exactly the right place and at exactly the right time." The moment when you start to understand how the complex system works is the most gratifying element of this job."

### Regulation and control of the complement system in immunity

The complement system is vital in preventing disease caused by infections. The system is also implicated in many diseases associated with excess inflammation. We are studying the classical and mannose-binding lectin (MBL) pathways of complement activation, both of which are associated with inflammatory diseases. These pathways involve the sequential activation of proteins by a cascade of proteases. Our lab focuses on the initiating proteases of the two pathways: C1r, C1s and the MBL-associated serine proteases (MASPs). Our lab examines how these proteases interact with their target substrates and their regulatory inhibitor, C1-inhibitor. We plan to develop specific protein and peptide inhibitors of the different proteases to determine their roles in diseases.

### The enemy within: targeting the virsl entry facilitator of SARSCoV2

The COVID-19 pandemic caused by SARS-CoV-2 has posed an enormous challenge to public health, and the threat still has a significant impact on humanity. The molecular properties of SARS-CoV-2 infection have been quickly elucidated, paving the way to therapeutics, vaccine development, and other medical interventions. Despite this progress, the detailed molecular mechanism of SARS-CoV-2 infection remains elusive. Given virus invasion of cells is a determining factor for virulence, understanding the viral entry process can be a mainstay in controlling newly emerged viruses. TMPRSS2 is a type II transmembrane serine proteases (TTSP) that has been shown to be crucial for host cell viral entry and spread of SARS-CoV-2, as well as SARS-CoV, MERS-CoV, and influenza A viruses. Our team has extensive expertise in the study of serine proteases involved in infection-driven inflammation and intracellular host responses. We will use our cross-disciplinary expertise to examine the proteolytic signature of viral infectivity by examining the enzymatic function and structure of TMPRSS2. We will then use this knowledge to dismantle the host cell machinery that enables the virus to infect the host cell and spread from one cell to another. We anticipate that this work will provide mechanistic insights into precisely how TMPRSS2 acts as a host factor that is essential for the infectivity of SARS-CoV-2. Many medically significant viruses require host cell proteolytic activation to result in functional infectious particles, making the unravelling of the infection process by targeting host-derived machinery in this study highly relevant to both basic science and potential therapeutic applications.


Lab Head: Dr Lakshmi Wijeyewickrema
(L.Wijeyewickrema@latrobe.edu.au)
Lab members:
Professor Rob Pike; Ms Jing Pang

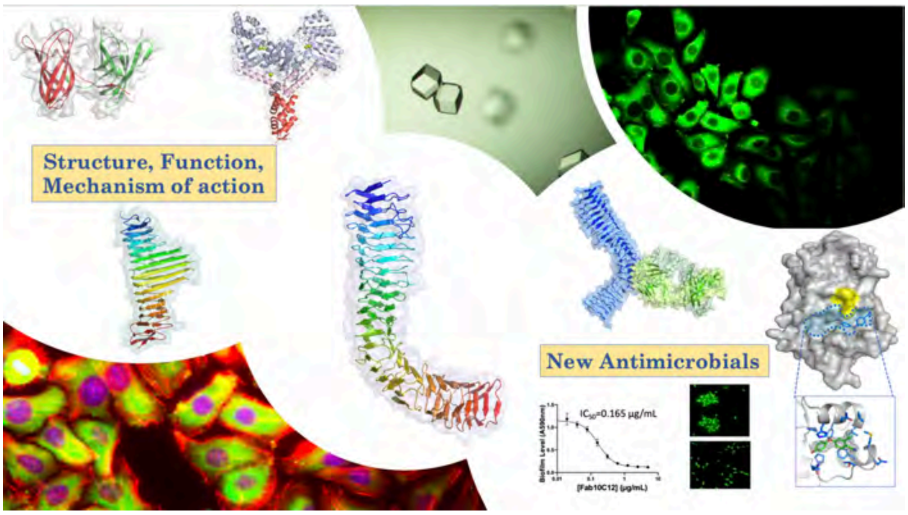

Fields of Study:
Innate Immunity; Enzymes; Enzyme inhibitors; Coagulation; Viral Entry.

Capabilities and Techniques:
Protein production; Enzyme kinetics; Protein Biochemistry.

Translational Opportunities:
Development of specific inhibitors.

# Structural Biology and Bacterial Pathogenesis Group

Antimicrobial resistance (AMR) is recognised by the World Health Organisation (WHO) as a critical threat to human health. The overuse of antibiotics has led to AMR bacteria (superbugs), which are now widespread in hospitals around the world. In 2019, AMR infections were associated with 4.98 million deaths worldwide, placing resistant bacteria among the leading causes of death for people of all ages. Meanwhile, the antibiotics development pipeline is near-empty which demands for the urgent development of new molecules to fight bacterial infections. Our research examines the molecular mechanisms underlying bacterial infections. Our multidisciplinary approach combines X-ray crystallography, molecular biology, biochemistry and biophysics to investigate the structure-function relationships in proteins involved in bacterial pathogenesis. Our work provides new knowledge on therapeutically important microbial proteins and the tools to guide the development of new antimicrobial classes.




**Structure, Function and Mechanism of action of bacterial virulence proteins** Bacterial pathogens deploy an arsenal of virulence factors to establish infection and cause disease. Autotransporter proteins, the largest group of outer membrane and secreted proteins in bacteria are involved in host cell adhesion and toxicity, and promote the formation of aggregated communities and biofilms, which are critical strategies bacteria use to resist the host immune response and antibiotics. Autotransporters are also highly immunogenic and are integral components of human vaccines. We study how autotransporter proteins promote disease and allow bacterial survival by forming protective biofilms. We focus on important therapeutic autotransporters and investigate their mode of action at atomic resolution, as well as whether inhibition of autotransporter function prevents infection.

**How bacterial pathogens make toxins and antibiotic resistance enzymes**
Bacteria produce folding enzymes (foldases) necessary to produce functional virulence factors. These include the Dsb family of proteins, which catalyse a key step in the protein-folding pathway, the introduction of disulfide bonds. Mutants defective in the Dsb pathways have reduced fitness and pathogenic potential. Our team, in collaboration with national researchers, is leading the structural-functional characterisation of these key bacterial enzymes. We dissect the molecular mechanisms through which some bacteria catalyse the folding of proteins involved in host infection and bacterial resistance. Our studies provide structural information to guide inhibitor development.

**Harnessing structural information to drive the discovery of antimicrobials**
The increase of antimicrobial resistant infections highlights the critical need for new therapeutics. We are developing novel antibiotics that target virulence rather than viability. Disarming rather than directly killing bacteria is a new paradigm for antibacterial therapy that will lead to lower resistance rates than current antibiotics. We are developing small drug-like molecules or antibody inhibitors against key enzymes, secreted toxins and biofilm forming proteins from multidrug-resistant *Enterobacteriaceae*. For example, we have developed monoclonal antibody-based inhibitors that bind to specific autotransporter proteins and prevent the formation of bacterial biofilms. We have patent-protected this novel technology, which represents an entirely new strategy for targeting bacterial biofilms and meets all four innovation criteria defined by the World Health Organisation (WHO) - new mode of action, no cross-resistance to antibiotics, new target and new chemical class.

**Lab Head:** Associate Professor Begoña Heras (B.Heras@latrobe.edu.au)
**Lab members:** Dr Jason Paxman (Snr Postdoc); Dr Tony Wang (Adjunct); Dr Pramod Subedi (Adjunct); Dr Lilian Hor (Adjunct); Mr Carlos Santos; Ms Akila Pilapitya; Ms Kaitlin Clarke; Ms Taylor Cunliffe; Ms Stephanie Penning.

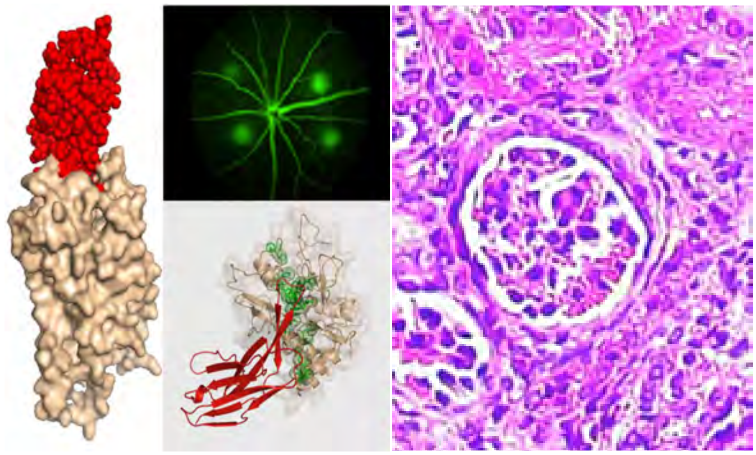
**Fields of Study:**
Structural biology; Biochemistry; Microbiology; Host-pathogen interactions.

**Capabilities and Techniques:**
Structural biology (X-ray crystallography, SAXS); Biochemistry (protein chemistry, enzyme kinetics, redox biochemistry, stopped-flow assays, enzyme kinetics); Biophysics (Analytical Ultracentrifugation, CD spectroscopy, SPR); Microbial assays (biofilm and aggregation assays, motility, in vitro susceptibility testing,); Structure-based drug design and computational biology (molecular docking); Bacterial/eukaryotic cell culture; Microscopy.

**Translational Opportunities:**
Develop new antibiotic classes to counteract antimicrobial resistant infections; develop antimicrobials against critical priority pathogens recognised by WHO; develop small molecules and biologics targetting virulence.

# Translational Biology Group

Our group studies the molecular basis of various inflammatory diseases and we aim to develop therapies to combat these. Inflammation is essential in alerting the immune system to infection or tissue injury so that the host's white blood cells can quickly locate and combat the pathogen or engage in tissue repair. This response is tightly controlled, with inflammation waning after infection/injury is resolved – returning to basal levels with the host's white blood cells following suit. An uncontrolled inflammatory response leads to various diseases such as multiple organ failure in sepsis, various fibrotic diseases and auto-immune diseases (e.g. psoriasis, systemic lupus erythematosus and inflammatory bowel disease etc). Our lab has identified upstream cell surface receptors regulating these diseases and we aim to develop therapies by blocking receptor activation.



Inflammation in various structures

### Treml4 receptor and innate immune memory

We have identified Treml4 receptor as the master regulator of inflammation during polymicrobial sepsis. Genetic ablation of this receptor in mice offers almost absolute protection from sepsis-mediated inflammatory pathology and immune cell apoptosis. Our findings suggest that ablating this receptor can induce neutrophil memory after exposure to sepsis, which enables the mice to combat blood-born Candida infection. This protection can last up to a month despite neutrophils lasting only 24 hours in the blood, and suggests neutrophil memory, which is a new concept. We have evidence this memory is imparted through epigenetic modification in the bone marrow compartment and we are studying the underlying mechanism using ChIP-Seq and single cell RNASeq analyses.

### Developing biologicals against Treml4 receptor

We identified the Treml4 receptor in a genome wide CRISPR screening of mice undergoing polymicrobial sepsis and developed an *in vitro* assay to test the functionality of this receptor family. We are also developing humanized mouse models expressing the human receptor to enable us to study the function of this protein in an *in vivo* system and allow testing *in vivo* of any biologicals that we develop (i.e., monoclonal antibodies (mAbs), i-Bodies, shark antibodies and human Fabsas) to treat sepsis, psoriasis, SLE and IBD.

### Single domain antibodies against fibrosis and inflammatory diseases

Shark antibodies (VNARs) are a subset of antibody-like molecules found in sharks and rays. Some VNARs have been shown to possess a long CDR3 loop, which is much larger than those of human and murine antibodies. This extended CDR3 loop is ideal for penetrating cleft-type epitopes such as enzyme active sites and ligand binding sites of surface receptors that are otherwise inaccessible to conventional antibodies. We created a humanized version of these antibodies, called i-bodies, and identified binders from this library that bind to the chemokine receptor CXCR4. This molecule is up regulated in many cancer cells and is expressed in organs that have developed fibrosis and other inflammatory diseases. The i-body that binds to CXCR4 (AD-214) can bind to and block the migration of inflammatory cells towards the site of inflammation thereby preventing the development of fibrosis in animal models of pulmonary fibrosis, kidney fibrosis and eye fibrosis in macular degeneration. The biotechnology company, AdAlta has completed manufacturing, toxicity, and a Phase 1 human clinical trial with AD-214. AD-214 was shown to be safe and is currently progressing towards the clinic for Idiopathic Pulmonary Fibrosis. We are examining how AD-214 can block the molecular signaling pathways of CXCR4 and prevents inflammation and fibrosis.

### Single domain antibodies in malaria

The *Plasmodium falciparum* parasite causes severe malaria in humans. We identified VNARs and i-bodies that block invasion of malaria into host erythrocytes. The structural complex of one of these VNARs and its target AMA1, revealed that the long loop of the VNAR can penetrate a hydrophobic trough on this protein and block the function so the parasite is unable to invade the red blood cell. We identified i-bodies that bind to AMA1 from all *P. falciparum* strains and have shown that some can block parasitic invasion into blood cells. We are collaborating with colleagues to develop these i-bodies as potential therapies to understand the molecular tricks that the malaria parasite uses to invade blood cells.

**Lab Heads:** Associate Professor Hamsa Puthalakath (H.Puthalakath@latrobe.edu.au) and Professor Michael Foley
**Emeritus:** Professor Robin Anders
**Lab members:** Dr Dimuthu Angage, Dr Tony Wang, Mr Hussam al Siraji, Mr Corey Pollock and Ms Nicki Badii.

**Fields of Study:**
Inflammation; Innate immunity; Fibrosis; Antibody development.

**Capabilities and Techniques:**
CRISPR gene editing; mouse models; i-Body/ Fab library panning; disease models

**Translational Opportunities:**
Developing biologicals against human inflammatory pathologies.

# Vascular Cell Death, Clearance and Inflammation Group

Billions of cells in the body die every day as part of normal cellular turnover and in disease. The removal of dying cells by phagocytes, known as 'efferocytosis', is a critical biological process that mantains tissue homeostasis through replenishing dying cells and limiting inflammation.

Our team aims to understand how dying cells within the blood vessels communicate with surrounding tissue and to elucidate the importance of cell clearance by vascular cells, both in the context of normal vessel maintenance and to promote vessel repair following injury or disease. We have a special interest in how vascular cells participate in efferocytosis during inflammatory vascular diseases such as atherosclerosis and hope to identify novel therapeutic targets that may limit plaque progression.

### Targeting efferocytosis in atherosclerosis

Atherosclerotic plaques that block arteries can lead to life-threatening clinical events such as heart attack and stroke. During atherosclerosis, dead cell removal (efferocytosis) is impaired and contributes to plaque growth, although there are currently no treatments that boost dead cell removal in plaques. Our team has recently found that increasing the way cells break apart or 'fragment' when they die enhances their ability to be removed by phagocytes. Using complimentary genetic and pharmacological approaches including a genetic mouse model of enhanced dying cell fragmentation and FDA-approved drugs that promote dying cell fragmentation, our team aims to examine the impact of boosting dead cell removal on plaque growth during atherosclerosis.

### Endothelial cell efferocytosis

Efferocytosis is a critical process that prevents inflammation and replenishes damaged cells. Although efferocytosis is a well-described function of certain cell types (e.g. macrophages), the role of vascular endothelial cells that line the blood vessels in mediating efferocytosis is currently unknown. Our team aims to define the mechanisms and functions of efferocytosis by vascular endothelial cells using cell-based methods as well as in vivo transgenic animal models of cell clearance including zebrafish and mouse. Our research aims to determine the importance of endothelial cell-mediated efferocytosis and the impact of enhancing this process in diseases characterised by vessel damage, such as diabetes.

Lab Head: Dr Amy Baxter
(A.Baxter@latrobe.edu.au)

**Lab members:**
Donia Abeid
Cailin Vella.

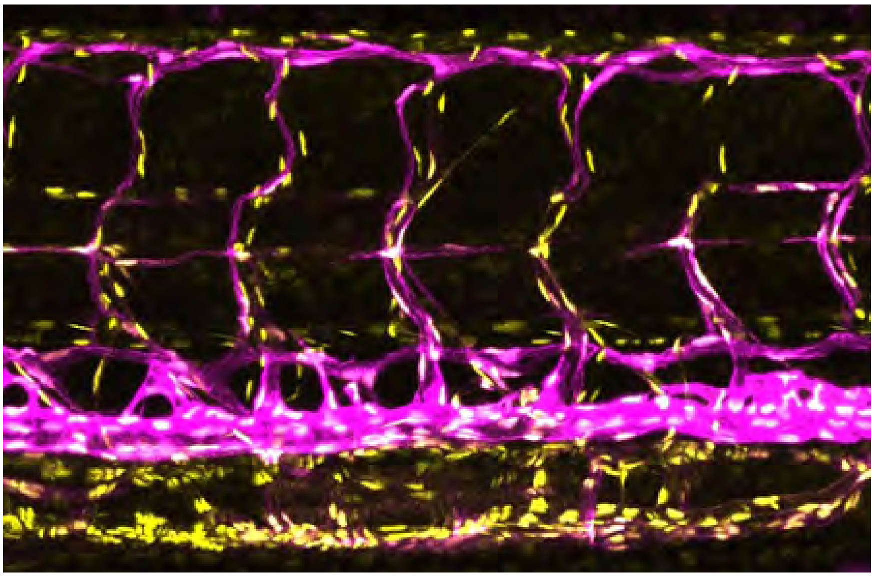
**Fields of Study:**
Cell death and clearance biology; vascular biolology; cardiovascular disease; extracellular vesicles.

**Capabilities and Techniques:**
Tissue culture and mammalian cell death and clearance assays; protein biochemistry, molecular biology (e.g. qPCR, RNAseq); zebrafish and mouse models of disease; confocal, spinning disk and IVIS imaging; extracellular vesicles isolation and characterisation.

**Translational Opportunities:**
Through identifying novel therapeutic targets of in our pre-clinical models, we aim to establish a drug discovery platform that will lead to the development of novel compounds to treat cardiovascular diseases.

# Vascular Therapeutics and Regeneration Group

Blood and lymphatic vessels play important physiological functions in our body and are dysregulated in various human diseases. Excessive blood or lymphatic vessel growth leads to vascular anomaly including lymphatic malformations and increases the risk of cancer metastasis by providing pathways for cancer cells to disseminate. Inversely, lack of lymphatic vessel growth/ regeneration results in primary or secondary lymphoedema, a major burden for post-cancer surgical/radiation therapy patients. Our group uses the optically transparent zebrafish model to identify vascular modulatory therapeutics that could be used to treat these diseases. We also characterize dynamic signaling mechanisms that drive vascular maintenance, regeneration and pathologies using various biosensor zebrafish transgenics and zebrafish disease models to decipher targetable therapeutic targets for these diseases.



Endothelial cell nucleus in zebrafish blood and lymphatic vessels. (Photo credit: Kazu Okuda)

## Pro-lymphangiogenic therapeutics

Lymphoedema is a disease associated with excessive tissue swelling. When left untreated lymphoedema symptoms can worsen, leading to decreased mobility, chronic pain and increased risk of potentially lethal infection. Primary lymphoedema (caused by genetic mutation) is currently incurable, and treatment options available only alleviate the symptoms. While several surgical treatment options exist for secondary lymphoedema (acquired through lymphatic trauma), data on patient outcomes are still limited, as surgical approaches are highly personalised to each case and outcomes can be highly unpredictable. Using cutting-edge methodologies in zebrafish, we seek to understand the mechanisms that drive/ inhibit lymphatic regeneration to reveal therapeutic targets for stimulating lymphatic regeneration. We are also using various in vivo (zebrafish) screening approaches to identify pro-lymphangiogenic therapies that will be tested on our zebrafish lymphoedema models.

## Anti-(lymph)angiogenic therapeutics

We have a strong track record of using the zebrafish model to identify novel mechanisms of (lymph)angiogenesis. These mechanisms could be targeted to inhibit pathological lymphatic/blood vessel growth in human diseases. We are particularly interested in RNA helicase DDX21, which we recently found to be selectively required for lymphatic development in zebrafish. We are now investigating the mechanisms that drive this selectivity. We are also conducting drug screens in zebrafish to identify promising anti-(lymph)angiogenic small molecules. We have already identified several promising leads including 3, 4-Difluorobenzocurcumin and Canthin-6-one. The mechanism of action of these leads will be elucidated to potentially identify novel therapeutic targets for anti-(lymph)angiogenic therapy. We are also testing whether these leads could be novel therapeutics for lymphatic malformations and cancer.

## Understanding dynamic signaling activity in blood and lymphatic vessels

The optical transparency of zebrafish embryos/larvae allows live-imaging of developing/functional/regenerative/ pathological blood and lymphatic vessels at unprecedented resolution. We have developed zebrafish biosensor transgenic lines that enable real-time visualization of important signaling activities in blood and/or lymphatic endothelial cells such as ribosome biogenesis and Erk signaling. We are developing new biosensor zebrafish transgenics that enable visualization/ quantification of various signalling activities in endothelial cells. We will use these biosensor transgenics to elucidate dynamic mechanisms that drive vascular development, maintenance, and regeneration.

**Lab Head:** Dr Kazuhide Shaun Okuda (K.Okuda@latrobe.edu.au)

**Lab members:** Dr Srdjan Boskovic; Ms Valeria Impicciche; Mr Bhavya Viradia; Ms Ira Ghosh; Ms Pooja Shree Rnagaraj; Ms Linda Jiabao Woo.

**Fields of Study:**
Vascular Biology; Drug discovery; Regeneration; Disease modeling.

**Capabilities and Techniques:**
Zebrafish research; High resolution/speed live-imaging and analysis; Drug screening and characterisation; CRISPR gene editing; Disease modeling; mRNA technology research.

**Translational Opportunities:**
Vascular modulatory therapeutics we identify could be used to treat human diseases such as lymphatic malformations, lymphoedema and cancer.

# Viral & Structural Immunology Group

We focus on how to combat viral infections. Viruses are part of day-to-day encounters that our immune system needs to deal with. How the immune system "sees", recognises and eliminates viral infection is not fully understood. Indeed, viruses can mutate and escape the immune system surveillance. If we are to develop better vaccine and drugs, it is essential to understand the mechanism of viral recognition and escape prior to this. Our laboratory combines both the cellular and molecular approaches to understand the immune system. Our goal is to deeper our current understanding of T cell activation and recognition mechanism, especially in the context of viral infections such as SARS-CoV-2, influenza and HIV.


The Gras Lab

### Viral Immunology
Our lab is focused on understanding infections by viruses that are a health burden. Aiming to understand why some of us are at higher risk of developing severe infection due to those viruses, while other seems to be able to handle the virus and have an immune system allowing them to control the infection.

### COVID-19 disease
We study COVID-19 disease to understand the immune response to SARS-CoV-2 and its variants. We work in collaboration with other teams in Australia and overseas to fully dissect the T cell, B cell and Antibody responses toward the virus. We aim to map and characterise in depth SARS-CoV-2 peptides able to stimulate T cells in better understand the progression of the disease, the role of T cell in COVID-19. This information can help anticipate or predict which mutation will be an issue for T cell recognition, as well as quickly assessing the impact on the immune system, and immune protection, that new SARS-CoV-2 variants might have. This also will help us understand the risk factor worsening the COVID-19 disease, if some marker can be used to predict the evolution of the disease. We also study the level of protection from the vaccines to help inform the need for future booster shot. Our lab has discovered the first genetic link associated with the lack of symptom in COVID-19 published in *Nature*.

### Influenza disease
Influenza viruses cause significant morbidity and mortality worldwide. Although a vaccine is available, it primarily induces a humoral response (antibody) and requires updating annually. Also, the vaccine provides protection if the predicted strains match the circulating strains, but sometimes the virus mutate away from the prediction and the vaccine will have minimal benefit. Our aim is to develop a universal influenza vaccine that could provide protection against distinct influenza strains. This will allow a one-shot vaccine to be developed, instead of having the "jab" every year.

### AIDs disease
While antiretroviral therapy (ART) has dramatically improved the health of HIV-infected individuals, comorbidities associated with persisting inflammation have emerged as complications. It is imperative to develop new treatments (and ideally, a vaccine) for this virus. Our work focuses on individuals known to control HIV infection and/or delay disease progression. They have strong T cell responses and understanding the mechanism behind it is central for informing therapeutic or vaccine development against HIV. We aim to understand how HIV controllers T cells are protective, their functional but also molecular features, which could lead to new therapeutic avenues.

**Lab Head:** Professor Stephanie Gras (S.Gras@latrobe.edu.au)

**Lab members:**
Dr Emma Grant, ARC DECRA fellow; Dr Dimitra Chatzileontiadou; Dr Janesha Maddugage, Dr Anurag Adhikari; Mr Dhilshan Jayasinghe; Mr Lawton Murdolo; Mr Samuel Liwei Leong; Ms You Min Han; Ms Georgia Dow, Ms Jamie Tuiebo.

**Lab adjuncts:**
Dr Christopher Szeto; Dr Andrea Nguyen.

**Fields of Study:**
Cellular Immunology; viral disease (e.g. influenza, SARS-CoV-2, HIV); T cell activation; epitope presentation; Structural biology.

**Capabilities and Techniques:**
X-ray crystallography; biochemistry; protein interaction; human samples biobank; cellular assay; immunology; single cell sequencing; flow cytometry.

**Translational Opportunities:**
T cell engineering; biomarker identification; risk factor of disease; drug design and anti-viral development.

**Web site:** www.graslab.com.au

# Department of Ecological, Plant and Animal Sciences (EPAS)

## School of Agriculture, Biomedicine and Environment

*Research in agricultural and animal sciences, agronomy, biodiversity, botany, ecology, environmental science, evolution, genetics, plant science, soil science, and zoology*

latrobe.edu.au/school-agriculture-biomedicine-and-environment

# EPAS Contents

# EPAS Contents (continued)

# Department of Ecological, Plant and Animal Sciences

The Department of Ecological, Plant and Animal Sciences has 23 continuing and fixed-term academic staff, including one ARC Future Fellow, two ARC DECRA Fellows and approximately 26 Postdoctoral and Research Fellows and two technical and support staff. The Department also houses the equipment and staff of the La Trobe University Genomics Platform.

The Department has a dynamic higher degree by research program that reflects the disciplinary interests of the staff. We are currently training 94 PhD students and typically host an additional 30-35 MSC and Honours (4th year Research) students from Australia and overseas.

Staff and postgraduate students work in a range of environments 'from the sea to the mountains', including arid and semi-arid deserts and woodlands, agricultural landscapes, alpine and subalpine landscapes, grasslands, tall wet forests and rainforests, and marine and freshwater habitats.

We teach >3000 undergraduate students enrolled in 32 subjects.

Our courses include:

- Bachelor Biological Sciences
- Bachelor of Wildlife and Conservation Biology
- Bachelor of Science
- Bachelor of Agriculture
- Bachelor of Animal & Veterinary Biosciences
- Bachelor of Veterinary Nursing (in partnership with Melbourne Polytechnic)

We also maintain close relationships with external research partners in state, federal and non-government agencies.

Trichomes on '*Arabidopsis thaliana*' seedlings (Photo credit: Ritushree Jain)

Research carried out in the Department is world leading. The Department underpins a rating of '5 – well above world standard' in the disciplinary areas of Ecology and Zoology, and underpins a rating of '4 – above world standard' in Ecological Applications. The Department also contributes to similarly high ratings in the areas of Genetics, Plant Biology and Soil Science. Plant Biology, Soil Sciences, Animal Production, Crop and Pasture Production, and Veterinary Sciences. It also contributes to similar "well above world standard' ratings in the areas of Biochemistry and Cell Biology.

The Department maintains a diverse portfolio of research programs encompassing the full range from fundamental to highly applied, with particular strengths in animal immunology, health and disease, cell wall biology, medicinal agriculture, plant biology, plant energy metabolism, soil science agronomy, terrestrial ecology encompassing plant and animal ecology, landscape ecology, conservation, ecological genetics, invasion biology, fire ecology and management.

Members of the Department are also key contributors to La Trobe's Research Themes (five cross-disciplinary research areas that address some of the most pressing questions affecting the future of human societies and their environments), particularly '*Sustainable Food and Agriculture*,' '*Resilient Environments and Communities*' and '*Protection and restoration of vulnerable ecosystems and community resilience in the face of environmental and climate threat.*'

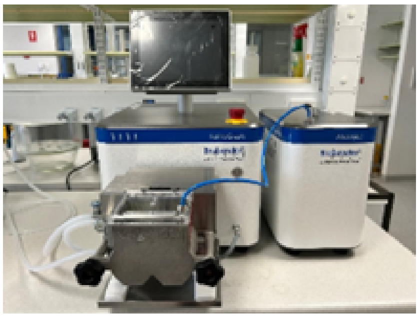
The Department's research environment is dynamic and growing, and includes several major Research Centres:

- La Trobe Institute for Sustainable Agriculture and Food
- Centre for Food Science
- ARC Industrial Transformation Research Hub for Protected Cropping
- ARC Centre of Excellence in Plants for Space
- Centre for Freshwater Ecosystems (formerly the Murray-Darling Freshwater Research Centre)
- Research Centre for Applied Alpine Ecology
- Research Centre for Future Landscapes (collaboration with the Arthur Rylah Institute of DELWP).

# Research Centres

# Centre for Food Science

The Centre for Food Science is a key part of LISAF, advancing Food, Nutrition & Health (Domain 4) through three core goals: developing sustainable food and biomanufacturing technologies, sustainable ingredients, and creating foods that support longevity and vitality. Our research explores food structure and functionality, focusing on proteins, polysaccharides, and lipids to understand their interactions within food systems. We advance sustainable food and biomanufacturing technologies, study food texture in relation to formulation and processing, integrating novel techniques to enhance material properties and ensure sustainability. By bridging material and food science, we develop innovative and cost-effective food and material processing solutions, troubleshoot food manufacturing challenges, and facilitate the production of high-quality, consumer-focused and nutritious food products.



### Solid-State Fermentation of Foods

Solid-state fermentation (SSF) of legumes is improving the food system by enhancing nutrition, flavour, and sustainability. This natural process improves protein digestibility, reduces unwanted compounds, and creates rich, savoury flavours, making legumes more appealing in plant-based diets. By unlocking their full potential, SSF helps develop innovative, high-protein foods while reducing reliance on animal-based ingredients. As demand for sustainable nutrition grows, fermented legumes offer a promising path towards healthier and more environmentally friendly food choices. In this project, we are investigating the impact of different microbes, fermentation processes and pretreatments of legumes on fermented products. This research aims to optimise fermentation strategies for producing nutritious and sensorially appealing plant-based foods.

### Oleosome Extraction: A Natural Solution

Harnessing eco-friendly methods for oleosome extraction and processing can reshape the food system by reducing reliance on synthetic emulsifiers and chemicals and energy- and water-intensive processes. By adopting greener techniques, such as enzymatic and aqueous extraction, we can enhance food stability, improve nutritional quality, and minimise environmental impact. This shift towards This shift towards sustainable oleosome production supports cleaner-label ingredients, promotes resource efficiency, and aligns with the growing demand for natural and minimally processed foods—paving the way for a healthier and more sustainable future.

### Plant-based Alternatives

Plant-based alternatives are transforming the way we eat, offering delicious, nutritious, and sustainable options. From meat-free burgers to dairy-free milks, these foods are crafted from natural ingredients such as legumes, grains, and plant oils, delivering great taste while reducing environmental impact. We are actively developing plant-based proteins and fats designed to replace animal counterparts in foods, offering sustainable and functional alternatives without compromising quality or taste. Additionally, we employ advanced methodologies to characterise fat/salt distribution in food matrices, ensuring optimal flavour balance, functionality, and health benefits.

**Lab Head:** Prof Roman Buckow (R.Buckow@latrobe.edu.au)

**Lab members:**
Dr Deepa Agarwal
Dr Yakindra P Timilsena

**Fields of Study:**
Food Processing; Food Structure & Physics; Food Chemistry & Flavour; Bioprocessing; Food Nutrition

**Capabilities and Techniques:**
Innovative food processing; new product development; material characterisation; root-cause analysis of food production issues; heology (rheometer, Farinograph); RapidOxy 100; high pressure homogeniser; pulsed electric fields, membrane separation techniques.

**Translational Opportunities:**
Food safety & regulatory compliance; process design and optimisation; functional ingredients and foods; post-harvest management; gut microbiome & health.

# ARC ITRH for Protected Cropping

Protected cropping is the production of horticultural crops sheltered by structures to provide optimum growing conditions, protecting them from pests, diseases and unfavourable climate. The protected cropping industry is the fastest-growing food-producing sector in Australia, employing 10,000 people and worth $16.6 billion annually, a figure set to rise by six per cent by the end of 2024, according to Hort Innovation Australia.

The Australian Research Council Industrial Transformation Research Hub for Protected Cropping (PC Hub) aims to transform the production of high quality horticultural and medicinal crops into an integrated, national industry that spans primary producers and manufacturers and to address knowledge gaps in the protected cropping (PC) sector, including plant health and breeding, waste valorisation, digital technologies, novel extraction technologies and chemistries, through to the discovery and functional characterisation of bioactives.

The Hub is supported by a $5 million Australian Research Council grant and funding from La Trobe University and industry partners. The $28 million Hub's program has been co-designed with consumers, producers and policy makers, and will leverage existing investments in state-of-the-art plant phenotyping facilities and molecular, cellular, digital and imaging technologies.

The PC Hub has been established as a multi-disciplinary hub in collaboration with the following industry and research partners:

- Cann Group Limited
- Phytogro
- BioPlatforms Australia Ltd.
- Gaia Project Australia Pty Ltd.
- Photon Systems Instruments
- SpexAI
- The Florey Institute for Neuroscience and Mental Health
- The University of Melbourne
- Olivia Newton-John Cancer Research Institute

**Director:** Prof Tony Bacic, FAA (T.Bacic@latrobe.edu.au

# ARC Centre of Excellence in Plants for Space

The ARC Centre of Excellence in Plants for Space (P4S) aims to create a legacy of global leadership in engineering on-demand, zero-waste, high efficiency plants and products to support a bold new future in Space exploration. Our overarching objective is to re-imagine plant design and bioresource production to enable off-Earth habitation and provide transformative solutions for on-Earth sustainability. Our sophisticated designs will create flexible, plant-based solutions to support human physical and psychological well-being during Space travel and settlement. Simultaneously we will deliver a step change in plant efficiency, productivity, and processing technologies on Earth.

P4S success will be defined by:
- Establishing Australia as an international authority and focal point for plant-based Space food, material, and engineering advances, capitalising on world-leading excellence in configurable plant design and processing.
- Creating new technologies and capabilities in plant modification, with valuable IP and pipelines for successful research translation to on- and off-Earth applications. Our products will be tested on Space missions and will unlock new opportunities for domestic and international food and bioresource markets.
- Training >400 researchers as the foundation of a new generation of internationally connected and industry-focused plant, food, and Space researchers.
- Accelerating growth of the burgeoning national and international controlled environment agriculture (CEA) industry to support high-value on- and off-Earth ventures.

Generating plants for use in Space will integrate and fundamentally advance emerging technologies e.g., programmable gene editing, digital modelling, artificial intelligence (AI), and plant-based food processing. The modification of plant form and function will push the boundaries of growth and productivity, providing new solutions for sustainability and efficiency gains in primary production on Earth. Novel post-harvest processing methods will offer improvements in the nutritional value and shelf-life of plant-based foods, and new processing technologies will generate a suite of desirable textures and tastes. Robust technologies to sustainably produce valuable non-food biomolecules from plants will open new options for the pharmaceutical and manufacturing industries. Legal and policy frameworks will be explored, and a means to connect industry and public stakeholders established, to ensure P4S outputs remain relevant and translatable for end-users. An ambitious P4S education and training program will inspire higher uptake of STEM careers by students and deliver a new generation of industry-focused researchers.

Our four integrated, globally connected, and transformative research programs are designed to drive sector co-ordination, build the workforce, and innovate with industry-ready solutions.

Our integrated research programs are designed to deliver industry-ready solutions. Building upon the experience, background IP, and specialist resources of our CIs and PIs, we have developed 4 integrated Programs (P1–4) to achieve 4 ambitious transformational outcomes:
- Zero-waste plant growth and processing
- Designer, plant-based solutions for health and wellbeing
- Future-ready people, processes, and products for on- and off-Earth industries
- A globally connected Space plant and food sector, co-ordinated through Australian leadership.

P1 (Plants) will use molecular techniques to deliver food from plants: tailored 'pick & eat' crops to supplement dietary needs, and a suite of 'complete nutrition' plants to solve the challenge of total caloric replacement. Plant biofactories and bioprocessing technologies developed in P2 (Products) will be vital to sustain closed environments for extra-terrestrial settlement, and provide new advances for on-Earth manufacturing of pharmaceuticals and plant-based foods. P3 (Processes) will develop engineering solutions and new experimental platforms that have undergone rigorous lifecycle and techno-economic analyses, and explore legal and ethical frameworks to ensure our innovations are fit-for-purpose and readily translatable to meet current timelines.

P4 (People) will implement a bold, long-term approach to education and training to inspire more students into STEM subjects and establish a new generation of Australian Space-fluent researchers. P4 will also be home to translation pathways, working closely with POs to maximise synergies, while also providing international Space sector co-ordination in plant and food scientific research. We are uniquely positioned to lead global innovation in Space-inspired plant research. P4S partners 15 academic institutions, 5 Space agencies and enablers, 5 CEA companies, 6 education providers, and 7 government and technology partners. P4S has 16 Chief Investigators (CIs) from 5 Australian universities: Adelaide (UoA), Flinders, Melbourne (UM), La Trobe (LTU), and Western Australia (UWA). Centre Director (CD) Gilliham (UoA), Deputy Director (DD) de Zwart (Flinders), and DD Gras (UM) bring extensive experience in successful leadership of transdisciplinary initiatives, globally acclaimed research, and industry translation. P4S CIs connect world-class skillsets in molecular plant science (Millar, Lister, Small, Gilliham); advanced medicinal agriculture (Johnson, Lewsey); plant physiology (Watt) and biotechnology (Tucker, Mortimer); innovative food and bioprocessing (Gras); sensory science (Fuentes); nutrition (Feinle-Bisset); Space engineering (Hessel); psychology (Kemps), and Space law (de Zwart). P4S represents a major contribution to the Artemis goals, and with NASA and Axiom as a key stakeholders, we have hard-wired connections into current mission needs and planning. Our collective multidisciplinary expertise within P4S will lead innovation in Space plant production systems, and realise the Centre's multi-faceted legacy to fulfil the ambition of humans to go, rather than just look at opportunities beyond Earth.

Program leads: Assoc Prof Kim Johnson (K.Johnson@latrobe.edu.au) and Prof Mat Lewsey (M.Lewsey@latrobe.edu.au).

# Centre for Freshwater Ecosystems

The Centre for Freshwater Ecosystems (CFE) has been established to conduct high quality research to support the sustainable management of freshwater ecosystems. The centre brings together a wealth of expertise from a range of disciplines to better understand and to solve significant challenges in river and catchment management. It builds on a long history of research under the auspices of the Murray Darling Freshwater Research Centre.

The Centre operates from La Trobe's Albury-Wodonga campus, and also has strong links across the university's other campuses in Melbourne, Bendigo, Shepparton and Mildura. Our regional locations provide ready access to field sites across the southern Murray Darling Basin and are a vital connection with local communities.

The Centre's work directly supports decision making regarding maintenance and restoration of the long-term health of rivers, catchments, floodplains and wetlands.

Healthy freshwater ecosystems support immense biodiversity as well as providing highly valued goods and services that support human wellbeing and economic prosperity.

We seek to provide the critical knowledge to support the sustainable management of these important ecosystems across several key themes:

- measuring and conserving freshwater biodiversity
- balancing water allocations between communities, production systems and nature
- addressing the effects of catchment management and chemical pollutants on water quality
- understanding the influences of hydroclimatic variability and climate change on refuges and ecosystem resilience.

In striving to deliver world-leading research, the centre performs a role well beyond the Murray-Darling Basin, with research links nationally in Southern and Northern Australia, and internationally in southeast Asia, Europe and the Americas.

The centre also plays a key role in training the next generation of water managers and scientists through its contribution to both undergraduate and postgraduate teaching within the university.

The Centre is a strategic initiative of La Trobe University, which operates commercially and strives to conduct high impact scientific research.

Our expertise is in:

- Ecosystem monitoring and assessment
- Environmental chemistry and contaminants
- Fish ecology and management
- Genetics and DNA analysis
- Invertebrate community ecology
- Quantitative modelling and forecasting
- Conservation biology
- Social and environmental policy
- Spatial modeling and GIS analysis
- Water management
- Wetlands and floodplains
- Climate adaptation
- Social research
- Sustainable communities
- Sustainable agricultural production
- Terrestrial ecology
- Environmental risk assessment including climate change

We have facilities for:

- Field surveys on a range of biota and ecosystems
- Analytical chemistry laboratory for water quality and nutrient testing
- A macro-invertebrate laboratory with sampling and taxonomic skills
- Biogeochemical analysis in aquatic ecosystems and waste treatment
- Aquarium facilities and ecophysiology laboratory for studying fish and invertebrate behaviour
- Taxonomy, population genetics, metabarcoding and eDNA studies

**Director:** Prof Nick Bond (N.Bond@latrobe.edu.au)

www.latrobe.edu.au/freshwater-ecosystems

# Research Centre for Applied Alpine Ecology

The Research Centre for Applied Alpine Ecology (RCAAE) provides national leadership in the study of the ecology of alpine landscapes. Current members are professional scientists and academics from La Trobe University, University of Melbourne, Australian National University, Charles Darwin University and Deakin University.

Our scientific research includes ecological processes, rare and endangered species conservation, effects of fire, exotic plants and animals, human activities, and the management of these ecosystems in response to climate change.

Recent focus has been on the collation and publication of long-term datasets (e.g. 70+ year datasets examining the impact of, and recovery from, cattle grazing). This is one of the most important roles of the RCAAE. Ecological monitoring data (on animals, threatened species, weeds, pests) are all held in one database, making data retrieval simple and long-term analyses possible.

The RCAAE trains land managers and students via its long-term commitment to the Alpine Ecology Course and the Summer Studentship programme.

The Alpine Ecology Course (AEC) was initiated in 1989 by Victorian Department of Conservation to:

(i) teach basic ecology to land managers so that land management would be based on ecological principles, and
(ii) for active researchers in the alps to communicate their findings and the state of ecological knowledge to land managers.

La Trobe University has been involved in a teaching role since 1991, and became responsible for the course delivery in 2000. The course is held in the Alpine areas of Victoria on the Bogong High Plains. The format of the course is two days of formal instruction in geomorphology, soils and plant ecology, followed by four days of project-based work.

The RCAAE supports long-term Mountain Pygmy Possum (*Burramys parvus*) research through a collaboration between La Trobe University, University of Melbourne, UNSW and Mt Buller Resort. In 2018, the long-term monitoring of *Burramys* populations indicated that the Mount Buller central population was almost half of that recorded in 2004 and was experiencing events that could drive further declines, even local extinction. Introduction of male *Burramys* from another location prevented the local extinction of this isolated population, increasing genetic diversity and fitness. RCAAE ecologists have raised the alarm about the potential decline in Bogong Moths in the high country and it's potential to negatively affect the critically endangered *Burramys*. Declines of this nature are likely due to drought in the Bogong moth's breeding grounds highlighting the need for better understanding of the ecology of Bogong Moths and a better network of observation stations in the alps to understand year-to-year variations.

The RCAAE has also monitored the presence and impacts of Sambar deer since 2016 on long-term plots in snowpatches and herblands across the Bogong High Plains. These vegetation communities are listed for protection under Victoria's Flora & Fauna Guarantee Act and feral deer present substantial threats to their state and ecological functions. In 2018, the RCAAE worked closely with Parks Victoria to design new deer-proof fences to facilitate ongoing protection from deer and horses.

Recently, wildfires in 2020 have placed further pressure on alpine ecosystems and the RCAAE will use its long-term data to assess these recent impacts, while providing guidance of recovery.

**Director:** Assoc Prof Ewen Silvester
(E.Silvester@latrobe.edu.au)

https://rcaae.org/

# Research Centre for Future Landscapes

The Research Centre for Future Landscapes (RCFL) was established in 2017 and is a multi-disciplinary environmental research centre.

Our goal is to generate knowledge and solutions that address the global challenge of sustaining and restoring natural ecosystems in modified landscapes, and empowering people and communities to create more sustainable landscapes.

To do this, we foster research into:

- the drivers and outcomes of landscape change for nature and people;
- understanding ecological function in modified landscapes;
- solutions to improve environmental sustainability and community resilience; and
- land-use planning and management options for people, communities and future landscapes.

Landscapes sustain nature; provide people with food, fibre and fuel; shape cultural identity; and inspire creativity. Worldwide, the transformation of land and water to meet the demands of a growing human population, together with the impacts of a changing climate, are driving a global biodiversity crisis. The consequences of past, present and emerging human-induced landscape change pose enormous threats for nature and challenges for human society.

In Australia, land-use decisions over the last two centuries have profoundly transformed many landscapes. This has generated economic prosperity for the nation but at a significant cost to our native wildlife and plants, soil health, and land and water resources. Just as the legacy of the decisions make by our ancestors are felt today, the way in which we manage our land and water will shape the landscapes of the future for generations to come.

We undertake research that addresses the global challenge of sustaining nature in human-dominated landscapes.

Our research equips managers and communities with knowledge and solutions to increase ecological, economic and social sustainability in rural and regional landscapes.

We strive to be:

- Globally relevant; by producing world- class research on the drivers and outcomes of landscape change for nature and people.
- Collaborative; by partnering with government, industry, NGOs and communities to tackle the issues that matter to them.
- Applied; through conducting solution-orientated research to enhance biodiversity, sustainable production and human wellbeing in rural and regional landscapes.
- Multi-disciplinary; through integrating a range of disciplines to generate new insights and fresh ideas.
- Future-focused; we recruit, support and train the next generation of scientists committed to solving pressing environmental problems.

We have research expertise in:

- Landscape ecology
- Landscape planning
- Fire ecology
- Behavioural ecology
- Insect ecology
- Plant ecology
- Sustainable agriculture
- Natural capital
- Microbial ecology
- Conservation genetics

**Director:** Assoc Prof Jim Radford (J.Radford@latrobe.edu.au)

https://www.latrobe.edu.au/research/centres/environmental/future-landscapes

# Research Groups

# Agriculture Bio-Solutions Lab

The Agriculture Bio-Solutions Lab has access to state-of-the-art facilities for studying host-pathogen interactions in livestock. Due to industrialized farming, there has been an increase in endemic disease that has resulted in multi-million-dollar losses to the farming industry per annum due to poor productivity, failure to thrive and death. The use of antimicrobials to treat these diseases have led to an increase in drug-resistant strains of pathogens. Pathogen control programs based solely on the use of anti-microbial drugs are no longer considered sustainable because of an increased prevalence of bacterial resistance, high costs and concerns regarding residues in the food and environment.

To provide improved sustainable health and welfare outcomes in livestock production, the Agriculture Bio-solutions lab has developed a complete "Bench to Barn" research program focusing on 1) field-deployable diagnostics, 2) molecular understanding of disease pathogenesis 3) sustainable treatment solution (vaccines and breeding).

### FIeld-deployable diagnostics

The ability to quickly diagnosis infectious agents in the field will lead to better treatment and management decisions in real-time. The high sensitivity of LAMP assays enables detection of the pathogens in sample material without time-consuming preparation thus being able to detect pathogens within 30 min. We are working with Australian biotechnology company Geneworks to commercialize these assays for purchase by various Agriculture industries.

### Molecular pathogenesis

Pathogenic microbes that affect livestock have an arsenal of surface and secreted proteins to conquer the many unique niches they occupy throughout the course of infection. We use a combination of biochemistry, biophysical and proteomic approaches to determine the molecular role of these proteins in microbe pathogenesis. . These studies will form the basis of further studies to capitalize on the wealth of genomic data.

Cows (Photo credit: Travis Beddoe)

### Vaccine Development

An alternative way of injection is the establishment of protective mucosal immunity, achieved through vaccination via mucosal routes by non-invasive methods (i.e. oral delivery). Currently, work is underway investigating the use of AB5 toxin family as mucosal vaccine adjuvants and various no vel production vaccine platforms such as algae to produce lost cost vaccines.

Honey Bees, the most important livestock
Approximately, one-third of the Western diet requires bee pollination, honey bees are the primary pollinators of numerous food crops. We have combined our strengths in research to focus on improving bee health through:

1) field-deployable diagnostic test for viruses,
2) understanding of the seasonal dynamics and co-occurrence patterns of honey bee pathogens
3) development of novel therapeutic to aid honey bee health.

**Lab Head:** Professor Travis Beddoe (T.Beddoe@latrobe.edu.au)

**Lab Members**:
Dr Timothy Cameron;
Dr Bhuvana Shanbhag; Ms Jaclyn Swan;
Ms Lily Tran; Ms Gemma Zerna;
Ms Nur Nasuha Hafidi; Ms Alexandra Knox;
Mr Meysam Afarmajani; Ms Danielle Wiles;
Ms Leah Short; Ms Gopika Bhasi; Ms Huda Salah.

**Fields of Study:**
Glycobiology; infectious disease; Protein chemistry; Vaccine Development; Diagnostics.

**Capabilities and Techniques:**
Recombinant protein expression and purification; Protein biophysical characterisation; Vaccine development; enzymology; environmental DNA (eDNA) detection.

**Translational Opportunities:**
Livestock and wildlife eDNA infectious disease and health monitoring; Different vaccine development platforms for livestock, companion animals and humans; Rapid in-field diagnostics for disease detection, health, food authenticity and chemical residues.

**Website:** https://sites.google.com/view/beddoelab/home

# Animal Behaviour Group

Research in the Animal Behaviour Group (ABG) covers broad interests in animal behaviour,with both theoretical and applied benefits. Our research involves a combination of field and captive studies, and has focused on 60+ species across three continents.

### Motion vision in real environments

Our aim is to understand how animals detect biologically meaningful movements in natural environments. Motion vision is crucial in the life of animals. However, information on the conditions for motion vision in natural environments is limited.

*Virtual Lens Project*
We use 3D animation to determine how habitat structure, weather and motion vision influence animal behaviour. The use of virtual environment reconstruction encourages a fresh look at the physical world. A future project will implement novel methods to record neural signals from living lizards to identify potential neural signatures consistent with visual detection of whole animal movements in environmental noise.

### Ecology and behaviour of lizards across the globe

*Lizards of Ecuador*
Behavioural work in Ecuador is vital for conservation and species management. Our research investigates the behaviour of Microlophus and Anolis lizards from the Amazonian tropical forests, mountain and cloud forests to coastal habitats and islands of the Galapagos archipelago.

*Chinese Dragons*
Both male and female Qinghai toad-headed agamas (Phrynocephalus vlangalii) defend burrows using tail displays, which encode information about signallers. We are investigating this behaviour across the genus along with the Chengdu Institute of Biology and others.

*Microlophus grayii* of Floreana Island (Photo credit: Richard Peters)

*Dragons of Oz*
Our group focuses on territoriality, camouflage and thermal biology. We examine the structure of territorial displays in relation to habitat structure, weather and intra- and inter-species competition, as well as Jacky dragon (Amphibolurus muricatus) dorsal patterns as a function of geographic location due to habitat differences, and ontogenetic changes in appearance. A future project examining thermal adaptation strategies dragon lizards implement to endure environmental climatic conditions will provide data that can be applied to assess lizard populations in the face of climate change.

### Multimodal signalling of anurans

Signalling by Litoria fallax across its distribution from the tropical north to cool temperate regions is being studied. These frogs combine visual signals with acoustic calls and we are examining whether behaviour is influenced by habitat, climate and/or genetics.

Lab Head:Dr Richard Peters (Richard.Peters@latrobe.edu.au).

Postdoctoral Associates:
Dr Nicole Butler; Dr Xue Bian; Dr Jose Ramos.

PhD Students:
Ms Bhagya Herath; Ms Estefania Boada; Ms Estefany Guerra; Mr Jon Salisbury.

Fields of Study:
Behaviour; Ecology; Neuroethology; Thermoregulation; Vision.

Capabilities and Techniques:
Motion graphic technologies (3D animation); Matlab; Computer vision algorithms; Full spectrum image capture and analysis; Sound recording and analysis; Video analysis; Behavioural observations.

Translational Opportunities:
Climate change effects on animal behaviour; Conservation and species management; Species responses to environmental change.

Twitter: abg_ltu
YouTube: user = eriophora
Website: www.peterslab.info
Facebook: Animal-Behaviour-Group

# Applied Animal Physiology Group

We are broadly interested in how animals "work". Animals must balance demands of competing physiological functions to maintain homeostasis and survive. They also need to be able to consume enough energy and biomolecules in order to grow and reproduce. We study how environmental changes impact on these processes to determine how individual animals are affected by environmental change.

Murray River Turtle (Photo credit: La Trobe University)

### Freshwater Turtle Conservation

Currently, one of our focal areas of research is to understand the causes of freshwater turtle declines in Australia, and to develop novel ways of stopping those declines. Many freshwater turtle populations are composed primarily of older adult turtles, indicating that there is a lack of juvenile recruitment. So far, the evidence points to invasive red foxes (Vulpes vulpes) as being a major driver of turtle declines. Foxes destroy over 90% of most turtle nests, and this could mean that very few hatchlings reach the water. We are testing this hypothesis by developing a number of methods to protect turtle nests. We work closely with local community groups to implement these approaches throughout south-eastern Australia, and citizen science is becoming a major forefront of our research. If these methods work, we should see a corresponding increase in the number of juvenile turtles in the system. Alternatively, if these methods do not work, then they indicate that some other factor is killing juvenile turtles between the time that they hatch, and the time that they would reach sexual maturity. We are testing this hypothesis using medium-term mark-recapture and telemetry methods. At the same time, we are examining the effects of pollution and climate change on turtle reproduction and development. We are especially interested in how changes in the foodweb may be impacting the food available to turtles, with consequences for their growth, survival, and reproduction.

### Evolution and function of vertebrate placentas

Another field of our research is the evolution and physiology of the placenta in live-bearing vertebrates. The placenta connects a mother to embryos that are not genetically identical to her (half of their genes are from their father), and there is a risk that her immune system might kill them. How placentas provide nutrition to embryos, despite this immune challenge, has major implications for understanding how reproduction, development, and immune function are regulated so that both mother and baby survive. More broadly, all animals deal with similar immune and environmental challenges, and use many of the same molecular and physiological mechanisms to survive. Hence, animals are excellent models for discovering novel therapies for humans. The complex dynamic between placental and immune function may even explain why men and women suffer different rates of autoimmune diseases and cancer. We use a range of molecular and physiological techniques to study these mechanisms to improve environmental outcomes, with potential to help human health as well.

### Reproduction and environmental change

Animals must successfully deal with a number of environmental challenges in order to survive and reproduce the next generation. Our research aims to discover the novel mechanisms animals use to deal with environmental impacts on reproduction, development, and immune function. We are particularly interested in nutritional and pollution impacts. The nutrients animals eat provide both the energy and chemical building blocks animals need to produce new molecules, cells, and tissues. Pollutants, including heavy metals, interact with molecular processes and cause breakdowns in reproduction, development, and immunity. Two examples of our research focus on freshwater turtles, which have remarkable immune systems. Adults use a powerful innate immune response to prevent systemic bacterial infections after injuries. Eggs resist fungal infections despite not having an immune system aside from the immune factors provided by their mother during egg production. We use molecular and physiological approaches to determine how these functions work, and how they are maintained despite food restrictions and pollution.

LabHead: Dr James Van Dyke
(J.Vandyke@latrobe.edu.au)

Fields of Study:
Physiology; Ecology; Evolution; Conservation

Capabilities and Techniques:
Animal respirometry and performance; Field ecology; Stable isotope analysis; Histology; Endocrinology; Compositional analysis.

Translational Opportunities:
Wildlife ecology and conservation; Environment change impacts on individuals; Pollution impacts; Novel trait evolution.

# Applied Aquatic Ecology Research Group

Murray River, Barah-Millewa Forest (Photo credit: Alison King)

## Water Management and Environmental Flows

The natural flow regime of rivers, wetlands and estuaries in many regions of the world has been substantially altered to meet human water needs. This extraction and regulation of flows has had major impacts on aquatic ecosystems by decreasing the amount of water available, altering flow patterns and connectivity of aquatic habitats. The science of environmental flows - the water required to sustain aquatic ecosystems - has emerged as an important tool for water resource planners and managers to better manage the trade-offs between water for the environment, people and the economy. Our researchers work on environmental flow and water management issues in Australia, especially the Murray-Darling Basin, and similar issues in Asia, Europe, South America and the USA. Our research spans fundamental science on flow-ecology relationships, impacts of detrimental water management outcomes (e.g. managed low or high flows, hypoxic waters) through to supporting river operations and water resource policy. Our multidisciplinary teams incorporate Indigenous values and perspectives.

## Aquatic Biodiversity and Ecosystem Monitoring

Monitoring and assessment are critical components of adaptive and responsive management for aquatic ecosystems. Our studies determine the status of aquatic fauna, flora and ecosystem processes in response to environmental events (e.g. environmental watering, infrastructure changes, water quality, climate change) and evaluate the achievement of management objectives and expected outcomes. We also study the development and implementation of monitoring techniques, (eDNA, underwater video and high-resolution sonar).

## Improving aquatic restoration and management outcomes

Natural aquatic environments have had significant loss, degradation and habitat fragmentation due to human activities. Restoration activities are being undertaken to protect aquatic biodiversity (wetland watering, riparian planting, woody debris reintroduction, habitat and connectivity improvements). We study ecological processes influences on aquatic habitat restoration outcomes to minimise threat impacts, and understand how managed flow regimes and infrastructure affect the movement and maintenance of aquatic species.

## Aquatic invasive species

Aquatic invasive species invade ecosystems beyond their natural ranges and are common in Australian freshwater systems. Their presence may harm native species and affect ecosystem processes. We study their potential impact and spread and the impact and usefulness of mitigation strategies and management actions.

Theme Head: Prof Nick Bond
(N.Bond@latrobe.edu.au).

Theme Members:
Assoc Prof David Crook;
Dr Michael Shackleton;
Dr Luke McPhan;
Dr Caitlin Gionfriddo;
Dr Sally Maxwell.

Fields of Study:
Ecology; Hydrology; Restoration Ecology; Conservation Biology; Ecosystem Science.

Capabilities and Techniques:
Field-based aquatic sampling; Field & lab experiments; Environmental Risk Assessment; Experimental design & monitoring; Quantitative & predictive modelling; Food-web ecology (using stable isotopes); Population genetics; eDNA.

Translational Opportunities:
Water resource management & policy; Fisheries; Catchment and invasive species management; Environmental impact assessment; Habitat restoration.

# Biodiversity and Ecology Group

Our research group studies the biodiversity of aquatic ecosystems and the environmental factors that shape populations and communities. We work on a broad range of research areas that aid in expanding our knowledge of Australia's biodiversity including the discovery and description of new species, conservation and threatened species management, species distribution modelling, defining community assemblages, identifying biotic and abiotic factors that drive species' persistence, and population genetics. We apply a variety of quantitative techniques to answer ecological questions, including a mixture of field and lab-based methods. We use environmental DNA and next generation sequencing approaches to detect and monitor species and communities, DNA barcoding for species delimitation and description, and genotyping for investigating species' population genetics. We investigate species responses to environmental factors such as the developmental responses of organisms to different temperature regimes. We also use large-scale spatial data for modelling species distributions and predicting how those distributions are likely to change in response to landscape management or environmental change.

Damselfly

### Conservation, Biodiversity and Threatened species

Our research focuses on understanding the unique biodiversity of Australian freshwaters and the factors that influence the persistence of species, populations, and communities. We undertake taxonomic research to identify and describe new species and population genetics studies to understand species ranges and linkages among populations. We combine species records and large spatial datasets to model the distributions of species and how those distributions are influenced by factors such as land use and climate change. Lastly, we investigate the acute and chronic responses of species and communities to environmental impacts, such as climate change, through a mixture of laboratory and field research.

### Environmental DNA for monitoring species

Environmental DNA is the trace DNA left by plants and animals in the environment. These DNA traces can be used to monitor the presence of species without the need to directly interfere with organisms. We have used eDNA to monitor the community assemblages of aquatic plants and animals and for detecting specific species at sites, such as the threatened Alpine Stonefly. Our research is used to inform where species occur across landscapes and how they respond to environmental characteristics. We also investigate how eDNA behaves in the environment, which helps inform how to interpret field collected eDNA data.

### DNA barcoding

DNA barcoding is a useful tool for delineating species and is the backbone for genetic applications such as eDNA analysis. Our team uses DNA barcoding to identify and help describe new species. We maintain a genetic reference database of DNA barcodes linked to curated specimens of aquatic organisms. This database is critical for placing accurate taxonomic identities on eDNA sequence data and has been used by multiple institutions.

### Population genetics

Our research team uses genomic data to investigate how connected species populations are. Our research has included investigating populations of the threatened Alpine stonefly and wetland plant species. This research provides an understanding of how species disperse through landscapes and what local and regional factors may be important to maintaining connected populations.

Lab Head: Dr Michael Shackleton (M.Shackleton@latrobe.edu.au)

Lab Members:
Dr Julia Mynott;
Ms Oliviah Lines.

**Fields of Study:**
Freshwater ecology; Taxonomy, Species distributions; Genetics; Genomics; Environmental DNA.

**Capabilities and Techniques:**
eDNA sequencing and analysis; DNA barcoding; Taxonomy; Field sampling; Field and laboratory experimentation; Species distribution modelling; Population genetics; Quantitative modelling.

**Translational Opportunities:**
Understanding freshwater communities, species diversity, distributions and population connectivity; conservation and threatened species management; responses of species and populations to environmental factors; DNA-based biomonitoring.

# Biogeochemistry and Ecotoxicology Group

Our research investigates biogeochemical processes in aquatic ecosystems, the bioavailability and toxicity of contaminants, the response of aquatic ecosystems to natural and anthropogenic stressors and the effects of abiotic factors on aquatic biota. We use a range of field and laboratory techniques to address specific research questions. Our field sites span tropical, temperate and alpine environments including alpine streams, rivers, lakes and wetlands, both nationally and internationally. We also use controlled laboratory experiments to understand chemical processes, interactions of biota with their chemical environment, and the bioavailability and toxicity of contaminants.

Goobarragandra River (Murray-Darling Basin, near Tumut, NSW) (Photo credit: Ewen Silvester)

### Alpine aquatic ecology and Peatlands

Our research is critical for future management of the Australian alpine environment. Alpine peatlands are important in regulating stream flows and water quality and will be adversely impacted by climate change. Our work investigates chemical regulation processes that occur in alpine peatlands and associated headwater streams as well as the aquatic communities in these environments. Our recent projects include the response of alpine peatlands and aquatic communities to high intensity rain events.

### Characterisation and bioavailability of Dissolved Organic Matter (DOM)

DOM has an important role in regulating abiotic and biotic processes in aquatic ecosystems. We use a range of spectroscopic and analytical techniques to characterise the chemical composition and bioavailability of DOM in aquatic ecosystems. Our current research investigates the influence of tributary inflows on DOM cycling in regulated systems; metabolic dynamics in dryland lowland rivers, and characterisation of DOM in naturally acidic, circumneutral and groundwater fed systems.

### Bioavailability and contaminant toxicity

Contamination of aquatic ecosystems is increasing globally. We use chronic toxicity bioassays coupled with a range of analytical and speciation techniques to assess the toxicity and bioavailability of contaminants (e.g. metals) in aquatic systems. Our current research is directed towards understanding the influence of water quality in modifying the toxicity of metals and the use of field data to derive habitat guideline values.

### Effects of abiotic factors on aquatic biota

Environmental and anthropogenic factors (temperature, salinity, pH and contaminants) affect aquatic organisms and biological communities. We use molecular techniques, (metagenomics and eDNA) to study responses of organisms and communities to these factors. Examples include: the effects of water type on fish gill microbiome in the Amazon basin; influence of water quality on moss distributions; biofilm responses to DOM composition; metals and environmental stressors effects on the amino acid profiles and proteome of aquatic biota.

### Synchrotron-based techniques

We use Infrared Microspectroscopy (IRM), and X-ray Absorption Spectroscopy (XAS) to study elemental and chemical distributions in sediments and organisms.

**Lab Heads:** Assoc Prof Ewen Silvester (E.Silvester@latrobe.edu.au) and Dr Aleicia Holland (A.Holland2@latrobe.edu.au)

**Lab Members:** Dr Michael Shackleton; Dr Andre Siebers; Dr Luke McPhan; Dr Caitlin Gionfriddo; Ms Manisha Shakya; Ms Suman Acharya; Mr Lucas Morais; Mr Francesco Colombi; Ms Oliviah Lines; Ms Gabriella Macoustra; Ms Lakmini Egodawatta; Mr Gwilym Price.

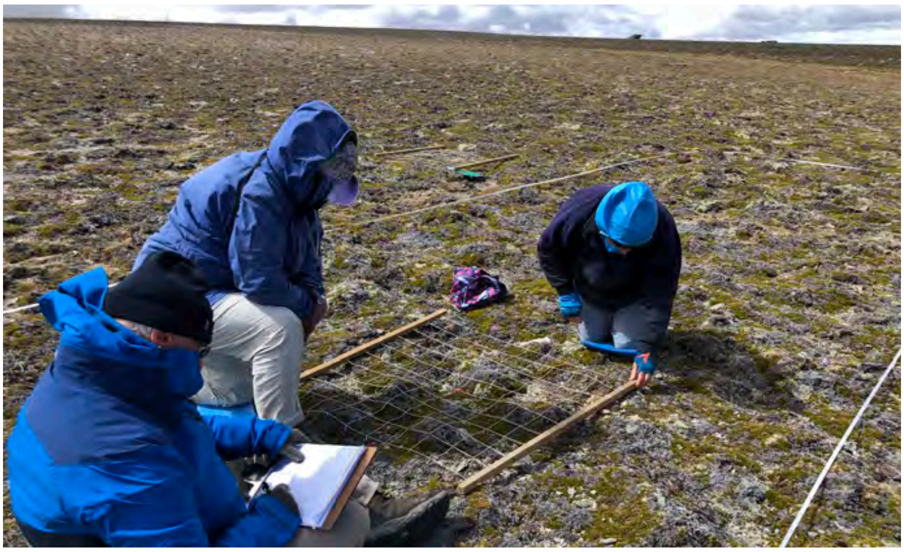
**Fields of Study:**
Freshwater Ecology; Environmental Chemistry; Biogeochemistry; Ecotoxicology.

**Capabilities and Techniques:**
Aquatic ecosystems field sampling; Water & soil analysis; Aquatic system productivity (GPP & ER); Laboratory risk assessment of contaminants; Liquid chromatograph mass spectrometry; Fluorescence and absorbance spectroscopy (FEEM); Synchrotron IRM & XAS; Metagenomics; Chemical speciation & thermodynamic modelling; Statistical modelling; Bayesian stable isotope mixing models.

**Translational Opportunities:**
Climate adaptation; Aquaculture stress and animal welfare; Agriculture, mining and urban effects on freshwater fauna; Species conservation; environmental perturbation; Environmental policy and management; Ecological restoration; Risk assessment.

# Botany and Plant Ecology Research Group

In the Botany & Plant Ecology Research Group, we study aspects of the structure, function and change of native ecosystems in Australia –threatened alpine, woodland and grassland ecosystems are where we do most of our work. Our research intersects with the ecological fields of regeneration ecology – disturbance ecology – interaction biology. We work to understand how species coexistence is maintained, how humans impact on these patterns, and how to apply ecological science to management and conservation of natural ecosystems. We are particularly interested is understanding how plant traits – the attributes of species such as seed mass, leaf area, plant height – shape the responses of plants to key drivers. A feature our work is to understand the long-term dynamics of ecosystems.



Field work (Photo credit: John Morgan)

### How did warm season (C4) grasses invade Australia - a land of shrubs and trees?

Forty million years ago Australia was connected to Antarctica then it broke away and drifted north along with plants (eucalypts, banksia and casuarina) and distinctive marsupials that had evolved at high latitudes. Australia was isolated until it collided with the Asian plate, 10-15 M yrs ago, by then it was undergoing aridification. As Australia drifted closer to the equator and Asia, a range of plants and animals dispersed from the northern hemisphere into ecosystems dominated by species of Gondwanan origin. Warm season (C4) grasses arrived about 3.5 M yrs ago but now cover 25 % of mainland Australia. Our research hypothesises that Australia's eucalypt woodlands function differently to northern hemisphere woodlands where tree shade is too dense for C4 grasses to grow. Eucalypts have the lowest leaf area of all trees. We are investigating whether the dappled shade of Australian eucalypts might affect what can grow underneath. With the absence of large grazing herds to curb C4 grass growth, fire became more frequent in ecosystems that had hitherto evolved within multi-decadal fire regimes.

### Optimizing current-day fire management for biodiversity conservation

For at least 60 M years fire regimes have shaped the structure and function of Australian natural ecosystems. Understanding fire history, including >40,000 yrs of aboriginal management, is crucial for managing the biodiversity of contemporary landscapes. Floral adaptations allowed some plants to prosper when fire became more common. Other species retreated into refuges where fire was less common. The spread of the new grasses played an important role in the flammability of the country and contemporary distribution of species.

### Maintaining Australia's rich biological heritage into the future

Since Europeans arrived in Australia – exotic invasive species (plants and animals), climate change and land use change (agriculture, urbanization) – all threaten our native plant and animal biodiversity. Today native grasslands and alpine flora are endangered ecosystems. We seek to quantify the vulnerability of such species, and examine strategies - like assisted migration - to ensure their persistence.

**Lab Head:** Assoc Prof John Morgan
(J.Morgan@latrobe.edu.au)

**Lab Members:**
Adj Prof Ian Mansergh; Dr James Shannon; Ms Sue Bryceson; Ms Steph Johnson; Mr Paul Foreman; Mr Dan Nugent; Mr Simon Heyes; Ms Annette Cavanagh; Ms Iris Hickman; Mr Luke Florence; Ms Nina Roberts; Ms Regan Beazley.

**Fields of Study:**
Ecological Applications; Global Change Biology; Landscape Ecology; Long-term Ecological Research.

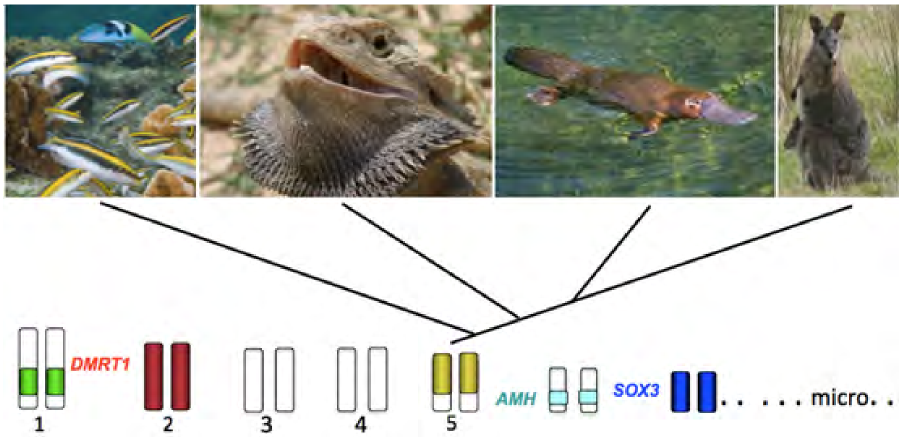
**Capabilities and Techniques:**

- Long-term ecological research (LTER) sites & associated field infrastructure in alpine environments;
- Data repository (Alpine Database, spanning >75 yrs of ecological research in the Australian alps);
- Co-ordinated Distributed Experiment Research (CDE) sites.

**Translational Opportunities:**
Assisted migration; Climate adaptation; Fire management; Species conservation; Environmental policy; Ecological restoration; Threatened species recovery; Invasive species management; Impact assessment.

# Comparative Genomics

Prof Jenny Grave's comparative genomics research is via national and international collaborations.



Comparative genomics cladogram (Diagram credit: Jenny Graves)

## Sex in Dragons

Since 2003, in collaboration with Prof Arthur Georges, and Prof Janine Deakin and Prof Tariq Ezaz (Institute of Applied Ecology, University of Canberra), we have been studying sex determination in the Australian lizard Pogona vitticeps (the central bearded dragon). We discovered a ZZ male ZW female chromosomal sex determining system with SF1 as the sex determining gene which delivers 50% male and 50% female hatchlings at physiological temperatures. At higher temperatures, all hatchlings are female; half of these are ZW (normal) female and half ZZ sex reversed female. By mating ZZ sex reversed females to normal ZZ males, we can completely swap the sex determining system from genetic to environmental in one generation. We are using this system to discover how environmental sex determination works, by examining transcription in normal and sex reversed animals, finding unique transcripts of epigenetic modifying genes, and upregulation of stress markers at sex reversing temperatures. We aim to explore the pathways by which epigenetic changes modify gonad and germcell development.

## Platypus sex and sex chromosomes

An ongoing collaboration with Prof Frank Grutzner (University of Adelaide) includes Dr Paul Waters (UNSW), and scientists in China (Shenzhen and Hangzhou) and Germany (Heidelberg). Building on our demonstration that platypus sex chromosomes share homology with birds, and our high quality platypus genome sequence, we can use new –omics techniques to explore how different autosomes became sex chromosomes in mammals, and examine a rare case of an autosome that is either an ex-sex chromosome, or a “wannabe” proto-sex chromosome. We will discover how different sex chromosome dosages in platypuses are compensated by epigenetic modifications to gene expression, and explore how different systems of dosage compensation evolved independently in monotremes and therian mammals.

## The origin of vertebrate chromosomes

Recent collaboration with the University of Canberra and scientists in Japan and Austria compares the DNA sequences of chromosomes of reptiles (including birds) to those of chordates such as Amphioxus. Sequence comparison is identifying extraordinary homology between chordate chromosomes and the gene-dense microchromosomes of birds and reptiles, implying that they, rather than the classical large vertebrate chromosomes, represent the original vertebrate chromosomes. The large, repeat-rich chromosomes of mammals seem to have been puffed up by insertion of transposable elements, and by duplications and amplification, allowing them to be greatly rearranged in evolution.

## The Earth Biogenome Project (EBP)

A large international collaboration costing USD14.6 billion, aims to sequence the genomes of all complex life on earth (1.5M identified eukaryote species) in ten years. By changing the way biology is done, reducing reliance on a few model species and facilitating studies of any species, it will solve questions of phylogeny, provide new opportunities for agriculture, and inform wildlife conservation and management. EBP is headed by scientists at UC Davis (USA) and the Sanger Centre (UK). As one of the pioneers of comparative genomics, who was involved in the first international vertebrate sequencing consortium (Genome 10K), Prof Jenny Graves has been on the frontline for launching this project, and is on the EBP Advisory Council. At the national level Jenny is involved in the Oz Mammal Genome (OMG) consortium that aims to sequence all Australian mammals, as well as new moves to gain support to sequence all Australian reptiles.

Lab Head:Prof Jenny Graves
(J.Graves@latrobe.edu.au)

Fields of Study:
Genetics; Genomics; Epigenetics; Evolution; Development.

Capabilities and Techniques:
Cytogenetic tools (chromosome sorting and chromosome painting; Gene localization by in situ hybridization, gene mapping), and –omics technologies (DNA sequencing, RNA transcriptomics, methylomics, metabolomics, chromosome conformation capture).

Translational Opportunities:
Discovery of new genes; New products; Generation of data useful in breeding domestic species and management of wildlife.

# Crop Agronomy Group

Agronomy is generally defined as the science and practice of understanding how agricultural systems work in order to improve their productivity, profitability and/or sustainability. It is an integrative profession – requiring an understanding of many scientific disciplines related to agricultural production, including plant and animal science (ecology, physiology, nutrition, genetics and pathology), soil science (soil physics, chemistry and biology), meteorology, economics, sociology, geomatics, statistics and data science.

The Crop Agronomy Group specialise in improving water limited productivity of dry-land cropping and mixed farming systems. Group research focuses on using combinations of management and genetics to increase productivity and profitability of grain-based farming systems with a current focus on Australia. The group has developed the philosophy of 'transformational agronomy' – which argues in favour of agronomists coordinating transdisciplinary teams to solve major constraints to production rather than working in isolation on strictly agronomic issues.

Photo credit: James Hunt

Keyprojects:

GRDC National Phenology Initiative
Partners: *CSIRO, NSW DPI, SARDI, DPIRD, Plant Food Research NZ*

This project aims to help Australian wheat and barley growers better match crop lifecycle with seasonal conditions optimal for growth

GRDC Management of Early Sown Wheat
Partners: *SARDI, Hart Field Site Group, Frontier Farming Systems, Birchip Cropping Group, Agriculture Victoria, FAR Australia*

This project evaluates regional adaptation of these genotypes, climatic conditions require for successful cultivation, and management practices specific to early sowing that can improve yields.

Smart Farming Partnerships - Djandak Dja Kunditja
Project lead: *Dja Dja Wurrung Clans Aboriginal Corporation*

This project aims to revive kangaroo grass as a commercial grain crop and will develop agronomic packages to improve sowing and harvest and maximise grain yield.

GRDC Optimising mungbean yield in the northern region - Mungbean Physiology
Partners: *University of Queensland*

This project aims to understand the physiological factors driving seasonal yield and quality potential of mungbean cultivars under optimal and sub-optimal conditions.

GRDC Integrating yield optimisation in mungbean
Partners: *CSIRO and University of Queensland*

Updating the APSIM crop model for mungbean will enable improved capacity to simulate mungbean growth and yield is used to inform agronomic recommendations that optimise mungbean grain yield and reliability across seasons and environments.

Group Head:
Dr Marisa Collins
(Marisa.Collins@latrobe.edu.au)

Group Members:
Dr Corinne Celestina; Dr Heather Pasley; Mr David Cann; Mr Max Bloomfield; Ms Niloufar Nasrollahi, Ms Cordelia Dravitzki; Mr Dylan Male.

Fields of Study:
Farming Systems Research; Crop and Pasture Improvement (Selection and Breeding); Crop and Pasture Nutrition; Agricultural Production Systems Simulation; Agronomy.

Capabilities and Techniques:
Field experimental design, conduct and statistical analysis; Controlled environment experimental design, conduct and statistical analysis; APSIM farming systems simulation.

Translational Opportunities:
High yielding populations of winter wheat derived from elite spring/spring crosses.

# Crop Plant Hormones Group

Inspecting crop varieties field trial. (Photo credit: Phil Brewer)

Plant hormones are master regulators of plant growth, development and stress response. Plant hormone pathways are key targets for crop breeding, particularly for optimising plant architecture. However, the biology of hormones is complex, often leading to unintended or unwanted side effects. Our Group investigates how to harness the full potential of plant hormones for crop breeders and growers. We conduct research at multiple scales, from the cell and molecular biology of model plants to hormone treatments of crops in glasshouses, and to field trials using innovative crop genetic variants. The research is collaborative and involves local, national, international and industry partners. The Group's work combines a deep understanding of the interconnectedness of plant signals, genes, proteins and cells, with real-world relevance.

### Crop Dwarfing

Our Group has a strong understanding of the networks of hormones that control crop plant height, and the side effects on other important traits, such as tillering. We have a strong track record of uncovering the impact of plant hormones on important crop traits, such as tillering, grain size and yield. Until early this century, it was thought that auxin alone controls tillering. Our research has challenged this assumption by revealing the involvement of other hormones, such as strigolactones, and demonstrating the significant impacts of hormones associated with sub-optimal growth conditions, such as poor soil fertility and drought. Our research been influential in changing models of plant signals that regulate growth, development and stress response. In collaboration with The University of Queensland and Bayer Crop Science USA, we are studying the effects of plant hormones on the height of corn and sorghum. In addition, we are researching dwarfing for crops in space and vertical farming with the Plants for Space ARC Centre.

### Plant Growth Regulators

A range of past and present projects by our Group have investigated the biology of plant growth regulators and biostimulants. These include work involving auxin, strigolactone and gibberellin, and other natural plant compounds. Current projects include work on the biosynthesis of strigolactones and actions of strigolactones on plant growth and tolerance to stress conditions such as low nutrients or drought. All of these projects have focused on understanding the basic biology and identifying the key processes involved and what management actions are most likely to enhance crop productivity.

### Growth Versus Defence Trade-Off

Climate and soils are increasingly hostile for crops. At the same time, greater productivity, particularly of healthier food products, is needed from farming. Crop varieties are needed that cope better with stress, while providing better nutritional profiles. However, all this often comes at a yield cost. Some of our hormone research has focused on the effect of plant hormones on the activity of cellular energy production. It may be that a better understanding the connections between plant hormones and cellular energy will reveal ways to genetically disconnect growth from defence, such that high quality and resilient crops can be grown without compromising yield. Our internationally collaborative research is revealing for the first time that strigolactones act as a master regulator of growth versus defence decisions. Our research explores which factors exacerbate or ameliorate the impact of hormones on cellular processes.

### Plant Hormone Biology

Our Group's research is driven by a deep curiosity to discover how plants work. Our goal is to conduct research that improves food production, particularly under ever more difficult climate and soil conditions. Whether we are studying a single cell, or the entire network of plant genes and signals, understanding plant responses to climate change and sub-optimal conditions is crucial for improving and adapting modern food crop production.

**Lab Head:** Prof Phil Brewer (P.Brewer@latrobe.edu.au)
**Lab Members:** Dr Adi Situmorang (Adelaide); Mr Jack Kelly (Adelaide); Mr Ben Kurya (Adelaide).

### Fields of Study:

Plant biology; Agricultural biotechnology; Biochemistry and cell biology; Crop and pasture production.

### Capabilities and Techniques:

Cell and molecular biology, transgenics, gene editing, transcriptomics; epigenomics, conceptual modelling of complex systems; analysis of complex data sets.

### Translational Opportunities:

Crop height and branching, Gene editing, Stress and Herbicide tolerance, Efficient nutrient use, Soil microbe symbiosis, Plant growth regulators, Biostimulants.

# Developmental Evolution Group

During the embryonic and juvenile life stages, animals acquire an incredible range of traits suited to their lifestyle and ecological niche. Many of these adaptations arise through evolved changes in developmental programs encoded in the genome. However, development isn't just a passive player in evolution. Our group studies how the genetic, epigenetic and mechanical processes of development have shaped trait diversity in animals, as well as their impact on the fitness of threatened species. We view the tree of life as an almost inexhaustible repository of naturally occurring experiments in trait construction. So, as we seek to learn more about the origins of macroevolutionary patterns and the links between genetics and population health, we emphasise the use of diverse, non-traditional model organisms.

### The Marsupial Advantage

Marsupials are perhaps the most iconic feature of Australia's native fauna. No other place on Earth has such a remarkable diversity of marsupial species. This group is distinguished from other mammals by its unusual mode of reproduction. All marsupials are born at an essentially foetal state of development. Yet, these tiny neonates make a heroic crawl to their mother's pouch within minutes of birth. Because of their short gestation, many processes that occur in utero in species like mice or humans happen postnatally in marsupials, providing unparalleled access to these early developmental events. Our group makes special use of this "marsupial advantage" to perform studies that would be difficult or impossible in other mammals.

### "Only" Skin Deep?

The skin forms the primary interface between an animal and its environment and provides a variety of critical functions. This, together with its incredible accessibility, makes the skin one of the best systems out there to study development. Currently our group is conducting research on the volar (palm) skin morphologies found across marsupials. Some species' paws have skin covered in small granules, some have hairy palms, and some have surprisingly human-like fingerprints. Across the marsupials, these three morphologies show up repeatedly, often evolving convergently between distantly related groups.

L: Foot pad morphologies of marsupials (Photo: D. Hamilton). TR: Endangered eastern quolls (Photo: B. Vercoe). BR: Australian tadpole shrimp, a living fossil (Photo: C. Feigin)

This suggests that it's a relatively small evolutionary leap to switch between these three skin types, but that it's rather hard to evolve a totally new morphology. Our goal is to understand the genetic changes that cause species switch between volar skin types and to learn how the mechanism controlling volar skin development constrain or bias the range of observed diversity.

### Beyond Conservation Genetics

Populations of many Australian native species have experienced steep declines in the modern era – a process that can cause harmful genetic variants to accumulate. This, paired with increased rates of inbreeding, can damage their fitness through a phenomenon called inbreeding depression. This is a grave threat that can inhibit species recovery, but determining its severity with genetic data alone is a challenge. However, the effects of both harmful and beneficial genetic variation are mediated by epigenetic mechanisms like DNA methylation. Our group aims to better understand the relationship between fitness and patterns of epigenetic change in threatened species like the endangered eastern quoll (*Dasyurus viverrinus*). Ultimately, we aim to use our findings to build models that can help conservation practitioners predict and even prevent inbreeding depression.

### If It Ain't Broke, You Can Still Fix It

Living fossils are an enigma that almost seem to defy evolution. Our work aims to show that, on the contrary, living fossils are among the most beautiful examples of the evolutionary interplay between DNA, development, and lifestyle. We are conducting genomic studies on tadpole shrimp (Family Triopsidae), a lineage whose shape has hardly changed in ~360 million years. These tiny arthropods are well adapted to their niche, but this isn't enough to explain their extreme morphological stasis in an ever-changing world. Our group is exploring the hypothesis that tadpole shrimp have continued to increase their fitness over time by evolving greater developmental stability (resistance to environmental and genetic perturbations). This can lead to more successful offspring, but may also be a double-edged sword, limiting their overall capacity for change. This balance between developmental stability and adaptability may be a fundamental explanation for the tempo of morphological diversification.

Lab Head: Dr. Charles Feigin
(C.Feigin@latrobe.edu.au)

Lab Members:
Mr. Riley Ferguson, Ms. Matilda Williams.

Fields of Study:
Evolution; Development; Genomics; Epigenetics

Capabilities and Techniques:
Multi-omic analysis; computational biology & bioinformatics; in vitro & in vivo studies.

Translational Opportunities:
Integrative approaches to conservation biology; Novel model systems for biomedically-relevant research.

# Environmental Impacts Group

The Environmental Impacts Team focusses on research to assist horticultural industries maintain production despite huge environmental impacts due to climate change and ozone depletion. The team has built up an international reputation for successfully finding solutions to replace chemicals which damage the ozone layer and the impacts of catastrophic bushfires caused by rising temperatures due to climate change on the wine industry. The team has state-of-the-art automated equipment for measuring greenhouse gasses, and an organic laboratory and field equipment to measure movement of pesticides and bushfire particles through the atmosphere. The group has taken on leadership roles for the Montreal Protocol in assisting national and international governments, and industry find more sustainable alternatives for plant production.

In the field (Photo credit: Ian Porter)

### Phase out of Methyl Bromide under the Montreal Protocol

Methyl bromide (MB) is a major ozone depleting chemical that was listed for phase out under the Montreal Protocol in all developed countries by 2005 and in developing countries by 2015. The Montreal Protocol however allowed critical use exemptions for industries and countries to continue MB use beyond these deadlines if no technically or economically viable alternatives existed. The team has a role to assist industries and to assess all international applications for critical use, and to review technical alternatives. The team also reviews the 10,000 tonnes of MB still used for quarantine and preshipment applications against pests, weeds and diseases. This use is presently exempt from phase out under the Montreal Protocol. The group has also provided expert advice on matters of atmospheric pollution by other ozone-depleting substances.

### Impact of Smoke Taint on the Wine Industry

The exposure of vineyards to smoke during the catastrophic bushfires in Australia in 2020 caused over $400 Million loss from smoke taint. Smoke taint is caused by an increase in the level of smoke compounds in grapes which cause chemical composition changes and render the wine unpalatable. The phenolic compounds are elevated to concentrations which give the wine smoky and burnt ashtray aromas and taste. The taint however is based on cumulative thresholds of specific phenols in smoke and grapes. The group is identifying how to use this information to develop an early warning system for industry which will provide alerts on a phone app through networks of smoke detectors placed throughout Australia. An accurate risk prediction system will save the industry substantially from not only lost production but also avoiding the huge costs at harvest in the event of excessive smoke.

### Measuring Greenhouse Gasses to provide Sustainable Solutions for Industry

Nitrous oxide is a greenhouse gas that is 300 times more potent at global warming than $CO_2$. For the last decade, the group has been monitoring nitrous oxide emissions to the atmosphere from fertilizer and organic amendment use and their interactions in the horticultural industries. Methods to reduce emissions have shown a 60% decrease with different nitrification inhibitors and other management techniques. Through the use of automated chambers, and mobile GC and air quality equipment, the group can continuously monitor and benchmark greenhouse gasses, nitrogen flows and other volatile pollutants.

Lab Head: Professor Ian Porter
(I.Porter@latrobe.edu.au)

Lab Members:
Mr David Riches; Dr Scott Mattner.

**Fields of Study:**
Greenhouse gasses; climate; atmospheric chemistry; soil science; Atmospheric chemistry; soil science; crop physiology; grape and wine biochemistry.

**Capabilities and Techniques:**
Measuring greenhouse gasses; an organic laboratory and field equipment to measure movement of pesticides and bushfire particles through the atmosphere.

**Translational opportunities:**
Reducing greenhouse emissions across horticultural industries, potential smoke taint in cherries and apple cider, using smoke risk prediction to assist human health studies.

# Evolutionary Ecology Group

Why do some species have restricted ranges while others can be found everywhere? Our research uses model (Drosophila) and non-model insects (native bees) to understand how abiotic and biotic interactions shape species distributions. We ask these questions within species using breeding designs and population comparisons and between species mapping traits onto phylogenies to determine the contributions of selection vs evolutionary history in shaping trait variation. We aim to understand the capacity of species to respond to novel environments via evolution and plasticity (flexible phenotypes). The questions we ask are often through the lens of climate change with the over-arching aim of understanding which species and environments are most vulnerable.

Tropical Drosophila and a native bee (Amegila) (Photo credit: Carmen da Silva and Andrew Weeks)

### Using traits to predict species at risk

Predicting which species will be at the greatest risk to climate change represents one of the greatest challenges for biologists. Our research takes a trait-based approach towards tackling this problem. We are interested in traits linked to current climates and, therefore, important in shaping the distribution of insects. We focus on ecologically relevant traits likely to underpin adaptation to novel environments. These include tolerance traits like heat and cold and fitness traits like fecundity and development time. Using these traits, we predict which species and environments (tropical vs temperate) are at the greatest risk to climate change.

### Evolution and plasticity in a changing world

Evolutionary responses will ultimately underpin the winners and losers of climate change. These responses can be divided into genetic (slow/across generations) vs plastic responses (rapid/within generations). My research group is interested in determining how genetic variation and plasticity contribute to trait variation within and between species.

We use family studies and experimental evolution to determine whether traits are underpinned by genetic variation and can respond to selection. My group is also interested in how phenotypic plasticity evolves. Do certain environments select for phenotypically plastic phenotypes (fluctuating vs stable), is plasticity in tolerance underpinned by trade-offs and ultimately, can we predict which species are more or less likely to be phenotypically plastic? To study phenotypic plasticity, we manipulate environments to determine what environmental cues induced phenotypic plasticity within and between species.

### Temperature and species interactions

We know species interactions, particularly competition, are often temperature-sensitive and that their impacts on community composition and ecosystem function will vary as the climate changes. Our research aims to understand how species interactions and temperature interact to affect evolutionary responses to climate change. We are interested in whether you can predict competitive outcomes using a trait-based approach and whether competition can change evolutionary trajectories through effects on genetic variation.

### Pollinators-native bees

As pollinators to native vegetation and crops, native bees are keystone species in many ecosystems. Our group's research aims to unveil the role of climate in shaping native bee distribution. We are interested in how rising temperatures will change pollinator communities in native and agricultural systems. By understanding thethermal biology of pollinators, we will be better placed to understand how climate change will shape pollination services and the agricultural systems on which we rely.


Lab Head:Dr Vanessa Kellermann
(V.Kellermann@latrobe.edu.au)

Lab members:
Mr Matt Elmer;
Mr Harley Thompson.


**Fields of Study:**
Ecology; Evolution; Thermal biology; Macroecology; Quantitative Genetics.

**Capabilities and Techniques:**
Field and lab experiments, experimental design, ecophysiology, high through-put phenotyping, quantitative genetic analysis.

**Translational Opportunities:**
Climate adaptation, pollination resilience, species conservation, environmental vulnerability.

# Fish Ecology and Fisheries Group

Our group in the Centre of Freshwater Ecosystems has extensive expertise in fish ecology and fisheries science, and works closely with industry and research partners across Australia and internationally. We study the behaviour, biology and ecology of freshwater, estuarine and marine fishes, and focus on understanding how human disturbances - including climate change, water resource use and fisheries – affect the viability and sustainability of fish populations. Our research supports the sustainable management of fisheries and associated natural resources.

Tagged Barramundi ready for release (Photo: David Crook)

### Movement and migration

Understanding how fish and other aquatic organisms are distributed in the environment over time allows for the identification of critical movement pathways and the impacts of human activities. We have expertise in a range of methods for studying fish movement and migration. We use radio- and acoustic telemetry to directly track the movements of fish and turtles in riverine landscapes, estuaries and the sea. We are also leaders in the use of otolith (fish earstone) chemistry analysis, which allows us to hindcast the migration histories of individual fish over their entire lives. The data we generate are integrated with environmental information (e.g. river discharge) to understand the responses of fish to environmental drivers and used to devise strategies to protect fish populations.

### Population structure

Fish populations are often comprised of distinct spatial units that are demographically isolated. Management of structured populations requires location-specific approaches that account for variable population dynamics across regions. We use a suite of natural tags, (otolith chemistry, parasites assemblage composition and population genetics - SNP, microsatellites) to examine population structure in freshwater, estuarine and marine fisheries. Our research is used by management agencies to define boundaries for spatial management of commercially and socially important fisheries.

### Biochronological analysis

Calcified structures, such as fish otoliths, provide the key to understanding many aspects of fish ecology and fish population dynamics. Otoliths provide a chronological record of a fish's age, migration history and growth rate across the entire life history. We use this information to build statistical models linking fish recruitment (year class strength) and growth rates to environmental variables such as river flow and large-scale climatic variation. These models are used to examine the outcomes of future climatic and hydrologic scenarios, and inform water resource allocation and fisheries regulation.

### Traits and life history

We use ecological species traits (e.g., morphological attributes) and life history attributes (e.g. reproductive groups) to explain and predict species abundance patterns, the likelihood of species extinction and invasion, and changes in species distributions caused by environmental change. Along with collaborators in Australia and overseas we apply trait-based ecology and life history theory to study how fish drive ecological function.

We study trait correlations and links between 'trait-scapes' and the environment to predict fish community assembly and responses to future hydrologic regimes and climate.

**Lab Head:** Prof Nick Bond (N.Bond@latrobe.edu.au)

**Theme members:**
Assoc Prof David Crook;
Assoc Prof Alison King;
Dr Luke McPhan;
Dr Michael Shackleton;
Dr Sally Maxwell.

**Fields of Study:**
Ecology; Fisheries Sciences; Conservation Biology; Ecosystem Science; Genetics; Behaviour; Comparative Physiology.

**Capabilities and Techniques:**
Otolith chemistry & biochronology; Radio & acoustic telemetry; Split beam sonar; Laboratory experiments; Static & flow-through respirometry; Fish surveys; electrofishing; eDNA; Stable isotope analysis; GIS; Quantitative modelling.

**Translational Opportunities:**
Fisheries management; Threatened species conservation; Climate change impact & mitigation; Water resource policy & management; Biodiversity assessment.

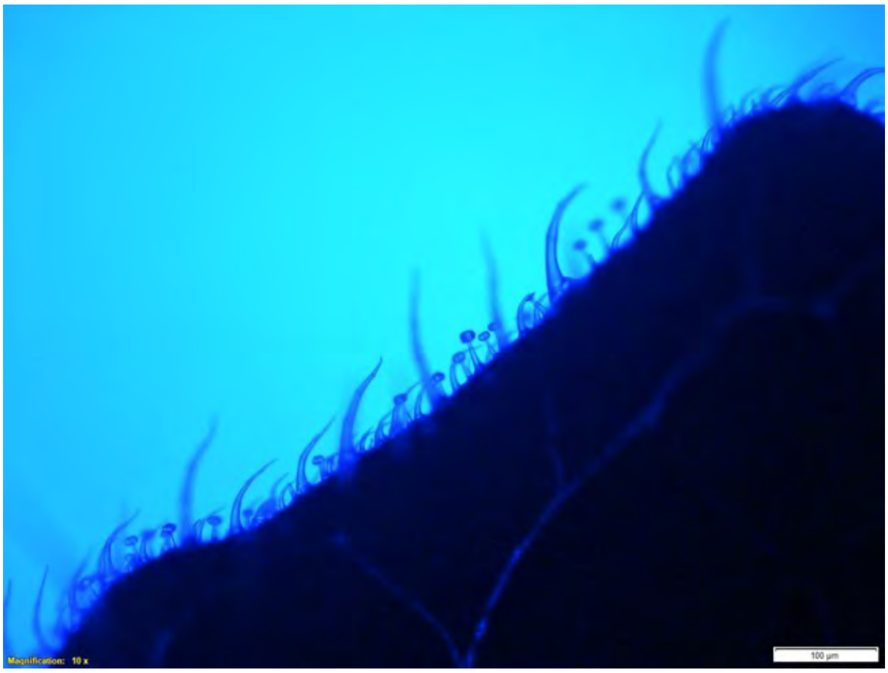
# Genome Regulation Lab

The genomes of organisms frequently encode tens of thousands of genes, each of which has a specific job to do in specific times and places. In the Genome Regulation Lab, we investigate how organisms control expression of these tens of thousands of genes at system-level. We do so to understand how organisms interact with and respond to their environments. Cutting edge 'omics technologies are key to our work and we have a keen interest in applying new laboratory and computational approaches. Some of our most recent achievements have been in single-cell genomics.

**Ready, Set, Grow: Gene Expression During Seed Germination**
Seeds are the single most valuable output from plant production, providing 70% of global food resources. They are also a critical input to agriculture because the lifecycle of most crops begins each season from their seeds, which must germinate, grow and establish. We examine the temporal and spatial hierarchy in genome regulation during germination that, if disrupted, results in erroneous germination and seedling growth.

**Grow-in-the-Dark: Systems Regulation of Hormone Responses**
Our research in this area focuses on understanding how the different plant hormone signalling pathways interact one-another and exchange information. Ultimately, we analyse how this affects genome-wide gene regulation and seedling development.

**Medicinal Agriculture: Cannabis and Opium Poppies**
Our lab is part of the ARC Industrial Transformation Hub for Medicinal Agriculture, lead by La Trobe University. Within the Hub we specialise in applying genetic and genomic analysis tools to producers' plant lines in order to improve crop yield and profitability. At La Trobe we have established a cluster of experts across the complete cannabis production cycle, from plant genetics, through cultivation, to downstream processing.



Glandular trichomes on the surface of tomato leaves (Photo credit: Lee Conneely)

**Plants on Film: High-Throughput Plant Phenomics**
Plants are surprisingly dynamic. Across a day, their leaves move up-and-down and side-to-side. Our lab uses time-lapse imaging to analyse the movements of hundreds of plants at once, measuring features down to sub-millimetre scale. We have a particular interest in the development of new image analysis algorithms that improve the speed, convenience and accuracy of analysing very large collections of images.

**La Trobe Genomics Platform**
The researchers of the La Trobe Genomics Platform are embedded within the Genome Regulation Lab. Our dedicated laboratory and bioinformatic staff provide an end-to-end service for both internal and external researchers. Areas of specialty include transcriptomics, single-cell analyses (using the 10x Chromium Platform), meta-analyses and machine learning. Our clients span plant, animal and medical research.

**Lab Head:** Assoc Prof Mat Lewsey (M.Lewsey@latrobe.edu.au)

**Lab Members:**
Dr Muluneh Tamiru Oli; Dr Bhavna Hurgobin; Dr Neha Patel; Dr Marta Peirats-Llobet, Mr Changyu Joe Yi, Dr Sophia Ng; Dr Mary Khodayari; Dr Esmaeil Ebrahimie; Ms Asha Haslem, Ms Uyen Hong; Ms Lingling Lynn Yin; Mr Diego Lozano; Mr James Lancaster; Mr Lee Conneely.

**Fields of Study:**
Plant biology; systems biology; bioinformatics; genomics; epigenomics.

**Capabilities and Techniques:**
High-throughput sequencing (ChIP-seq, RNA-seq, scRNA-seq, DNA methylome sequencing, others); bioinformatics and integrative data analysis; cell and tissue-specific analyses; genome regulatory network construction.

**Translational Opportunities:**
Our lab genomics and bioinformatics skills are of use to anyone who might like to apply these types of analyses, which is very common in agriculture and medicine. We have several commercial partners in this space already and welcome more.

# Landscape Ecology Group

Our group investigates how landscape structure, function and change influence the ecology and conservation of native fauna and flora. We work in a range of landscapes and focus on how changes associated with human land-use (e.g. agriculture, forest management, fire management, urbanization, restoration) influence Australian wildlife. An innovative theme in our research is a 'whole of landscape' approach in which we compare the biota of 'whole' landscapes that differ in the extent, configuration and composition of native vegetation, or pattern of land-uses. Our work, often in collaboration with land management agencies, aims to provide knowledge and solutions for more effective conservation of flora and fauna in Australia and globally.

Rural landscape in north-central Victoria (Photo credit: Andrew Bennett)

### Conservation in rural environments

Worldwide, agriculture is a dominant and expanding land use. The future of many species depends on their ability to persist in rural landscapes. A global challenge is to find solutions to balance human production of food and fibre with conservation of ecosystems and wildlife. We focus on identifying characteristics of rural landscapes that enhance the persistence of wildlife, particularly woodland birds. This includes 'whole landscape' characteristics (e.g. amount and pattern of native vegetation) and the role of key features (e.g. streamside vegetation, roadside networks, scattered trees). We also investigate the benefits of restoration through revegetation in farmland.

### Natural Capital Accounting

We are at the forefront of developing and testing Natural Capital Accounts as a tool for measuring and reporting on natural capital and ecosystem services at a farm-scale. This will be crucial for farmers to demonstrate their environmental performance as we move towards a 'nature-positive' future.

### Fire in the landscape

Fire, both wildfire and prescribed burning, generate long-term changes that affect native flora and fauna. We study the effects of fire regimes on conservation in a range of ecosystems – semi-arid mallee, box-ironbark forests, and foothill forests of the ranges. We aim to understand the long-term responses of native flora and fauna to fire, identify how spatial patterns of different post-fire age-classes of vegetation influence species and communities; and synthesise this knowledge for more effective fire management planning and practice.

### Conservation biology of wildlife

We study the conservation biology of individual species and communities in relation to changing land use. This includes threatened species such as White-bellied Whipbird and more widespread species such as White Ibis and Superb Lyrebird (as an ecosystem engineer); and faunal communities (e.g. woodland birds and insectivorous bats).

### Ecology of woodland ecosystems

Over the last 200 years, Australia's temperate woodland ecosystems have been greatly affected by human land-use, leaving highly fragmented systems. We undertake a range of projects, such as the long-term dynamics of bird communities, the effects of habitat fragmentation, the flowering ecology of eucalypts and effects of prescribed burning. Several long- term projects (>10 years) give key insights into changes through time (e.g. impacts of the Millennium Drought).

**Lab Head:** Assoc Prof Jim Radford (J.Radford@latrobe.edu.au)

**Lab members:**
Emeritus Prof Andrew Bennett;
Emeritus Prof Mike Clarke;
Dr Alex Maisey; Dr Grace Sutton;
Dr Will Mitchell; Dr Fred Rainsford (Adjunct);
Dr Kim Lowe (Adjunct); Dr Simon Verdon (Adjunct); Ms Annette Cavanagh;
Ms Berenice Della Porta; Ms Mads Dwyer;
Ms Lauren Haylen; Mr Rhys Makdissi;
Ms Bryony Margetts; Ms Rachel McIntosh;
Ms Nina Roberts; Mr Zebedee Muller.

**Fields of Study:**
Landscape Ecology; Conservation Biology; Wildlife Conservation; Ecosystem Services.

**Capabilities and Techniques:**
Field-based ecological studies; Study design; Wildlife surveys; Ecological data analysis and synthesis; Restoration ecology; Natural Capital.

**Translational Opportunities:**
Wildlife ecology; Conservation on farms; Revegetation and restoration; Fire management; Landscape change; Natural Capital Accounting.

# La Trobe University Herbarium

The Department of Ecological, Plant and Animal Sciences (EPAS) houses an internationally registered herbarium with over 20,000 vascular plant specimens, c. 9,000 of which are fully curated (pressed, mounted, labelled and databased). The herbarium is available for use by all members of the La Trobe community and the public by arrangement. The herbarium was first registered with Index Herbariorum under the code LTB in 1973. LTB is a member herbarium of the Council of Heads of Australian Herbaria (CHAH https://chah.gov.au/). The herbarium is actively used for teaching and by researchers and students who examine specimens, lodge their own collections, are able to access collections at other herbaria nationally and internationally though LTB's CHAH membership.

Microscope and one of LTB's early specimens (Photo credit: Alison Kellow)

## History

The La Trobe University Herbarium (LTB) was established in 1967 in the School of Biological Sciences (later to become the Department of Botany). It was started by plant geneticist Noel Thurling, who is responsible for many of the early collections. Trevor Whiffin, lecturer in plant systematics, took over running the herbarium in 1973. He kept this role until his retirement in 2008, and most of the collection was developed under his watch. The diversity of the collection mostly reflects the interests of staff and students in the Botany Department (now EPAS) over the last four decades, and are mostly from southern and eastern Australia, with an emphasis on *Eucalyptus, Angophora, Acacia, Correa* and rainforest plants, including Melastomataceae, Monimiaceae, and Rutaceae. There are also collections from Papua New Guinea and Thailand.

## Database

LTB's collection has been databased with support from the Royal Botanic Gardens Victoria, the School of Life Sciences (now SABE), Eucalypt Australia, and through the efforts of many student and ex-student volunteers. Data have been uploaded to the Atlas of Living Australia (ALA) and can be searched in depth on The Australasian Virtual Herbarium (http://avh.ala.org.au) Herbarium records are not just for taxonomists. They provide invaluable information regarding changes in species' distribution and flowering over time, underpinned by verifiable identification. This can be used for many types of research. In 2024, nearly 1 million records from LTB's database were downloaded in over 12,000 separate download events. There have been over 5 million record downloads in total. These records were documented as contributing to biosecurity management and planning, collection management, education, environmental impact and site assessment, and nearly half the downloads to ecological research.

## Current operations

LTB's collection is currently expanding as it incorporates specimens collected by current staff, research associates, and students in DEG. Links have also been established with other parts of the university and affiliates. For example LTB recently accessioned a collection of Thai Enthobotany vouchers from a past Linguistics PhD student, and collections of aquatic plants from staff at AgriBio (DEECA). On a regular basis, the herbarium provides advice and equipment for researchers undertaking collecting, and it can arrange direct access to collections from other herbaria around the world. There is a regular program for undergraduate student volunteers who provide most of the labour involved in specimen databasing and curation.

**Curator:** Dr Alison Kellow (A.Kellow@latrobe.edu.au)

**Fields of Study:**
Systematics and Taxonomy; Plant Ecology; Conservation Biology.

**Capabilities and Techniques:** Collections management; Field-based ecological studies; Plant identification.

**Translational Opportunities:**
National and international botanical exchange; Research collaboration; Preservation of holotypes and rare plants; Citizen Science; Botanical biosecurity.

# Legumes and Nitrogen Fixation Lab

Nitrogen fixation is crucial to the profitability and sustainability of legume production. We work with national and international collaborators to investigate how the efficiency of nitrogen fixation in the legume rhizobia symbiosis can be improved and to characterize seed components and root development of legumes. These outcomes will increase legume use and contribute to more sustainable agricultural systems.

**The symbiosome membrane: the interface between legume and rhizobia**
We are studying the composition of this specialized membrane using proteomics to identify components. We use molecular and genomics techniques to understand the role of proteins in nutrient transport and signaling between the two organisms and how these processes contribute to control and efficiency of nitrogen fixation

Left: chickpea plant with nodules.

Right: cowpea plant roots with nodules.

**Role of metals in the legume: rhizobia symbiosis**
For nitrogen fixation to occur, plants must take up metals from the soil and transport them through the nodule, into the infected cell and then into the symbiosomes. We are characterising proteins that are regulated by metals and that transport different metals in nodules. We are using a combination of molecular techniques, microscopy and proteomics to determine their cellular location and transport assays in heterologous systems to study their function.

**Improving the efficiency and resilience of nitrogen fixation**
Nitrogen and phosphorus are the two most important macronutrients for plant growth. The production of nitrogen and phosphorus containing fertilizers relies on non-renewable resources and contributes to global warming. Fertilizers when applied in excess can also pollute waterways causing eutrophication. Biological nitrogen fixation by rhizobia in symbiosis with legumes reduces our use of nitrogen fertilizers but requires a good supply of phosphorus to nodules to develop symbiosome membranes and for rhizobia function. This means that legume crops reliant on symbiotic N- fixation will be less productive in soils with low phosphorus content and require greater input of P fertilizers. We are screening chickpea genotypes to identify lines that fix nitrogen efficiently in low P conditions. We are also screening faba bean genotypes to identify lines with increased resilience of nitrogen fixation to environmental stress. We will then analyze the genetic basis for variation in these traits via genome wide association studies and other molecular analysis.

**Molecular analysis of legume seed components including allergens**
A number of health benefits have been associated with consumption of pulse legumes and there is increasing interest in pulse seed proteins as components for meat alternatives. High protein and fibre (and low allergen content) are important characteristics for pulses for human consumption. However, there is not a lot of information about what it is that determines the final components of the pulse grain or what the key components in the mature seed that give the positive (and negative) health benefits. We have been characterizing lupin seed components using genomic and proteomic approaches. In particular the allergens of lupin are being characterized to determine if there is cross-reactivity with peanut allergens. The long-term aim is to determine the regulatory processes involved in formation of protein and fibre and use this knowledge to improve the seed for human consumption.

**Lab Head:**
Associate Professor Penelope Smith (P.Smith3@latrobe.edu.au) and Dr Dugald Reid (Dugald.Reid@latrobe.edu.au).

**LabMember:** Dr Frank Bedon

**Fields of Study:**
Molecular Biology, Plant Biology, Biochemistry, Cell Biology, Crop Production and Plant Genetics.

**Capabilities and Techniques:**
Molecular Biology, Proteomics, Plant Transformation, Protein analysis, Microscopy, Gene expression analysis, Plant phenotyping.

**Translational Opportunities:**
Molecular Biology; Proteomics; Plant Transformation; Protein analysis; Microscopy.

# LISAF Mass Spectrometry Imaging Lab

Thanks to the combined funding contribution of BioPlatforms Australia, La Trobe University and the State government through the Victorian High Education State Infrastructure Fund (VHESIF), we have been able to establish a cellular resolution 'omics facility at the La Trobe Institute for Sustainable Agriculture & Food (LISAF). Located in AgriBio, the facility provides the ability to analyse transcripts, protein and metabolites with cellular resolution and a computational platform for the analysis and visualisation of these data.

A key component of the facility is the Mass Spectrometry Imaging Laboratory which provides:

- Spatial and Cellular level protein, glycan and metabolite analyses using state-of-the-art tissue mass spectrometry imaging.
- Advanced mass spectrometry capabilities
- A computational support pipeline that allows users, both those who generate the data and others, easy access to analysing, integrating and visualizing data.


Bruker timsTOF Flex MALDI-2 microgrid LC-ion mobility-MS/MS system. Example MALDI MS images (top to bottom, right to left) from phospholipid from barley root, cyanogenic glycoside from proteaceae floret & stem, honey bee, mouse eye and mouse brain phospholipids.

**Lab Head:**
Associate Professor Berin Boughton
(B.Boughton@latrobe.edu.au)

**Lab Members:**
Dr Myrna Deseo
Professor Tony Bacic

**Capabilities**

- Bruker timsTOF Flex MALDI-2 LC-ion mobility-MS/MS system
- Combined Microgrid and MALDI-2 capability allowing down to 5 µm spatial resolution
- Shimadzu IM Layer Matrix Vapor Deposition System
- Shimadzu IM Layer Aero Spray Deposition System
- Difficult sample preparation strategies & supporting equipment
- Leica CM3050 S Cryosectioning equipment
- Complementary biomolecule identification strategies via ion mobility and tandem-MS (nano-HPLC, microflow-HPLC)

**Translational Opportunities**

Improved opportunities across the spectrum of crop plants: the data and knowledge resources developed by this initiative provide novel knowledge that can be applied widely to a variety of situations to improve plant performance.

Position Australia as a leader in the Plant Cell Atlas Initiative: it is essential for both basic and strategic research that Australia maintains its position as research leader in plant agricultural science.

The IMS Lab provides researchers with the tools to do this in a national integrated system.

Provide unique opportunities across Biological and Biomedical research fields for fundamental and applied knowledge generation, enabling cross-disciplinary research and translational outcomes.

# Marine and Ecophysiology Group

The Marine and Ecophysiology Groups seeks to address important research questions and issues relating to the passions of its members. In doing so, we actively encourage inter and intra-disciplinary research collaborations and industry partnerships to achieve translational outcomes. We undertake diverse research projects focusing on understanding the physiology of animals, and how physiology underpins their behaviour, diseases, conditions or performance etc. Ultimately, this can be integrated with other information to assist in conservation and management strategies for complex reef systems, establishment of artificial reefs and to understand various conditions or disease processes.

Close up of the beautiful and fragile 'lace coral' (*T. umbonatum*) (Photo credit: Adrian Flynn)

### Western Port Wonders: unique Bryozoan reef systems

Bryozoa are non-photosynthetic invertebrate filter-feeders, which live in colonies, commonly referred to as 'lace corals' despite being unrelated. They are distributed worldwide, however the Western Port Bryozoans are special as they form unique extensive shallow water biogenic reefs. The Western Port Bryozoan Reefs are of potentially global significance. Biogenic reefs are important habitat for a multitude of marine species including fish, mollusks, crustaceans etc. They provide food, attachment substrate for sessile organisms, shelter from wave action and strong currents as well as concealment from predators for both adult and larval stage organisms. These complex habitats are often biodiversity hotspots compared to the surrounding habitats. They are typified by a rigid skeletal framework rising above the seabed and are comprised of biological deposits produced over a long period. Recently, our group has undertaken a large research project examining the unique bryozoan reef systems of Western Port. This multifactorial study engages Victorian Fisheries Authority (VFA) and our industry partner Fathom Pacific Pty Ltd. Our research team is currently working with key stakeholders in order to establish the conservation values of these communities, and to determine appropriate protective measures.

As part of this large project we aim to:

- Investigate the biodiversity of bryozoans and co-occurring fauna
- Determine the age and growth rates of these reef systems
- Determine the extent of biogenic bryozoan reefs
- Identify and quantify the key threats to these biogenic bryozoan reef systems
- Understand the recolonization processes and connectivity to other populations

### Muscle Physiology

The leader of the Marine and Ecophysiology Group is an expert in skeletal muscle physiology spanning over 20 years, publishing research articles on various aspects of muscle contractility and excitability. To understand how muscle function or performance may become aberrant under certain conditions, we must understand how it normally functions. Muscle plays a myriad of roles not just limited to power output or movement. Examining and comparing muscle's many roles and intricacies gives insight into muscle fatigue, muscle dysfunction and disease. Our world class muscle researchers have long-established collaborations locally and internationally.

Areas of interest include:

- Action potential generation and propagation
- Force development, maintenance and relaxation
- Calcium regulation and influence factors
- Physiological mechanisms and ultrastructure
- Protein analysis (quantification and modulation)
- Exercise physiology

**Lab Head:** Dr Travis Dutka (T.Dutka@latrobe.edu.au)

**Lab Members:**
Ms Nicole Wilson; Ms Adrienne Cheong; Dr Adrian Flynn (Honorary); Dr Adele Harvey.

**Fields of Study:**
Muscle Physiology; Comparative Physiology; Behaviour; Ecology and Conservation.

**Capabilities and Techniques:**
Force recording of intact, bundles & mechanically skinned single muscle fibres; Microscopy; Behavioural testing; Field sampling & observations; Access to Fathom Pacific Pty Ltd marine vessels for research dives, surveys, mapping, bioacoustics etc.

**Translational Opportunities:**
Environmental management strategies; Establishment of artificial reef systems; Restorative muscle function and prosthetics.

# Molecular Ecology Group

We a use range of genetic and genomic tools to study terrestrial and aquatic species. Our research ranges from addressing important population-level process such as genetic diversity, dispersal, kinship and population structure to deeper level evolutionary processes responsible for shaping present day biodiversity. We also use genomic methods to investigate elusive and hard to identify species from environmental DNA and to study species diets. Our research addresses a range of critical management questions including the conservation of threatened species, invasive species management and biodiversity monitoring. Our research is highly collaborative, with many industry and academic partners across Australia.

Blanche Cup Spring, South Australia (Photo credit: Nick Murphy)

### Freshwater Fish

Australian freshwater systems are under pressure from a multitude of stressors, including changes to flow regimes. To promote the genetic health of vulnerable Victorian fish species, we use highly resolving single nucleotide polymorphism markers (SNPs) and genome sequencing, to investigate the relationship between critical demographic factors (breeding dynamics and dispersal) with environmental watering and fish stocking programs. Our research across diverse species over multiple years is informing water management strategies to develop the best methods for promoting genetic diversity within the Murray Darling Basin.

### Invasive Deer

Our research is undertaken in collaboration with ongoing government partnerships aimed at improving deer management, mainly through detection of deer species and assessment of deer connectivity and density across Australia. We use genetic tools to identify deer hybridisation, population size, identify distinct management units, track dispersal and assess deer control methods. We study deer diets to identify effects on native flora and the potential to spread invasive weeds.

### Conservation Genetics

Many Australian species are threatened with extinction, and rapid declines can negatively impact the genetic diversity and fitness within the remaining populations. We directly inform endangered and threatened species managers on conservation strategies. We focus on genetic diversity patterns to define species management units and assist with genetic management plans. We have shown there are fitness costs associated with inbreeding in threatened species which can be addressed by incorporating genetics into species management plans (e.g. the helmeted honeyeater - *Lichenostomus melanops cassidix*).

### Trace DNA

We study trace DNA for conservation and management of species and ecosystems. We use eDNA techniques to detect single species of conservation importance or species of management interest. We also use DNA metabarcoding to characterize entire communities from both unique aquatic environments for biomonitoring, and from dung samples to characterize diet and food webs to better understand species interactions.

### Short Range Endemics

Vulnerable short range endemic species act as bioindicators for the overall health of their ecosystems. We study groundwater dependent and forest litter ecosystems to identify the biodiversity present and understand the ecological and evolutionary impacts of long-term environmental changes and short-term events on dispersal limited species.

**Lab Head:** Dr Nick Murphy
(N.Murphy@latrobe.edu.au)
**ARC DECRA Fellow:** Dr Katherine Harrisson.
**Lab Members:** Ms Erin Hil; Mr Jude Hatley; Mr James O'Dwyer; Mr Zac Billingham; Mr Matt Quin; Ms Jess Taylor.

### Fields of Study:

Population genetics; Conservation Genetics; Phylogenetics; Trace DNA; Evolution.

### Capabilities and Techniques:

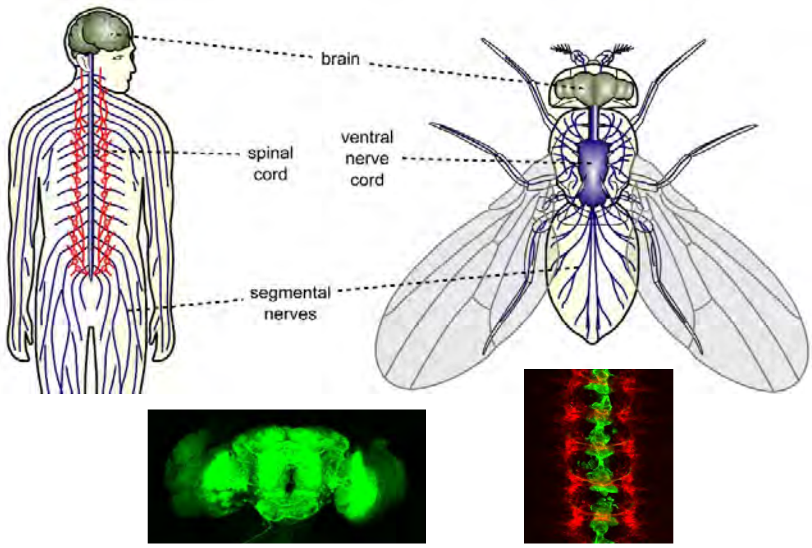
Amplicon sequencing; eDNA; qPCR; Species specific detection; Diet analysis; Metabarcoding genotyping; Next Gen Genotyping (ddRAD, SNP panels); Microsatellites; Bioinformatics; Species delimitation; Phylogenetics; Field sampling.

### Translational Opportunities:

Threatened species conservation; Invasive species management; Cost effective biomonitoring; Water management.

# Neural Cell Signalling Group

Our group studies how cells in the nervous system receive and respond to extracellular signals from their environment. An animal's nose can detect thousands of different chemicals in their environment. How does this occur, and how does the animal know what these represent and what the response should be? Other cells in the brain detect environmental signals that determine how fast an animal grows and to what size. How is this controlled? As well as these questions, we are also investigating how neuronal signalling goes awry in the devastating disorder motor neuron disease. We use the model genetic insect *Drosophila melanogaster* for most of our work, as cell signalling in the nervous system is highly conserved between flies and humans, and for flies we have many highly sophisticated genetic and molecular approaches available to study gene function and to interrogate the nervous system.




*Drosophila melanogaster* is a great model for studying the nervous system. GFP labelling of adult *Drosophila* brain and larval CNS (Photo credit: Dr Katherine Shaw)

## Molecular basis of odour detection in insects

In insects the sense of smell is vital for detecting plant or animal hosts for feeding or laying eggs, and for detecting potential mates. We are studying the signalling mechanisms used by the very large family of odorant proteins in insects, and how they evolve across species. As well as fundamental studies, we are investigating the odorant receptor family of the Australian sheep blowfly, a damaging pest of sheep in Australia. We aim to identify receptors for ecologically relevant chemicals, which may in future lead to more environmentally friendly methods of pest control. This project is a collaboration with Dr Trent Perry at the University of Melbourne.

## Neuropeptide regulation of developmental timing and growth

In animals developmental timing and growth are controlled by steroid hormones that are under complex regulation by both developmental and environmental cues. We are studying novel neuropeptide receptors involved in controlling steroid hormone production and growth in response to these cues in *Drosophila*. Many of these receptors have human counterparts, thus the knowledge we obtain may inform our understanding of growth in humans, and of disorders such as obesity.

## Role of neuronal excitability in Motor Neuron Disease

Motor Neuron Disease (MND) is a devastating and universally fatal late onset disorder for which there are no effective treatments or cure. In MND progressive muscle weakness results in sufferers becoming unable to use their limbs, and eventually being unable to breathe. Development of therapies has been very challenging due to MND being a complex disease, with many genetic and environmental components.

Prior to symptom onset all patients initially exhibit hyperexcitability (over responsiveness) of the motor neurons. We are focused on understanding the mechanisms by which this develops, as its commonality to all patients makes it an attractive therapeutic target. *Drosophila* is an outstanding model for this question - fly models of MND recapitulate the pathology seen in humans and we have the ability to easily experimentally manipulate neuronal function and see how this impacts disease. This project is a collaboration with Prof Tracey Dickson and Dr Rosie Clark at the University of Tasmania.

Lab Head: Professor Coral Warr
(C.Warr@latrobe.edu.au)

Lab members:
Dr Mackenzie Lovegrove;
Ms Emily Kerton;
Ms Natasha Fahey-Lozano;
Ms Sachini Arachillage Mallika;
Mr Stephen Penrose.

Fields of Study:
Molecular genetics; Cell Biology; Neurobiology; Developmental Biology.

Capabilities and Techniques:
*Drosophila* molecular genetics; All routine cell and molecular biology approaches; Many biochemical techniques; Many insect phenotypic assays (chemosensory behaviour and physiology, growth and developmental timing, embryo development and patterning, locomotory behaviour, immunity assays, microbiome assessment, ageing).

Translational Opportunities:
Our work is fundamental but may lead to targets for insect pest control methods; to future opportunities to develop better therapies for MND; and to novel targets for growth disorders in humans.

# Neuroecology Group

Neuroecology bridges the gap between our knowledge of the neural bases of behaviour in the context of an animal's habitat and ecology. Our collaborative research involves local, national and international partners using neurobiological techniques (molecular genetics, bioimaging, electrophysiology, anatomy and behaviour) to examine how elements of the physical environment (light, sound, odours, and electro-magnetic fields) are detected and processed by the peripheral and central nervous systems and how this influences behaviour. Perception of environmental cues is critical to the survival of each species. We use model indicator species to assess ecosystem responses to climate variability and habitat loss or degradation.

Grey reef shark at home reef (Photo credit: istock/strmko)

### Shark sensory systems and mitigation

Sharks and their relatives are apex predators and are an important part of aquatic ecosystems. However, very little is known about their behaviour. We assess the neural basis of behaviour in a range of species by investigating the ways they sense their environment. Sharks, skates, rays and chimaeras have evolved over a period of 400 million years, and they are adept at detecting environmental signals that indicate the presence of food, mates, predators and anthropogenic activity. We study these behaviours by uncovering basic neuroecological principles and translating discoveries into mitigation strategies to protect both humans and sharks.

### Environmental impacts on the neural basis of behaviour

Many living things rely on vision, olfaction, audition, lateral line, electroreception and gustation to find food and mates, avoid predation, orient within the water column and even migrate over long distances. We examine the importance of each of these senses by studying the peripheral sense organs and the brain and help environmental managers understand species vulnerability to environmental change and their capacity for sensory plasticity.

### Sensory ecology of deep sea organisms

Finding food and mates, avoiding predation, social communication and navigation are critical for fish in the mesopelagic ('twilight' zones) of the world's oceans. Survival depends on the ability to detect and react to environmental stimuli (residual downwelling sunlight, odours, bioluminescent light flashes, sound and hydrodynamic disturbances). We study sensory systems (vision, chemoreception, audition and lateral line sense) by quantitatively assessing inputs (nerve axons) sending information from peripheral sense organs to the central nervous system, and the size of sensory brain regions receiving input. We also study the hearing and visual sensitivity of deep-sea fish species that are being targeted as commercially viable.

### Sensory and bioengineering approaches to predict hearing abilities in fish

Using bioimaging and artificial intelligence to investigate the link between underwater soundscapes peculiar to the habitats of a range of fish species with the structure and function of their inner ear. This information can be used to predict the hearing abilities in fishes and the impacts of noise pollution.

### Chemoreception in fishes: Anthropogenic impacts on brain and behaviour

Using a multidisciplinary approach, we assess the fundamental impacts of chemical pollutants on the detection, perception and behaviour in fishes and the impacts of these contaminants on sourcing food, avoiding predation and finding mates.

### Plastic brains: Neural adaptations to changing environments in reptiles

Using cutting-edge micro-CT technology and advanced phylogenetic techniques, we investigate the evolution of brains of Australian goannas, dragons and venomous snakes, as these animals adapted to new habitats and climates.

Lab Head: Prof Shaun Collin
(S.Collin@latrobe.edu.au)
Lab members: Ms Caroline Kerr; ARC DECRA Fellow Dr Lucille Chapuis; ARC DECRA Fellow Dr Jenna Crowe-Riddell; Mr Myoung Hoon Ha; Ms Hope Robins; Ms Paola Talarico; Mr Fernando Navea Bravo; Ms Alecja Greczynska; Ms Annalise Ceddia; Ms Isabella Kassa; Ms Mia Richardson.

### Fields of Study:

Neurobiology; Marine Bioacoustics; Biomechanical Engineering; Molecular Biology; Behaviour; Ecology; Evolution; Development.

### Capabilities and Techniques:

Electron microscopy (scanning and transmission); Electrophysiology; MRI; micro Computed Tomography (µCT); Behavioural testing; Artificial Intelligence.

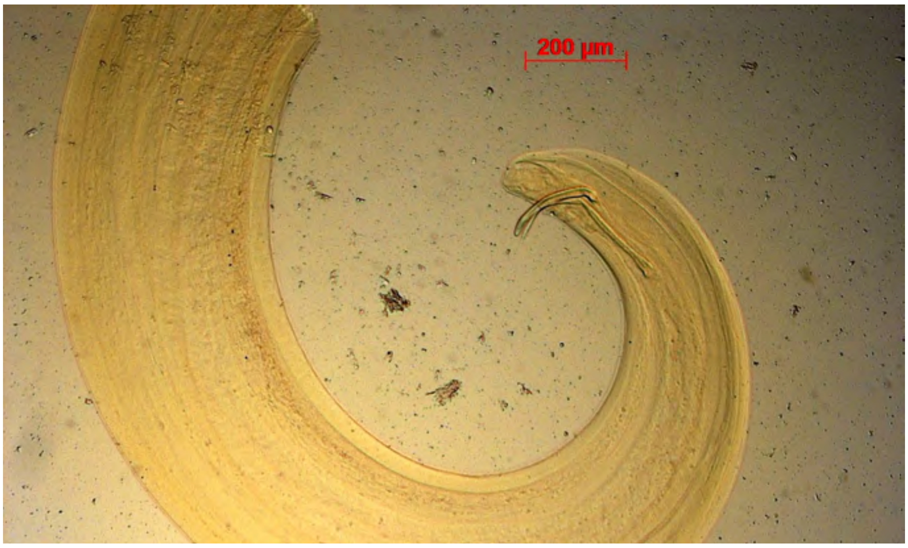
### Translational Opportunities:

Shark mitigation; Aquaculture stress/welfare; species conservation; environmental and sensory pollution; biomimetics; climate change and animal behaviour effects; deep-sea exploration; the blue economy.

# Parasite & Vector Genomics Laboratory

Over a billion people are infected by nematode parasite diseases, leading to poor childhood development, chronic physical disability, social ostracization, and ultimately contributing to economic and health disparities in rural and remote areas. These infectious diseases are preventable and treatable, but in many regions, people continue to be infected despite decades of drug administration to entire communities.

In collaboration with national and international stakeholders, we use genomics and modeling to figure out why drug therapies work well to eliminate the parasite in some communities but not in others. The lab's vision is to provide tools to aid in the elimination of parasitic diseases that are a public health threat, and to provide training for students and for workers in endemic countries to support the global use and development of these tools.



Dog heartworm tail (Photo credit: Haylo Roberts)

### Identifying causes for persistent disease

Parasitic species of roundworms (nematodes) cause diseases such as river blindness and lymphatic filariasis (LF) and are transmitted through the bites of blood-feeding insects called vectors (blackflies and mosquitoes). We use population genomics and landscape modeling of parasites and vectors to determine whether migration of infected people or insects causes re-introduction of the disease in areas where the disease was thought to have been controlled, or whether the drugs used to control the parasites are no longer effective. Based on this knowledge, policy solutions for public health that effectively use the limited resources available are adaptively developed to target the causes of persistent transmission.

### Predicting disease outcomes after change

Anthropogenic changes to the environment (e.g. from river dams or global climate), changes in human behaviour (e.g., refugee status or in compliance with health recommendations), and changes in policy (e.g. which drugs to distribute and where) impact efforts to eliminate infectious disease. We develop epidemiological models that incorporate geospatial ecological information and evolution of drug resistance to aid public health organizations in deciding when and where to safely stop drug distribution.

### Exploring how genome evolution impacts disease transmission

There is a complex mosaic of parasite and vector genomes across the areas we work in Africa and the South Pacific: there are many species of vectors that transmit parasites—parasites that are evolving to drugs and to both human and vector immune systems. The vectors are also evolving in response to their environment and to insecticides used to reduce their numbers. We predict the functional impact of parasite and insect vector genome evolution on transmission by the vector, infection of the host, and control of the parasite. We identify genes that have evolved due to selection from field-caught specimens and test their functions using model organisms in the laboratory. We then develop sensitive molecular diagnostic tests for changes in these genes in treated populations.


**Lab Head:** Dr Shannon Hedtke (S.Hedtke@latrobe.edu.au)


**Lab members:**
Emeritus Prof Warwick Grant;
Dr Neha Sirwani;
Anusha Kode;
Sindew Feleke;
Millicent Opoku.

**Fields of Study:**
Evolution; genomics; epidemiology; parasites; bioinformatics.

**Capabilities and Techniques:**
Genomics; bioinformatics; DNA-based diagnostic assay development (qPCR/HRM, LAMP); experimental evolution; nematode transgenesis.

**Translational Opportunities:**
Improved parasite & pathogen detection diagnostic tools; improved models for predicting infection risk; zoonotic human health risk identification; effects of environmental changes on vector transmission potential.

# Plant Bio-sensing Group

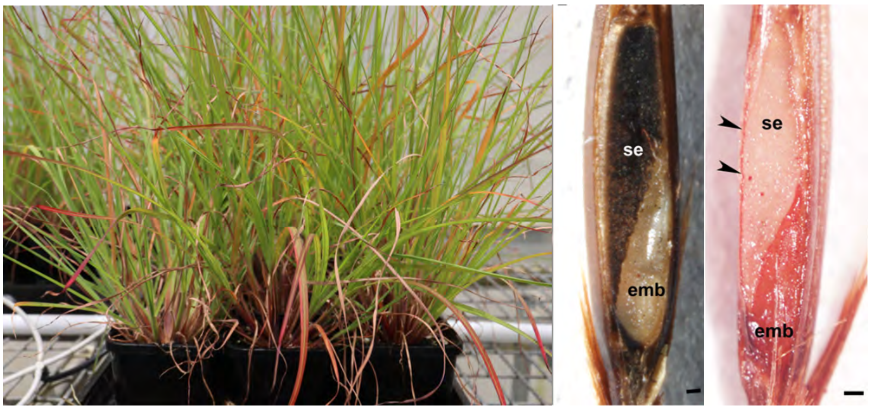
Our Group investigates how plants sense changes in their physical environment and 'move' their body and change shape to best adapt to the conditions. Our work investigates cell sensors that feel touch and activate response pathways that lead to changes in the cell wall and as a result, growth. This research aims to develop plants with greater plant biomass, optimize plant cell wall properties for food, fibre and biomaterials and enhance resistance to physical damage.

### Cell wall integrity sensors

Our Group has a strong track record of studying cell walls, dynamic structures that surround all plant cells, provide stability and shape and act as the interface between neighbouring cells and the environment. The structural integrity of the cell wall is essential for plant survival and as such plants have cell wall integrity sensors to monitor wall status. Detection of physical (also known as mechanical) 'stress' signals is important to adapt growth in response to the external and internal environment.  Our group have identified several classes of cell wall integrity sensors involved in recognition of wall changes during development and in response to stress. These include Ca+ binding wall glycoproteins (AGPs) and wall-associated kinases (WAKs) and a Ca+ mechanosensing channel Defective Kernel 1 (DEK1).  By investigating the molecular pathways involved in cell wall integrity responses we aim to use this knowledge to breed plants with improved growth and resilience to changing environments.

### Soil compaction responses

Soil health directly impacts the ability of plants to access the water and nutrients they require to grow. Degradation of soils therefore impacts agricultural productivity and biodiversity. Compaction is one of the most important issues associated with soil degradation and occurs when soil is pressed together reducing pore size, for example by heavy vehicles, continuous cropping and climatic effects. Our group studies the cell wall responses and root growth of plants to the physical challenges of soil compaction. As part of a Herman Slade foundation grant, our group aims to determine how native grasses, including kangaroo grass, curly mitchell grass, evans wallaby grass and silky bluegrass, respond to compacted soils and investigate their use in restoration of compacted agricultural or marginal land.




Kangaroo grass plants (left) and seeds (right) stained for starch (black) and fats (red) (Photo credit: Nitheeka Muthunuyake and Sarah Wilson)

### Plant defense and disease diagnostics

Disease can cause up to 50% crop loss in susceptible crops. Our group are investigating the role of the cell wall in plant defence, use of microbial communities to reduce the need for chemical fertilizers and fungicides and development of rapid molecular based methods for early disease detection in controlled environment agriculture and broadacre settings.  Replacing chemical-based fertilizers and fungicides with biological-based amendments aims to optimise plant health and enhance growth whilst reducing economic and environmental costs.
Working with regenerative agriculture groups we are assessing the impact of biological amendments on grain quality and soil health. We have developed environmental sampling and disease detection assays for a range of fungal pathogens that can be used as an early warning system for farmers.

### Flowering and metabolite production

Plant based medicinal compounds are often found in specialized cell types called trichomes and predominant in flowering tissues. Together with Anthony Gendall and Matthew Welling, our group studies regulators of flowering time that balance the amount of time plants spend in vegetative or flowering growth stages. Our group also study the importance of the Oxylipin pathways as the proposed biosynthetic origin(s) of the carbon building blocks required for production of medicinal compounds.

### Future foods

As demand for plant-based proteins increase there is potential to innovate locally produced and processed food products. Legumes are high protein grains rich in dietary fibre yet a challenge in legume-based food formulations are the 'green', 'grass' and 'beany' flavours and antinutritives. In addition, the influence of stress, such as drought and heat which are a feature of the Australian climate on grain quality have largely been unexplored. Together with Plants for Space and the crop agronomy and legumes groups, our work aims to optimize the nutritional profile of high protein plant-based foods and increase efficiency of growth for indoor and outdoor environments.

**Lab Head:** Assoc Prof Kim Johnson. (K.Johnson@latrobe.edu.au)
**Lab members:** Laura Steel, Aylwen Cotter, Gayathree Senevirathne, Oceane Perez, Louise Walker, Jiayue Wang, Ian Cullen.

**Fields of Study:**
Cell wall, Bio-sensing, growth, stress response, fibre.

**Capabilities and Techniques:**
Field-based disease diagnostics; Cell wall analysis; Grain nutritional composition; Fluorescence and electron microscopy; Phenotyping and genomics.

**Translational Opportunities:**
Sustainable agriculture practices, compacted land regeneration, crop disease resistance, plant-based foods, optimization of plant traits for different environments.

# Plant Cell Walls and Bioactive Secondary Metabolite Group

The Plant Cell Walls and Bioactive Secondary Metabolite Group aims to understand how biopolymers are made and regulated. Biopolymers and secondary metabolites include some of the most abundant and renewable carbon-based molecules on earth and have a range of applications for biomaterials, food and medicines. By understanding how biopolymer levels are controlled, we can ultimately breed plants with optimal levels for specific end uses. Our Group is also part of the Medicinal Agriculture Hub that aims to improve production of plant-derived medicinal products, including cannabinoids, terpenes and other plant secondary metabolites.

### Plant Cell Surfaces (Cell Walls)

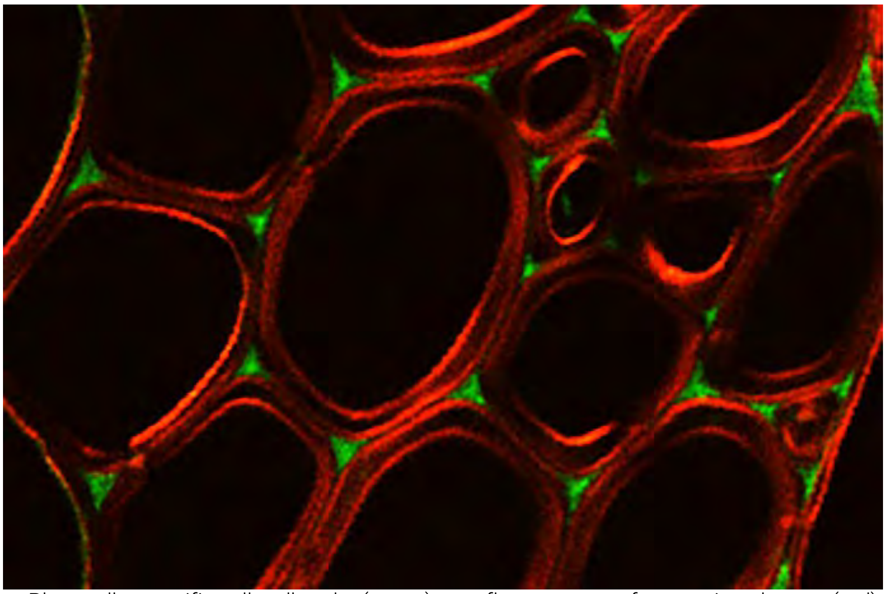
Most plant biomass consists of a carbohydrate-rich matrix present in cell walls. Cell walls, a major carbon sink, are our most renewable bio-resource and determine the products (food, fibre and fuel). Primary cell wall components are a key source of soluble fibre products. Secondary cell walls are the major constituents of insoluble fibre for textiles, pulp and paper manufacture and timber products and increasingly for fuel and biocomposite construction. Understanding how these cell walls are made, what they are composed of, and what determines their mechanical properties gives us the capacity to make 'designer walls'.

### Dietary Fibre for Human Health

Mixed linkage glucan (MLG) is a soluble dietary fibre found in cereals. Chain structure strongly influences its solubility, with MLG in oat and barley being much more soluble than in wheat. Our research aims to understand how the biosynthesis, assembly and turnover of MLG is regulated. By understanding how MLG levels are controlled, we can ultimately breed cereals with optimal levels for specific end uses.

### Cell Wall Sensing: Plants Have Feelings Too!

Plants can sense changes in their physical environment and 'move' their body and change shape to best adapt to the conditions. Our work investigates cell sensors that feel touch and activate response pathways that lead to changes in the cell wall and as a result, growth.



Plant cells: specific cell wall probe (green); autofluorescence of aromatic polymers (red)

This research aims to develop plants with greater plant biomass, optimise plant cell wall properties for food, fibre and fuel applications and enhance resistance to physical damage.

### Ambassadors of Agriculture Program

La Trobe University offers one of only two Bachelor level agricultural science degrees in Victoria and is the largest trainer of post-graduates. Our research team contributes to various outreach programs that run at La Trobe including the Ambassadors of Agriculture Program.

### Group Leaders:

Professor Tony Bacic (T.Bacic@latrobe.edu.au), A/Prof Monika Doblin, A/Prof Kim Johnson and Prof Wei Zeng (Zhejiang A&F University (ZAFU) and Taizhou University, China)

### Fields of Study:

Cellular Interactions; Plant Cell & Molecular Biology; Crop and Pastures Biochemistry and Physiology; Expanding Knowledge in the Agricultural and Veterinary Sciences; Medical Biochemistry and Metabolomics.

### Capabilities and Techniques:

- Genetic transformation and Gene Editing for cereals and legumes.
- Extensive Growth Facilities (Glasshouses, CERs (PC2/QC2)).
- Sequencing Platform.
- Transcriptomics (small RNA, DNA methylation sequencing, protein-DNA interactions, genome sequencing).
- Omics (Genomics/ (Phospho) Proteomics/
- Metabolomics/ Glycomics) and associated bioinformatics platforms.
- 10x Genomics single cell sequencing analysis.
- Laser Capture Microdissection.
- Fluorescence Activated Cell Sorting (FACS).
- Mineral and chemical analyses of soil, plant and seeds.
- Plant Phenomics (3D, RGB, fluorescent and hyperspectral with cloud-based analytics).
- Big Data integration and analysis.
- High-end imaging mass spectrometry.

### Translational Opportunities:

Improving crop productivity (yield and quality) and sustainability; Improving the nutritional quality of grains e.g. cereals and legumes/pulses; Stem fibre quality; Plant synthetic biology; Biomass utilisation and waste valorisation; Ameliorating soil constraints; Reducing environmental impacts; Supporting agricultural education.

# Plant Development and Physiology Group

The Plant Development and Physiology Group (Gendall Lab) uses genetic and molecular approaches to study aspects of plant development and physiology, primarily using the model plant *Arabidopsis thaliana*. We are particularly interested in using the natural variation present between different varieties (ecotypes or accessions) as a starting point to identify and characterise genes that regulate particular characteristics.

### Seed biology and biotechnology

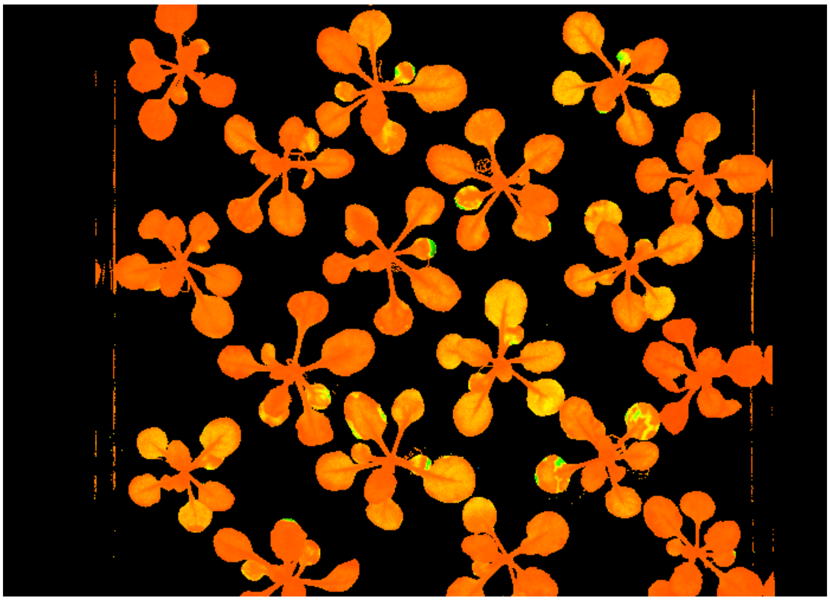
A major area of interest in the lab is the regulation of ion homeostasis by a family of intracellular Na+/H+ antiporters in the model plant *Arabidopsis*. Overexpression of many of these family members leads to increased salt tolerance, but the mechanisms for this resistance is poorly understood.

We have shown that two of these antiporters are required for normal plant development and have roles in intracellular protein trafficking. These antiporters regulate the pH of intracellular compartments, and influence ion sensitivity and protein trafficking by interacting with specific components of the protein trafficking, sorting and recycling machinery.

We have recently shown that these antiporters affect the processing an accumulation of seed storage proteins and other vacuole localised proteins, and this suggests that pH regulation is likely to be important for seed development and grain quality in crop species.

### Plant Growth Regulators

Some soil bacteria are able to promote the growth of host plants and result in an increase in plant biomass and root length. In collaboration with Professor Ashley Franks, we are using QTL mapping and genetics approaches to investigate the genetic basis of host-specificity in the variable response to plant growth promoting rhizobacteria, with the long term aim of developing specific host-inoculum combinations that promote plant growth.



*Arabidopsis thaliana*'s photosynthetic rainbow. (Photo credit: Lianna Sliwcyznski)

### Herbicide Development

With herbicide resistance increasing, there is great demand for herbicides with new modes of action. In collaboration with Tatiana Soares da Costa, we have developed novel herbicides with new modes of action that target key steps of the lysine biosynthesis pathway in plants.

### Improving Medicinal Cannabis

(as part of the ARC Industrial Transformation Research Hub for Medicinal Agriculture - MedAg Hub) We have a project to understand the regulation of flowering in cannabis by identifying the genes responsible for variation in flowering between different varieties, and characterizing their activity.

**Lab Head:** Dr Tony Gendall (T.Gendall@latrobe.edu.au)

**Lab Members:**
Ms Charlotte (PhD) Francois; Ms Lianna Sliwcyznski (MSc), Mr Cody Hall (PhD), Ms Laura Steel (PhD), Ms Emily Mackie (PhD), Mr Daniel Hawkins (PhD), Mr Ryan McClean (MSc), Dr Shamila Abeynayake (Honorary), Ms Nicole Ristevski (Hons)

**Fields of Study:**
Cell and Molecular Biology; Plant Development; Plant Breeding and Genetics; Plant Biotechnology; Plant Reproduction.

**Capabilities and Techniques:**
Confocal microscopy; in vitro plant analysis; plant genetics.

**Translational Opportunities:**
Herbicide development; contract/ consultancy for plant breeding.

**Website:**
https://www.latrobe.edu.au/animal- plant-and-soil-sciences/research/ gendalllab

# Plant Disease Resistance and Immunity Group

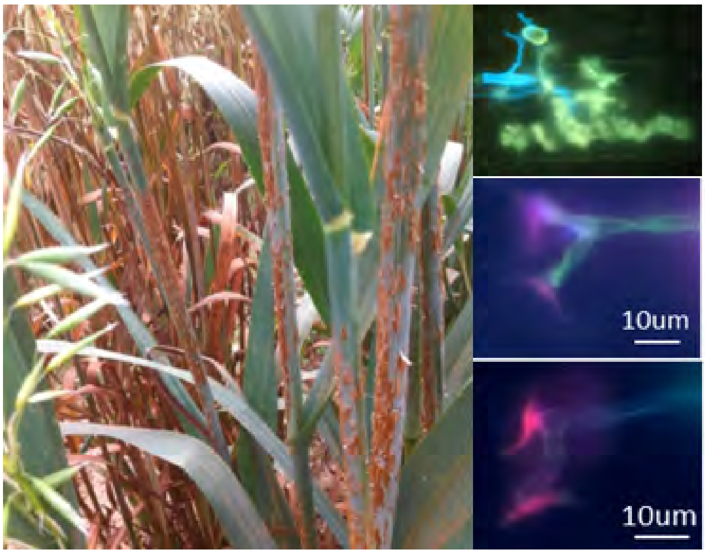
The Plant Disease Resistance and Immunity Group (Dracatos lab) uses digital agriculture, genetics, molecular and genomic approaches to study how plants defend themselves to protect yield when challenged by plant pathogens. We mainly focus on identifying and characterizing diverse mechanisms of disease resistance to economically significant fungal diseases using the cereal grain barley as a model crop organism. Identifying the genes that underly and regulate fungal disease resistance mainly involves utilizing naturally occurring variation present in cereal grain accessions and landraces spanning diverse wild and cultivated gene pools. Our work combines a deep understanding of the molecular genetic basis of resistance and plant microbe interaction studies and uses the latest micro-phenomic approaches in digital agriculture to accurately assess and track disease progression in cereals. Our goal is to conduct research that informs improved disease management and ultimately alleviates pressures on global food security.

### Barley Net Blotch and Scald Resistance

We have a research program funded by the Grains Research Development Corporation in collaboration with national pathologists and experts pioneering novel breeding technologies focused on identifying and further characterising durable genetic resistance mechanisms to necrotrophic diseases such as Net Blotch and Scald. The project involves developing the micro and macro-phenomic capabilities of a newly developed digital platform to accurately phenotype plant diseases at numerous stages after infection. The project will involve mechanistic mode of action studies to clone and functionally validate functionally diverse Net Blotch resistance genes. The project will also facilitate tracking these pathogens and the host response at early timepoints after infection.

### Cereal Rust Resistance

Cereal rust diseases (caused by biotrophic pathogens in the genus *Puccinia* spp) have plagued farmer's fields since the domestication of cereal grain crops in the fertile crescent approx. 10,000 years ago. The plants immune system is multi-layered and complex. The focus of this project is to identify and characterise the function of diverse mechanisms of rust resistance in cereal grain crops such as wheat, barley, and oat. We use both forward and reverse genetic approaches and the latest genomic resources to identify the gene/s underpinning rust resistance in cereals. This knowledge can then be used to engineer crop plants with resistances that are less vulnerable to the forces of pathogen evolution preventing the slowing the breakdown of resistance in the field.



Stem rust infection on cultivated oats (left photo by Peter Dracatos) and on 3 different barley genotypes with nonhost resistance (photos by Peter Dracatos & Michael Ayliffe)

### Nonhost Resistance

Plant species have diverged over millions of years, co-evolving with few specific pathogens. Therefore, most plant are resistant to most diseases they encounter during their growth cycle. This is partly due to genetic factors in the host and pathogen. Cereal rust pathogens display high host specificity because of ongoing co-evolution with a narrow range of grass species. In rare cases, some plant species are in a transition from host to nonhost or are intermediate hosts (near nonhost). We use the barley (near nonhost) -*Puccinia* rust model for molecular studies to understand the mechanistic basis of nonhost resistance in plants. This research is aimed at identifying genes in the plant that are involved in host specialization and genes in the pathogen that contribute to host jumps.

### Nutritional Immunity

Biotrophic pathogens such as rusts develop feeding structures (haustoria) in the mesophyll cells of their preferred hosts to acquire nutrients they require to sporulate and maintain fitness. Our group studies how changes in the plants nutritional status affects the successful growth of fungal pathogens *in planta*. We aim to understand how diverse genetic mechanisms affect the supply of micro and macro nutrients to the pathogen and how this affects the outcomes of pathogen colonization. Our group targets naturally occurring mutations in nutrient transporter genes to functionally verify variants that may result in partial resistance to rust diseases.

**Lab Head:** Dr Peter Dracatos
(P.Dracatos@latrobe.edu.au)

**Fields of Study:**
Cereal Genetics, Plant Pathology, Genomics, Plant Molecular Biology/ Biotechnology, Digital Agriculture

**Capabilities and Techniques:**
Micro-phenomic disease assessment; Genomics, Gene Cloning, GWAS, RNA-Seq, Gene Sequencing, Pathogenicity studies.

**Translational Opportunities:**
Breeding Resistant Crops, Gene Editing, Enhanced Disease Management, Disease, Food Security.

# Plant Reproduction and Conservation Genetics Group

Our research is diverse and includes aspects of plant conservation, demography, ecology, reproduction and genetics/genomics. The group has a strong research interest in the application of conservation genetics and genomics to management of native flora, as well as applied studies in relation to weeds and crops. A variety of techniques are used by the group including traditional field-based ecological approaches and morphological investigations, alongside next-generation genomic approaches.

We are collaborative and work with other research organisations, state and federal departments, NGOs and community groups.

(Photo credit: Susan Hoebee)

## Unravelling the evolutionary history of iconic Australian plants

Using genomic approaches coupled with pollination studies, we aim to identify processes involved in speciation in a number of Australian plants genera with a strong focus on those within the Proteaceae and Myrtaceae. In these studies, the identification of processes underpinning population structure and driving species evolution will aid conservation management for several taxa.

## eDNA approaches to pollination studies

Floral visitors leave traces of their DNA on flowers they visit. This environmental DNA (or eDNA) can be harnessed to build a picture of the community of animals visiting plants. Traditional approaches, including recording animal behaviour on the flowers and confirmation of pollen transport, are then applied to better identify pollinators from all floral visitors. We are using these approaches in a threatened grassland community.

## Harnessing genomics to restore resilience

We are working in two spaces relating to resilience. Following the 2019/2020 Black Summer Bushfires, we embarked on an initiative to secure the future of East Gippsland's threatened flora by combining site surveys with assessment of the genomic diversity and structure of surviving, resprouting or emerging plants from a number of impacted species. Post-fire recovery and establishment of risk mitigation plans for the survival of select plant taxa are the focus of this collaborative work.

We are also involved in generating genomic data associated with provenance and maternal lines in established Climate-ready Revegetation plots to evaluate and enhance habitat resilience to the uncertain and unpredictable effects of climate change.

## New ways to find old mates – rapid identification of sex genes in plants

Approximately 60% of plant species use a self-incompatibility (SI) system to prevent inbreeding caused by self-fertilisation. Although there are many SI systems, only three have been characterised at the molecular level, with the remaining systems very poorly described. Understanding these systems has implications for conservation and restoration programs, weed control, as well as crop and horticultural breeding programs. SI related research has involved internal collaboration supported by industry funding.

**Lab Head:** Dr Susan Hoebee (S.Hoebee@latrobe.edu.au)

**Lab Members:**
Mr Mark Clifton;
Mr Stanislaw Wawrzyczek;
Mr Simon Heyes;
Ms Allison Menzies;
Ms Jennifer Longo;
Ms Amelia Mendes.

**Fields of Study:**
Conservation; Ecology; Evolution; Genetics/ Genomics; Plant Reproduction; Pollination.

**Capabilities and Techniques:**
Field skills; Refractometry and Reflectance (with application to floral traits); Standard and High-throughput genomic techniques; Scanning electron microscopy; eDNA applications; Pollen viability assessment.

**Translational Opportunities:**
Species conservation, utilisation and/or management; Plant breeding; Genomics for future climates.

# Plants and Pollinators Group

We have a broad interest in the ecological and evolutionary consequences of the interactions between plants and pollinators. This topic is critical for understanding the incredible morphological and taxonomic diversity of both flowering plants and nectar feeding animals. Further, in Australia there are many cases of relatively specialised pollination systems, meaning that numerous plants are vulnerable to the loss of pollinators following the extensive modification that the Australian landscape has experienced. Studies of plant-pollinator interactions encompass a range of approaches including field experiments, analysis of plant and pollinator communities, studies of animal behaviour, and molecular approaches. At present, we undertake field research in both south-eastern Australia, and the south-west Australian biodiversity hotspot.

A honeyeater feeding on kangaroo paw, *Anigozanthos flavidus.* (Photo credit: Myles Menz)

### Pollination biology in conservation and restoration

Despite widespread concerns about declining pollinator populations, pollinators are rarely considered when attempting to improve the conservation of threatened plant species. In a partnership with the Royal Botanic Gardens Victoria, we have developed a project aiming to optimise the establishment of new populations of threatened orchids based on knowledge of pollination biology. We are also interested in how incorporating pollinators into ecological restoration could lead to greater animal biodiversity and improved plant recruitment in restored landscapes.

### The evolution of deceptive pollination strategies in Australian orchids

Australia is home to some of the world's most remarkable orchids, many of which use deceptive pollination strategies. This includes orchids that mimic rewarding flowers, but also species that attract male insect pollinators through mimicry of females.  We aim to understand how deceptive strategies evolve, which floral traits attract pollinators, and how the evolution of deceptive pollination  strategies has affected diversification of orchids. Through collaboration with Australian and overseas scientists, our research has already led to the discovery of new sexually deceptive systems and the chemicals involved in pollinator attraction.

### Understanding the ecological and genetic consequences of pollination by vertebrates

The Australian flora is characterised by numerous plants pollinated by vertebrates, including many of our most iconic plants. Our research has focused on testing the hypothesis that, for floriferous shrubs and trees, pollination by birds rather may lead to greater pollen dispersal and more fit seed. However, many Australian plants that appear to be pollinated by birds or mammals are morphologically specialised understory species. Until now, the consequences of vertebrate pollination for this intriguing group of plants remains essentially untested, inspiring this to become a new research focus for our group.

### Floral adaptations to pollination niches

As a requirement for plant reproduction, pollination is a critical component of a plant's ecological niche. We are interested in using plant-pollinator networks as an objective way of recognising groups of ecologically similar pollinators that could represent pollination niches. Having recognised such niches, we aim to test the role of visual and chemical cues in attracting these pollinators. This represents a potentially powerful new approach for understanding floral adaptation and how this might affect co-existence in plant communities.

**Lab Head:** Dr Ryan Phillips
(R.Phillips@latrobe.edu.au)

**Lab Members:**
Ms Amelia Mendes; Mr Andrew Bird; Mr Eamonn Culhane; Dr Linda Riquelme; Dr Marinus De Jager; Ms Rebecca Grinter; Mr Stan Wawrzyczek.

**Fields of Study:**
Ecology; Evolution; Conservation Biology; Behaviour; Restoration Ecology.

**Capabilities and Techniques:**
Field experiments; Behavioural observations;  Plant-pollinator networks; Spectral reflectance analysis; Camera trapping; DNA barcoding.

**Translational Opportunities:**
Species conservation; Ecological restoration; Threatened species recovery; Invasive species management.

# Reproductive Ecology and Conservation Biology Group

Our group's research is broadly focused on reproductive ecology and conservation biology in captive and field-based wildlife studies. Current reproductive research examines maternal/paternal effects on offspring phenotypes, sex allocation, mate choice and the physiological and endocrinological basis for variation in life history. Our conservation research address questions on endangered species, anthropogenic disturbance (especially artificial light at night and climate change), captive breeding, behavioural traits and reintroduction success. We use a multidiscipline approach to question-oriented research using a diverse range of taxa, including but not limited to reptiles, birds, bats and marsupials.

Bridled nailtail wallaby *(Onychogalea fraenata)*. (Photo credit: Kylie Robert)

### Understanding the mechanisms and adaptive advantage of sex allocation

Sex allocation theory predicts parents bias their investment into the offspring sex that maximises their fitness. Current theories on adaptive adjustments in offspring sex ratios and have provided some compelling examples. However, offspring sex ratios in many taxa (especially mammals) have proven difficult to understand and would be better facilitated by a mechanistic understanding. Our research focuses on unravelling mechanistic underpinnings of adaptive sex allocation from paternal contribution in ejaculate to maternal condition at time of conception and the role of sex steroid and glucocorticoid hormones. Our research uses the unique ability to access marsupial pouch young as neonate equivalents in-utero to test the adaptive advantage of raising one sex over the other through cross-fostering offspring prior to significant maternal contribution.

### Ecological impacts of artificial lighting on wildlife

Artificial lighting fundamentally changed the earth's night-time environment, with a wide range of biological effects on animals. Organisms have evolved to respond to natural light cues to control or modulate behaviour, activity, reproductive timing and physiological function. We study artificial light impact on reproduction timing in seasonally breeding wildlife. Using our knowledge of the visual and non-visual sensitivities of our target species we workwith industry to develop and test wildlife friendly lighting options (LED lights that combine custom wavelengths) to mitigate the negative effects of light at night.

### Captive breeding and reintroduction biology

Captive breeding is one aspect of threatened species conservation, however attempting to breed and raise species in captivity presents many challenges for recovery programs. Captivity results in various environmental modifications that can lead to behavioural, morphological and physiological changes that result in potentially detrimental effects upon release. Some of our research has focussed on maternal mate choice to improve both conception rates and offspring fitness in captive breeding programs. While other research is assessing predator recognition, behavioural, personality and cognitive traits linked to survival success post release. Another area we are working on is the integration of gut microbiome research for enhancing translocation of threatened species. Captivity has profound effects on the hosts microbiome which has been implicated as a cause of post release failure. If captive populations are to effectively act as insurance and source populations for threatened species, they must retain essential traits for survival post-release. As part of our reintroduction biology research we have also worked with engineering colleagues to develop a long range (LoRa) radio and Internet of Things (IoT) system for passive tracking of translocated wildlife. Our WildTrack system has gone through two development and testing phases and provides a non-invasive way to track difficult to monitor species. The system is highly scalable with 1000's of modules able to connect to a single LoRa gateway enabling the future use of long-distance arrays to increase detection rates, examine dispersal distances and determine home ranges of more mobile species.

**Lab Head**: Dr Kylie Robert (K.Robert@latrobe.edu.au)
**Lab Members:** Dr Zak Atkins, Dr Stephen Griffiths, Angela Russell, Kushini Kularatne, Angela Simms, Stacey Phillips

**Fields of Study:**
Animal Behaviour; Anthropogenic disturbance; Conservation ecology; Reproduction; Translocation.

**Capabilities and Techniques:**
Animal field ecology (trapping, handling, monitoring, tracking); Behavioural observations; Sperm analysis; Respirometry; Endocrinology; Thermal biology; Captive animal colonies.

**Translational Opportunities:**
Reintroduction biology; Species conservation; Mitigation of artificial light at night; Threatened species biology; WildTrack network.

**Website:** www.robertlab.com

# Riverine Landscapes Research Group

Our group, located in the Centre for Freshwater Ecosystems, has expertise in spanning hydrology, spatial modelling, GIS, ecology, ecosystem science, molecular and genetic techniques and has strong links to industry and research partners in Australia and worldwide. We study interactions between the physical environment, (climate, hydrology, fire and land-use), and how these affect ecological patterns and processes across the landscape, including species distributions, population dynamics, connectivity and food-webs.

### The effects of climate-variability and change on species distributions

Australia has extreme patterns of interannual climate variability and frequent drought. We use field and modelling approaches to relate aquatic ecosystems species distribution to water stress, hydrology, fire, climate change and other physiographic variables. Our predictions of potential future shifts in species range, abundance and occupancy are combined with conservation planning models to prioritise areas for protection and targeted management interventions. We work with Melbourne Water and the University of Melbourne to develop the Habitat Suitability Models for stream and wetland fauna around Melbourne, and we are monitoring the 2020 bushfires impacts on the nationally endangered Alpine Stonefly (*Thaumatoperla alpina*).

### Ecohydrology of intermittent stream networks

Up to 80% of river networks worldwide experience regular periods without surface flow. Dry period water habitats can contract to isolated waterholes along river channels which become critical refuges for aquatic biota. In human modified landscapes, sedimentation, groundwater extraction and runoff catchment interception cause declines in refuge quality and quantity. We study surface-groundwater interactions and food-web structure within individual waterholes, as well as, catchment hydrology roles roles determining waterhole persistence and metapopulation structure and dynamics

### Aquatic biodiversity conservation and management

Freshwater ecosystems account for around 10% of global biodiversity, but are declining at a rate far exceeding terrestrial or marine ecosystems. We study the ecology and fundamental biology of aquatic biota, including threatened species and other significant species of management interest (e.g. fishing target species); with the goal of improving management decisions and actions for these species. Our research includes evaluating and improving conservation strategies for threatened species, threatened species detection and distribution, and assessment of population viability through modelling. We are currently compiling genetic databases of freshwater invertebrates to map species distribution and use DNA metabarcoding to assess biodiversity and inform conservation measures.

### Aquatic ecosystem processes and food-web ecology

Our research explores how ecosystem processes (such as nutrient cycling, decomposition) and food-webs (ecosystem energy and matter flows) are influenced by human induced threats. We study how environmental change (such as altered river flows) affects connectivity, ecological processes and the trophic structure of aquatic food-webs. Our research, under field and laboratory conditions, often includes experimental manipulation in many aquatic ecosystem types.

**Theme Head:** Prof Nick Bond (N.Bond@latrobe.edu.au)
**Theme Members:** Assoc Prof David Crook; Assoc Prof Alison King; Dr Luke McPhan; Dr Michael Shackleton; Dr Sally Maxwell; Dr Julia Mynott.

**Fields of Study:**
Ecology; Hydrology; Landscape Ecology; Ecosystem Science.

**Capabilities and Techniques:**
Quantitative modelling: spatial, GIS, population models; Species-distribution; Environmental hydrology; Food-web ecology (stable isotopes use; Molecular techniques (population genetics, eDNA).

**Translational Opportunities:**
Water resources management and policy; Catchment management; Climate change impact and mitigation; Environmental impact assessment; Habitat restoration; Spatial prioritisation and conservation planning.

# Sleep Ecophysiology Group

Sleep is something we all do. We sleep for one-third of our lives; some animals are asleep much longer. We tend to look forward to sleeping; we feel, and perform, poorly when we don't get enough. Sleep behaviour reveals little about its function. For instance, we inhale to draw oxygen-rich air into our lungs. We eat to obtain energy for metabolism and growth. Conversely, the specific functions served by remaining outwardly inactive for long periods of time is less obvious. Our group studies sleep behaviour and neurophysiology in animals, including mammals, birds, fishes, and invertebrates, often in naturalistic or wild environments. Using this strong comparative approach that integrates classical behavioural ecology with neuroscience, we study: (i) evolution and function of sleep and sleep state components; (ii) the role of ecological factors and life history, including predation risk and breeding systems, respectively, in shaping where, when, and how long animals sleep; (iii) sleep-dependent cognition; (iv) effects of environmental pollution, e.g. light and urban noise, on sleep in wildlife.

Artificial light at night disrupts sleep in wildlife. (Picture credit copyright: Damond Kyllo)

### Evolution of sleep

Unearthing the evolution of sleep can provide insight into its function. In humans and other mammals, there are two kinds of sleep: non-rapid eye movement (non-REM) and REM sleep which can be distinguished using various behavioural and physiological measurements. These sleep states serve different functions, but our understanding of those processes remains incomplete. We compare sleep across animals to learn how and why sleep has changed with the appearance of new 'types' of animal.

### Ecology of sleep

The timing, amount, composition, and intensity (or depth) of sleep is also likely to be strongly influenced by an animal's ecology. Predators strongly shape the structure and organization of sleep in prey. Studies reveal that REM sleep is a particularly dangerous sleep state from an anti-predator point-of-view, perhaps because it is one of the deepest forms of sleep. Breeding systems in which males compete intensely for access to fertile females also favour great reductions in sleep, allowing the least restful males to secure additional paternity. Studies reveal sleep loss can be adaptive and favoured by selection, challenging popular notions that sleep loss is always detrimental to performance.

### Sleep-dependent cognition

Sleep is known to maintain waking performance in diverse animals. When animals are kept awake, they perform poorly. Their motivation and attention are reduced, coordination and memory are impaired, and emotions become more reactive. We study sleep's role in cognition in ecologically-relevant situations, mostly (but not exclusively) on Australian magpies.

### Disruptive effects of pollution on sleep

Humans have modified natural landscapes to contain sleep-disturbing pollution, such as artificial light at night, urban noise, and psychoactive pollutants in waterways. Until recently, we did not understand how sleep physiology was impacted by these forms of human pollution. Recent studies showed birds exposed to streetlights have a great reduction and fragmentation of sleep. Species responses to pollution appears to be species-specific, so we cannot endorse a single solution to ameliorate pollution effects on wildlife sleep.

**Lab Head:** Dr John A. Lesku
(J.Lesku@latrobe.edu.au)

**Fields of Study:**
Neurobiology; Behaviour; Ecology; Evolution.

**Capabilities and Techniques:**
Electrophysiology; Behavioural testing; Endocrinology; Molecular Biology.

**Translational Opportunities:**
Modified landscapes disruption to sleep affect wildlife conservation and management. Animals sleeping near streetlights can sleep 40% less than those in darker areas. Sleep affects waking performance, immune system functioning, clearing of nervous system metabolic waste, DNA repair, early brain development and energy conservation. Sleep disruption may directly affect an animal's ability to survive and reproduce.

# Soil-Plant Interactions Group

(Photo credit: Caixian Tang)

Soil degradation and nutrient deficiency in agro-ecosystems are worldwide problems and limit sustainable food production under current climate change settings. Our interdisciplinary and multi-institutional research focuses on management of soil constraints and nutrients, soil-plant interactions (including rhizosphere biochemistry) and impacts of elevated $CO_2$ and farming practices on soil processes and carbon sequestration.

## Impact of elevated $CO_2$ on crop growth and soil nutrient dynamics

Climate change and increasing $CO_2$ are impacting food production. Although increases in [$CO_2$] are predicted to initially increase plant productivity, achieving these benefits will be limited by water and/or nutrient deficiencies. It is unknown how Australian grain production systems, which have low- rainfall and infertile soils, will respond to increased $CO_2$. We study the interactions between elevated $CO_2$, nutrient supply and water availability on biomass distribution, $N_2$ fixation, litter quality, chemical and microbial processes regulating the cycling of carbon, nitrogen and phosphorus. We provide evidence of elevated $CO_2$ impact on root exudation, soil phosphorus dynamics, and on the activity and structure of microbial communities.

## Rhizosphere processes and phosphorus acquisition

Phosphorus (P) fertilizers are important in sustaining crop yields in modern farming systems. Each year, Australian farmers use about 450,000 tonnes of P as phosphate fertilizer. Only 10-30% is absorbed by crops, leaving unused P remaining in the soil. We study the impact of crop species, soil type and farming practice on chemistry and microbiology at the soil-plant interface (rhizosphere) to understand how to enhance the absorption of soil P by crop plants. We aim to identify crops that can access and absorb P from unavailable pools in soil, to improve P-use efficiency and to reduce P fertiliser use.

## Impact of farming practice on soil carbon dynamics

Soils can potentially sequester 2/3 of global soil carbon as soil organic matter, which is about 3.2 times the size of the atmospheric pool. Small changes in soil carbon content could lead to a significant change in atmospheric $CO_2$ level. We study how crop species, and farming practices such as crop-residue addition and lime application affect decomposition, preservation and carbon composition of soil organic matter to provide insights into on-farm management impacts on soil carbon dynamics over the long term.

## Amelioration of soil contamination

Land contamination is a serious worldwide issue and technologies such as applying biochar are being developed to address heavymetal contamination. We study the chemical and microbial immobilization of heavy metals in soils treated with biochar.

## Management of soil constraints

Subsoil acidity and compaction limit crop production in Australia, and are costly and often impractical to fix. We have compared different crop species/genotypes in their adaptation to the constraints, and assessed many organic and inorganic materials such as crop residues, biochar, animal waste materials, and calcium nitrate for their ability to overcome these constraints and studied amelioration processes and factors that improve subsoil conditions and crop yields.

**Lab Head:** Prof Caixian Tang (C.Tang@latrobe.edu.au)

**Lab members:** Dr Gary Clark; Dr Jian Jin; Assoc Prof Peter Sale; Adj Prof Roger Armstrong; Dr Tharanga Bandara; Dominic Lauricella; Kate Carson; Zahra Latifi; Rachel Davis.

**Fields of Study:**
Nutrient cycles; Plant nutrition; Plant-soil microbe interactions; Rhizosphere; Soil Science.

**Capabilities and Techniques:**
AgriBio modern research & plant growth facilities; Fitotron $CO_2$ growth chambers; 13C-labelling devices; Perkin Elmer CHNS and ICP analysers; Lachat flow- injection analyser; Infra-red $CO_2$ analyser; TOC analyser.

**Translational Opportunities:**
Carbon sequestration; Soil contamination & constraints amelioration; Efficient fertilizer use; Carbon & nutrient cycling.

# Weed Science Group

We deal with the 'bad guys' of the plant world. Weeds and invasive plant species, often labelled as 'unwanted plants', have far-reaching impacts on food security and environmental protection. These noxious plants cost the global economy billions of dollars each year. The cost of weeds to the Australian economy is over $4 billion per annum through reduced food production and expensive weed control practices. To better manage weeds, it is important to better understand them. Our research is focused on weed biology, invasion ecology and integrated weed management (IWM). The overarching goal of our research is to improve our understanding of weed biology and evolution to be able to develop sustainable management strategies. We study the ecological mechanisms driving weed adaptations to the changing climate, land use and management practices. Development of true IWM programs is at the core of our applied research.

**Ali Bajwa** with one of hundreds of weed species (*Gazania* spp.)

### Tackling the 'Weeds–Climate Change' Nexus

Our Group has a strong focus on understanding and combating the confounding nexus between weeds and climate change. Climate change is not only increasing the number of weeds infesting natural and agro-ecosystems but also expanding the range of problematic weeds while making them more competitive and difficult-to-control. We are conducting cutting-edge, empirical research to understand adaptive mechanisms, especially phonological changes and their physiological and genetic bases in weed species exposed to different selection pressures. We study the individual and interactive impacts of key climate change elements, including high temperature, drought and elevated atmospheric carbon dioxide concentration on productivity, physiology, phenology, competition ability and reproductive output of problematic agricultural and environmental weeds. Our research also optimizes the existing chemical control options in the wake of a changing climate.

### Understanding the Invasion Ecology and Competition Dynamics

Another major component of our research is understanding the invasion pathways, dispersal mechanisms and competition dynamics of weeds across different geo-climatic and land-use situations. We study how new weeds get introduced in novel environments, how they compete with the existing flora and what makes them so invasive. This work entails understanding the seed dispersal pathways, ecological and socio-economic impacts of weeds, functional traits as well as environmental and genetic factors enabling weed spread, establishment, and persistence. Empirical experimentation and modelling approaches are integrated to help understand the diverse interactions of weeds, host systems and management efforts.

### Breaking the Dormancy

Seed dormancy is problematic trait many weeds possess making their management a very long-drawn task. We work to understand the physical, physiological, and genetic intricacies of this important phenomenon. Our research is exploring the levels of dormancy across different populations of many weeds and decoding ways to overcome dormancy. Efforts are also underway to explore the genetic control(s) of weed seed dormancy. We also study the effect of a range of environmental conditions such as light, temperature, moisture, and soil factors on seed germination dynamics of weeds. This helps us gain important insights into population dynamics and emergence timing of weeds that is crucial for developing strategic, timely weed management programs.

### Systems Approach to Integrated Weed Management

The knowledge gained through our foundational research on weed biology, invasion ecology and weed evolution forms the basis of our strong applied research into developing IWM. We take a 'systems approach' to ecologically based weed management practices. We are optimising the current herbicide programs while incorporating innovative cultural or technological methods as feasible. This is all done in compatibility with agronomic, land-use or farming system practices.

**Lab Head:** Dr Ali Bajwa
(A.Bajwa@latrobe.edu.au)
**Lab members:** Dr Babar Shahzad;
Mr Muhammad Adnan; Mr Tyler Beale.

**Fields of Study:**
Weed Science; Invasion Ecology; Agronomy; Climate Change.

**Capabilities and Techniques:**
Seed biology and germination ecology; Farming systems & agronomy; Herbicide application and optimization; Plant stress physiology; Species distribution modelling; Climate-based weed invasion risk assessment; Genetic diversity; Metabolomics.

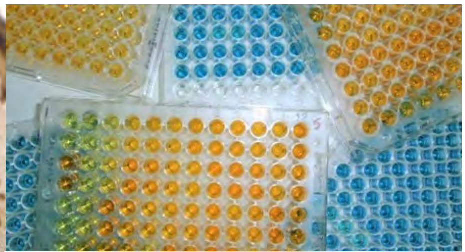
**Translational Opportunities:**
Crop productivity improvement; Resilient environment Biodiversity conservation.

# Wildlife Conservation & Reproductive Endocrinology Lab

The Wildlife Conservation and Reproductive Endocrinology Lab (WiCRE) is dedicated to advancing the understanding of endocrine function. Through our research, we strive to provide valuable insights about reproductive biology and stress physiology that will inform conservation strategies and enhance animal health and welfare.

WiCRE is one of the few labs in Australia that specializes in non-invasive hormone monitoring techniques. Using faeces, urine, and other biological samples, we can provide a window into animal physiology with minimal impact on the individual. These techniques are crucial for assessing the health and reproductive status of vulnerable or sensitive animals. We have developed and optimized non-invasive monitoring tools for a wide range of species.

WiCRE has a strong partnership with Zoos Victoria. We work with conservation biologists, ecologists, and medical researchers to bridge scientific knowledge with real-world impact.



(Photo credit: Kerry Fanson)

### Advancing reproductive physiology of Australian wildlife

Australia is facing an extinction crisis, endangering many of its unique species. To combat this, conservation breeding programs have been initiated. However, a significant hurdle is the lack of information about the reproductive biology of Australian species.

Our lab uses innovative, non-invasive hormone monitoring techniques to gain critical insights into the reproductive biology of threatened species in order to:

- Characterise reproductive physiology for priority conservation species
- Develop novel diagnostic tools to confirm and monitor pregnancy
- Analyse successful and unsuccessful breeders to identify causes of and potential treatments for reproductive dysfunction.

### Stress and reproductive function

We are working to develop a more comprehensive understanding of how glucocorticoids influence reproductive function, with a particular focus on ovarian biology. By improving our understanding of how these hormones are involved in female reproduction, we hope to offer novel insights into causes of female infertility. Current projects in this area include:

- Mapping normative patterns of glucocorticoid expression across reproductive stages
- Examining changes in expression of glucocorticoid receptors in the ovary

### Anthropogenic impacts

Human activities have substantially altered the environment and it is important to understand the impacts our actions have on wildlife. Our group investigates how environmental changes impact wildlife and why some species successfully adapt to these changes while others do not. Our group approaches this question from multiple perspectives, exploring questions such as:

- Do individual animals cope differently with anthropogenic stressors?
- What is the effect of artificial light at night on wildlife physiology?
- How do environmental pollutants disrupt endocrine signalling and reproductive physiology?

**Lab Head:** Dr Kerry V. Fanson (K.Fanson@latrobe.edu.au)

**Lab members:**
Dr Alica Dimovski, Andrea Bueno Pedraz, Thy Nguyen.

**Fields of Study:**
Endocrinology; Reproduction; Ecology; Conservation; Welfare.

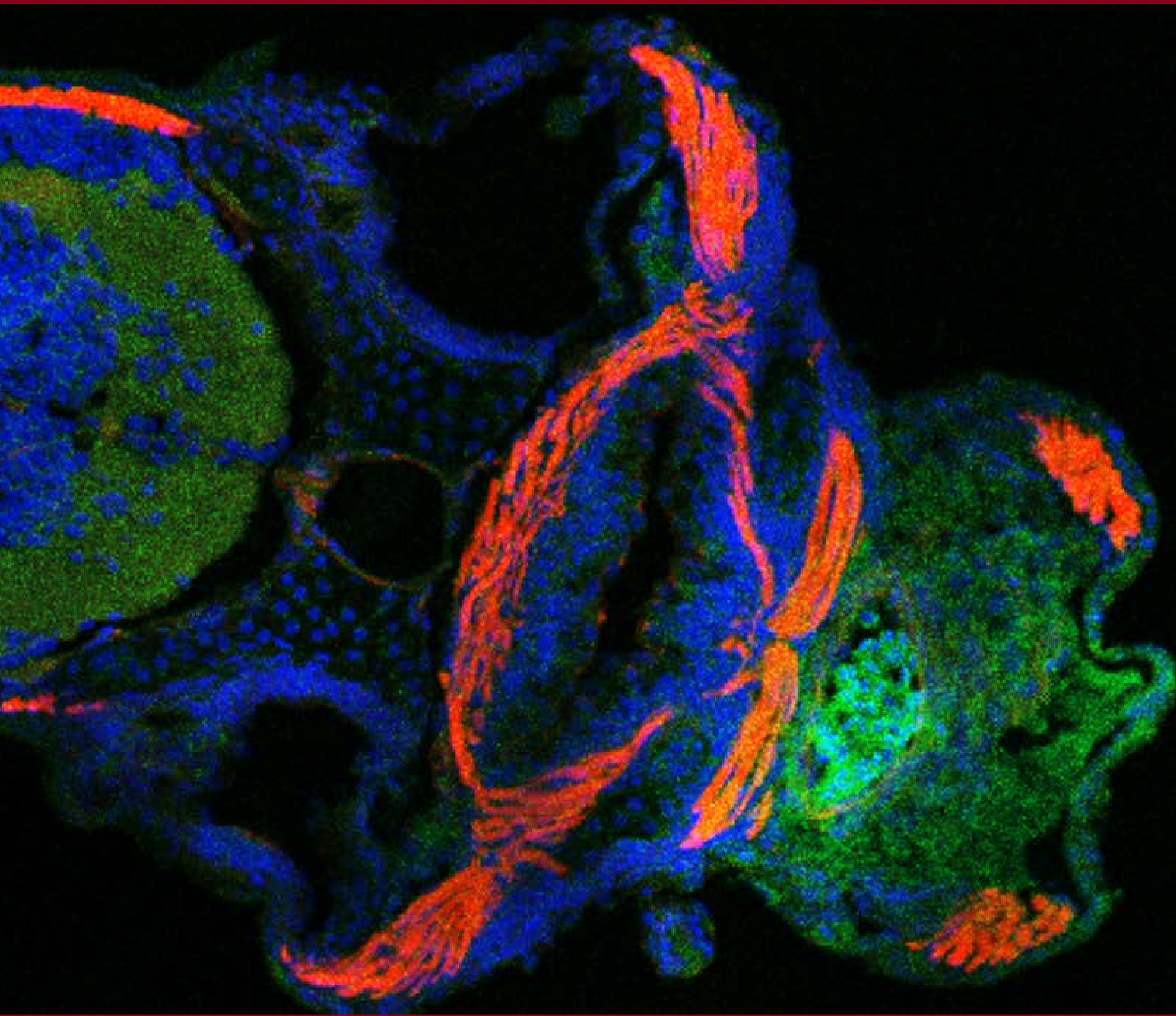
**Capabilities and Techniques:**
Non-invasive hormone monitoring; enzyme-immunoassays; behaviour assessments.

**Translational Opportunities:**
Understanding infertility in humans and animals and identifying potential treatments; enhancing success of conservation breeding programs; wildlife conservation; assessing human-animal interactions and implementing stress-reduction strategies to enhance welfare of captive animals; informing animal management policies.

# Department of Microbiology, Anatomy, Physiology and Pharmacology

## School of Agriculture, Biomedicine and Environment

*Scientists at the forefront of knowledge into how biomolecules, cells, organ systems, disease and the environment interact to form functioning organisms (i.e. viruses, bacteria, animals, humans, etc.)*



latrobe.edu.au/school-agriculture-biomedicine-and-environment

# MAPP Contents



*Cover Photo:*
*Expression of fibronectin in the anterior region of a zebrafish larva (Photo Credit: Nishanthi Mathiyalagan)*

# Department of Microbiology, Anatomy, Physiology and Pharmacology

The Department of Microbiology, Anatomy, Physiology and Pharmacology is one of the largest academic departments at La Trobe University. The Department consists of 50 continuing and fixed-term academic staff, including one Tracey Banivanua Mar Fellow, one ARC DECRA Fellow, and one NHMRC emerging leadership fellow. Professor Elly Djouma serves the role of Head of Department.

We teach >3000 undergraduate students enrolled across 32 subjects. We take great pride in providing a friendly and supportive environment, taking particular care to ensure a positive experience for undergraduate students.

We teach into La Trobe's undergraduate Science, Biomedicine and Allied Health ` and offer fully online subjects through Open Universities Australia. A number of our teaching staff have been recognised as Fellows/Senior Fellows of the UK's Higher Education Academy, and have received university and national awards for innovation and excellence in curriculum design and delivery.

Our Department produces graduates who are ready to take up a diverse range of job opportunities, with potential careers in government departments and agencies, hospitals, community health centres, rehabilitation centres, pharmaceutical and biotech companies, private health-care organisations and research centres.

The Department has a dynamic Higher Degree by Research (HDR) program that reflects the disciplinary interests of the staff. We are currently training 75 PhD and Masters students and 20 Honours (4th year Research) students from Australia and overseas.

Research carried out in the Department is world leading and focusses on some of today's biggest challenges in health and the environment. Staff and postgraduate students research the structure, function and environment of microbes, animals and humans in health and disease. Our breadth of expertise and co-location in world-class facilities create opportunities for new discoveries in cardiovascular biology and disease, neuroscience, developmental biology, musculoskeletal function, host-pathogen interactions and microbial ecology. Through this research, members of the Department are key contributors to La Trobe's new Research Themes of:

- Understanding and preventing disease
- A healthy, safe and equitable life course for everyone
- Production of quality foods and medicines
- Protection and restoration of vulnerable ecosystems

The Department's research activities also underpinned La Trobe University's ratings of '5 – well above world standard' in the latest round of Excellence in Research Australia (ERA) in the disciplinary areas of Physiology, Microbiology and Cardiovascular Medicine. The Department also contributed to similarly high ratings in the areas of Neuroscience and Soil Science.

The Department's research environment is dynamic and growing, and includes close relationships with world-renowned medical research institutes such as the Baker Heart and Diabetes Institute and the Howard Florey Institute of Neuroscience. We also have research partnerships with state, federal and non-government agencies, and are home to a major Research Centre:

- The Centre for Cardiovascular Biology and Disease Research

# Research Centre

## Centre for Cardiovascular Biology and Disease Research (collaboration with the Baker Heart and Diabetes Institute)

# Centre for Cardiovascular Biology and Disease Research

Cardiovascular disease refers to chronic diseases involving the heart and/or blood vessels, often leading to heart attack, stroke, heart failure and kidney disease. Cardiovascular disease is also a major cause of dementia.

In Australia, 4 million people suffer from cardiovascular disease, costing the economy $5 billion annually. Alarmingly, cardiovascular disease claims more than 40,000 Australian lives per year, with the highest death rates amongst Aboriginal and Torres Strait Islander peoples, socioeconomically disadvantaged groups, and those living in remote and regional areas. It is for these reasons that cardiovascular disease is recognised as a National Health Priority area by the Australian Government.

There is an urgent need for more research and greater public awareness to address the enormous health and economic impacts of cardiovascular disease.

The Centre for Cardiovascular Biology and Disease Research was established in 2018 by Professors Chris Sobey and Grant Drummond. In just five years, the Centre has attracted more than $13 million in research funding and is now home to more than 75 research staff and students, making it one of the largest cardiovascular research groups in Australia.

Our researchers utilise leading animal, organoid and cell culture models, and cutting-edge technologies including mouse genetics, physiology, immunology, single cell and spatial transcriptomics, proteomics, microbiomics and molecular imaging. This enables translation of discoveries into novel diagnostics, preventions and treatments for cardiovascular disease.

Our experimental findings on cell therapy in stroke have recently been translated into Phase I and Phase II clinical trials.

Our Centre is located in the heart of Melbourne's northern suburbs, serving a community that is disproportionately impacted by the devastating


consequences of cardiovascular disease and stroke. Our researchers work closely with the local community through public awareness campaigns, high school education programs, and partnerships with local government, health care providers and industries. The Centre also seeks input from members of the local community for strategic decision making, research planning and dissemination of findings.

**Co-Directors:**
Profs Chris Sobey and Grant Drummond
(c.sobey@latrobe.edu.au)
(g.drummond@latrobe.edu.au)

**Research Divisions and leaders:**
Cardiac Cellular Systems
(Associate Professor Alex Pinto)

Cardiac Disease Mechanisms
(Dr James Bell)

Cardiorenal Disease
(Dr Brooke Huuskes)

Cardiovascular Physiology
(Associate Professor Colleen Thomas)

Cerebrovascular Disease
(Dr Michael De Silva)

Diabetes Development and Prevention
(Associate Professor Hayder Al Aubaidy)

Dying Cell Communication and Clearance
(Dr Amy Baxter)

Hypertension and Diabetes
(co-led by Associate Professor Antony Vinh & Dr Maria Jelinic)

Immunometabolism and Macrophage Biology (Dr Katrina Binger)

Microbial Genetics and Interactions
(Associate Professor Steve Petrovski)

Molecular Proteomics
(Dr David Greening)

Stroke and Brain Inflammation
(Dr Helena Kim)

Vascular Therapeutics and Regeneration
(Dr Kazuhide Shaun Okuda)

**Strategic Partners:**
Australian Cardiovascular Alliance,
Baker Heart and Diabetes Institute,
CAD Frontiers, and
Beluga Foundation.

# Research Groups

# Anatomical Sciences and Higher Education Research Group

Anatomy ('to cut up') is the study of the structure of an entity.

Therefore, Human Anatomy concerns itself with the study of how the human body is structured.

It is often said that there is nothing new to discover about the human body.

For hundreds of years, it was believed that we know how many muscles and bones and organs we have.

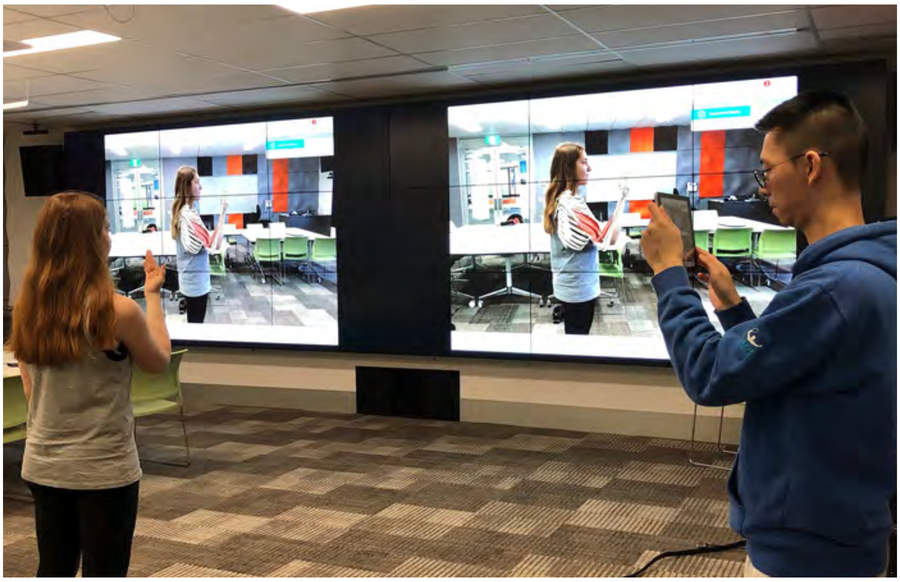
Therefore, there must not be much more to study!

However, anatomical research continues to make new discoveries about the human body, such as identifying new structures previously unknown (e.g. there are actually five muscles forming the 'quadriceps femoris' group, and there are lymphatics in the brain when previously it was thought there were none).

These new findings are helping to improve medical interventions such as surgical techniques, as well as the functional and clinical understandings contributing to health and disease and injury management.

Additionally, studying Human Anatomy is considered one of the most challenging topics in a science degree.

Helping students develop meaningful ways to study and apply their anatomical knowledge is essential.

Anatomical education has evolved significantly since the days of the didactic 'sage on a stage' lecture.

Although students think they learn more by watching a good lecturer up on stage, they ultimately understand less when compared to those engaged in active learning activities.

Our research group is interested in both anatomical science research (focused on better understanding the anatomical relationships in the body and their clinical applications) and developing and evaluating better ways to teach and learn anatomy.

In combination, these areas of focus ensure that students are being taught the most current anatomical information and are also being taught using evidence-based, contemporary teaching and learning methods.


GroupHead:
Assoc Prof Aaron McDonald
(a.mcdonald@latrobe.edu.au)

Group Members:
Dr Laura Whitburn
Dr Heath McGowan
Dr Brooke Huuskes
Dr Narbada Saini
Dr Jency Thomas
Ms Melby Tentrisanna
Mr Shane Cassar
Ms Frances Deen


Fields of Study:
Gross anatomy; topographical anatomy; higher education research in human anatomy.

Capabilities and Techniques:
Human dissection; ultrasound; qualitative and quantitative analysis; digital educational technologies; curriculum development; student-teacher co-creation; peer-peer learning.

Translational Opportunities:
Education; curriculum development; human dissection; sports and exercise science; medical research.

# Antiviral Innate Immunity Group

Viruses infect all living organisms. Our laboratory studies both viruses of animals and humans to unravel the role of novel host and viral proteins in the control of viral infection, with a goal towards development of novel strategies to combat viral infection in both humans and animals. Our group uses advanced imaging, molecular, and genomic techniques to perform research across 2 main themes: (1) Host Induction of an efficient antiviral response and (2) Control of viral pathogens.

Theme 1: Host Induction of an efficient antiviral response
When a virus infects a cell, the host cell has sentinel receptors to detect foreign viral material. Receptor activation triggers a cascade of signaling pathways resulting in the upregulation of interferons, the main antiviral cytokines, which further upregulate thousands of antiviral gene products. Limited drugs are available to treat viral infections, and many significant viral infections have no treatments other than supportive care. We study molecular mechanisms that underpin the ability of a host cell to upregulate the most effective antiviral response. We focus on multiple viral pathogens across many animal and human models to uncover novel pathways and host proteins that will assist in developing next generation anti-viral drug treatments for multiple viruses.

Lipid droplets (LDs) as a novel antiviral target
Our group has recently demonstrated that the lipid droplet (LD) is an essential organelle in facilitating an efficient and robust antiviral response for the first time. LDs contribute to key pathways important for the physiology of cells. In a homeostatic view, they regulate the storage of neutral lipids, facilitate removal of toxic lipids, and are involved in cellular communication. Recent advances in the field show these organelles are essential for cellular stress response mechanisms, including inflammation and immunity, with LDs acting as hubs to integrate metabolic processes.

Lipid droplets inside mosquito ovaries. (Photo credit: Ebony Monson)

Changing proteome/lipidome of LDs Recent attention has focused on LDs because of their ability to rapidly change their proteome and our team has described the changing LD proteome during viral infection for the first time. We can isolate LDs from tissues and cells and have developed methods to separate out the proteins and lipids from the LDs giving us a very unique analysis pipeline to examine individual lipids and proteins using advanced mass spectrometry methods on the LD during virus infection.

Development of artificial LDs (aLDs)
We have now developed a pipeline to make aLDs in collaboration with Prof Adam Mechler's group (BC, LIMS) and are developing these aLDs as a novel antiviral strategy for the first time.

Theme 2: Control of viral pathogens
Viral pathogen control is solely restricted to vaccines in the veterinary sector, with vaccines and a small handful of drugs available for the treatment of some viral infections in humans. In collaboration with the Prof Travis Beddoe's Group (APSS) we work on developing new vaccines and tools to run vaccine trials for the veterinary sector. We focus on solutions for viral pathogens in small aquatic animals, where they do not have an adaptive immune system, and rely on innate immunity to control viral pathogens. We use our host induction research to develop new immune priming strategies to target viral pathogens in the aquatic livestock industry.

Lab Head: Prof Karla Helbig
(k.helbig@latrobe.edu.au)

Lab members: Dr Ebony Monson; Ms Irumi Amarasinghe; Ms Zahra Telikani; Ms Jacinta Agius; Mr Darcy Beveridge, Mr Garry Chahal, Mr Lachlan Ridgeway, Mr Lachlan Wallace

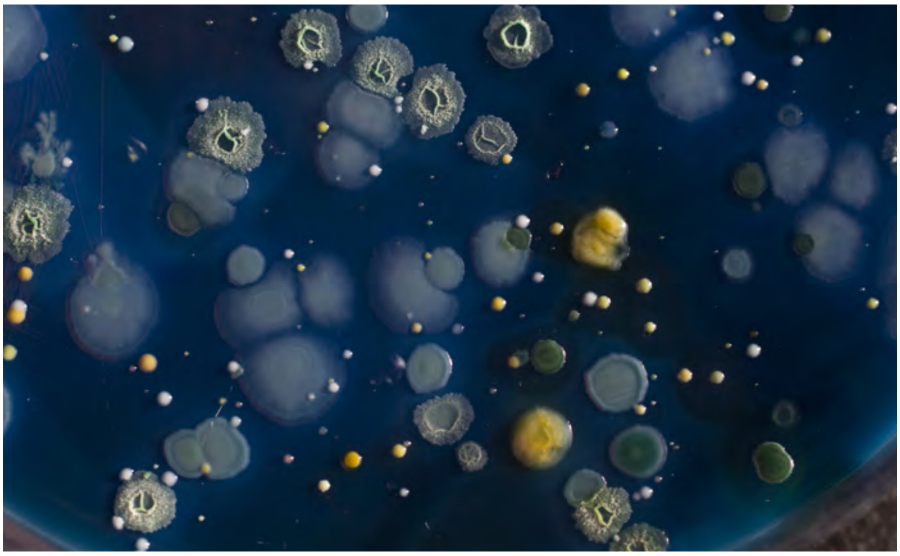
Fields of Study:
Virology; Innate Immunology; Immunity; Lipid droplet biology; Lipids; Veterinary pathogens.

Capabilities and Techniques:
High end microscopy including confocal, super resolution, light, fixed, live cell & imaging of complex tissue types (brain, lungs, and mosquitos); Cell & virus culture & propagation; Primary cell culture; Animal husbandry (mice/abalone); Viral delivery of genetic material; CRISPR/ cas; High sensitivity proteomics and lipidomics; Lipid droplet isolations; Protein expression & purification; Next generation sequencing; General molecular biology (ELISAs, western blotting, RT-qPCR etc.).

Translational Opportunities:
Viral animal pathogen detection; Targeted drug development and management; Characterisation & modulation of innate immune responses; Development of novel antiviral therapeutics; Vaccine/ immune priming design/ delivery.

# Applied and Environmental Microbiology Group

Our research investigates a diverse range of microbiomes associated with soil, human and ecosystem health. We have in-house Illumina Next-Generation sequencing facilities and develop custom bioinformatic pipelines for structural and functional community analysis. We have custom made equipment for the study of anaerobic microorganisms including electroactive bacteria, gut and soil microbes. We collaborate with medical, soil science and ecology researchers as well as NGOs, corporate partners, landholders, national and international partners. We lead the microbial branch of the La Trobe Applied Microbiomes project (LAMP) and pioneer the use of functional traits in microbiome research.



Culturing diverse microorganisms  (Photo credit: Gene Drendel)

### Pioneering trait ecology in microbiome analysis

From soil to human health, there is an urgent need to predict how changes to microbial community structure impact community function. We pioneer the use of functional traits to study microbial communities and how they impact environment functions. Traits go beyond looking at 'who' is present in a community, to understanding 'how is the community behaving', leading to identifiable opportunities for 'engineering' these communities for beneficial outcomes in health, disease and environmental research.

### The human microbiota in infant health

The human microbiota contains trillions of microbial cells with most present in the gut. Branched chain fatty acids (BCFA) in breast milk influence normal human microbiota development, infant gut epithelial cells, and the immune system. Preterm infants and those mainly fed on formula often lack BCFAs. We isolate bacteria producing BCFAs to study their impact on human microbiota and gut health. Our research may lead to new infant formulas for optimal infant gut and microbiota development.

### The microbiome in health and disease

The human microbiome, performs vital health functions that influence immunity, synthesis of essential molecules, and even our mood. Interactions between the microbiome, genetics and physiology are complex. We collaborate with clinicians, neurobiologists and physiologists to study the microbiome's role in Parkinson's disease, Autism and other disorders.

### Promoting  ecosystem health  from the ground up

Agricultural and natural ecosystems rely on soil microorganisms to drive key ecosystem functions. For example, microorganisms are gatekeepers of the carbon cycle, both creating and removing carbon from soil systems. We study how the ecology of a microbial community governs these key ecosystem services, the wider implication for ecosystem function and interactions with climate. The answers to these questions have far reaching implications for the role of soil health in ecosystem restoration and sustainable farming and climate change mitigation.

### Applied electromicrobiology

The developing field of electro-microbiology investigates bacteria with novel electrical properties including the ability to transfer electrons between each other and onto stable surfaces such as electrodes. We use microbial fuel cells
(MFCs) and plant MFCs to study these electroactive microbes and key roles they play in corrosion in bioremediation processes.

### Rare and extreme microbiomes

We study microbial survival in extremeenvironments to understand the role of microbes in biogeochemical cycling, primary production and as mediators and mitigators of climate change.

**Lab Heads:** Dr Jennifer Wood (jen.wood@latrobe.edu.au) and Prof Ashley Franks (a.franks@latrobe.edu.au)
**Lab Members:** Dr Anya Shindler (senior researcher); Mr Luke Bosnar; Ms Berenice Della Porta; Ms Edden Subejano; Ms Lauren Haylen; Ms Nadia Zermani; Mr Kyle Iseppi; Ms Urja Amin.

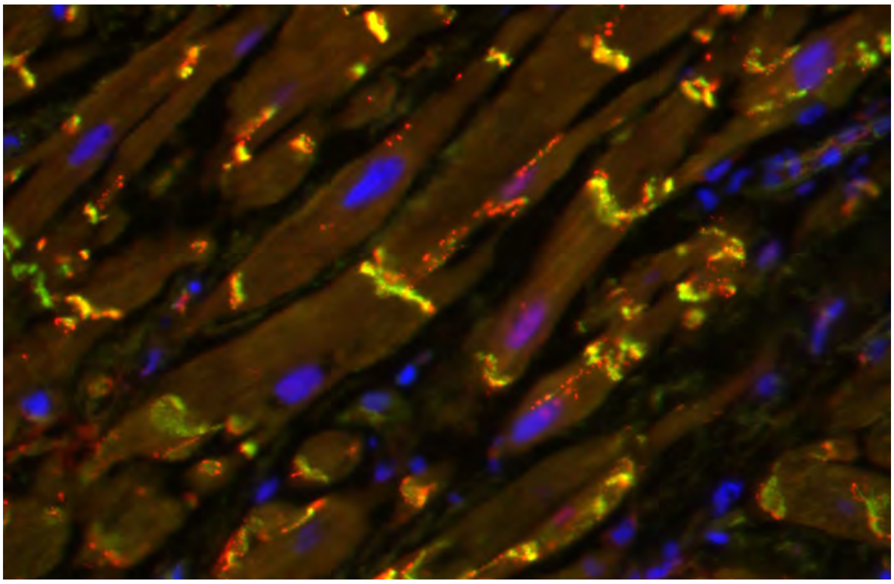
**Fields of Study:**
Microbiology; Ecology; Health; Bioremediation; Soil Science.

**Capabilities and Techniques:**
Next-generation sequencing, quantitative PCR; Anaerobic microbiology (gassing station & anaerobic chamber); Electro-microbiology; Trace gas analysis; multivariate statistics; bioinformatics.

**Translational Opportunities:**
Early detection/alleviation of human disease phenotypes (in Parkinson's Disease & Autism); improved sustainable agricultural land management practices; holistic ecosystem conservation and monitoring; soil contaminants bioremediation.

# Cardiac Disease Mechanisms group

The Cardiac Disease Mechanisms Laboratory seeks to understand the cellular and molecular mechanisms driving diseases in the heart in a bid to identify new candidate targets for future therapies. One in five of all deaths in Australia are due to heart disease – a devastating public health and economic burden that will continue to escalate with an increasingly aged and obese population. This new research group within the Department has extensive expertise in in vivo, in vitro and molecular methodologies, with a focus on examining the underlying causes and pathological consequences of irregular heart rhythms (arrhythmias), heart attacks (myocardial infarction) and chronic heart failure.



Cell-to-cell communication proteins in human cardiomyocytes (Photo credit: Jim Bell)

### 'Heart fat' emerging as a critical mediator of heart disease

Increased body fat (especially visceral tummy fat) is known to be an important contributor to the development of heart disease, releasing factors into the blood that travel to the heart and disrupt function. Up until recently though, the role of the fat immediately surrounding the heart has been largely overlooked. This 'heart fat' increases markedly in obesity, with aging, and in post-menopausal women – all important risk factors for heart disease. Heart fat is increasingly thought to be critical to the development of irregular heart rhythms and relaxation abnormalities that represent a primary component of cardiac demise.

### Inter-cellular communication between heart fat and muscle cells drive irregular heart rhythms

We have very recently shown that heart fat exerts a unique, detrimental influence on the surrounding heart muscle. Our findings show that the very close proximity between the fat and muscle cells within the heart greatly increases the potential influence of this local fat on heart function. We have taken the first steps in identifying the factors released from the heart fat, and look to establish how these modulate the function of neighbouring heart muscle cells in a manner that increases their vulnerability to potentially fatal irregular heart rhythms.

### Relaxation abnormalities in fatty hearts?

We are also taking the field in a new direction, by investigating a very recently described clinical link between heart fat and the capacity of the heart to relax. An inability of the heart to relax properly disrupts its capacity to fill with blood, and is an emerging global health issue with no effective therapies available. Building on our growing understanding of the factors released from heart fat that influence heart rhythmicity, we seek to also identify how these may drive relaxation abnormalities that eventuate in heart failure and death.

Our research capacity is supported by ongoing pre-clinical/clinical collaborations developed both locally (University of Melbourne, Baker Heart Institute) and internationally (University of Birmingham, UK).

**Lab Head:** Dr Jim Bell (j.bell@latrobe.edu.au)

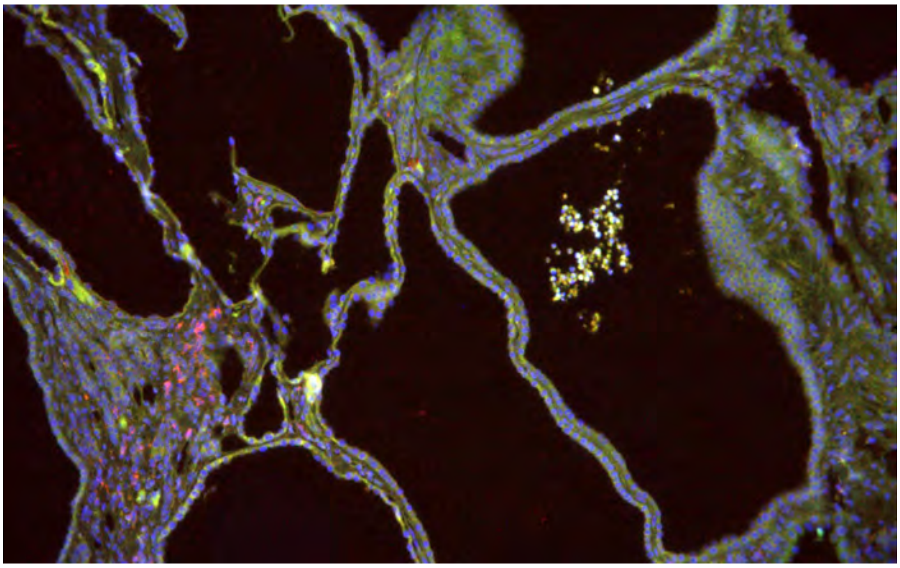
**Lab members:**
Sarah Hayes; Hamish Lindstrom.

**Fields of Study:**
Cardiac arrhythmias; Heart failure; Adipose tissue; Intercellular signalling; Sex steroids.

**Capabilities and Techniques:**
Human cardiac tissue collection & rodent models of obesity; isolated heart & cardiomyocyte contractility; electrophysiology & conduction mapping; protein biochemistry; fibrosis/adipose infiltration quantification.

**Translational Opportunities:**
This research will identify novel molecular targets that advance preventative therapies for aged and obese populations at risk of developing heart disease.

# Cardiorenal Disease Research Group



Macrophage staining in polycystic kidney disease. (Photo credit: J. Gasperoni)

Kidney disease affects around 12% of the population and places a huge burden on the individual suffering the disease. The only option for patients is dialysis or transplantation. Dialysis is life limiting and there is a sever organ shortage meaning long wait times for those in need. Devastatingly, people with kidney failure often die of a cardiovascular event before even getting a lifesaving transplant. Imagine a world where we can completely reverse the effects of kidney disease. That is the goal of the Cardiorenal Disease Research Group, to unravel the mysteries of chronic kidney disease and find new ways to stop the progression of this disease, and even regenerate the kidney. Further, we are using qualitative research methods to understand how transplant recipient experience the public health system and also investigate how to increase the number of organ and tissue donors in Australia.

### Does the immune system contribute to polycystic kidney disease progression?

Polycystic kidney disease (PKD) is a genetic condition affecting up to 1in 400 people worldwide. This inherited condition comes in two forms: Autosomal Dominant (ADPKD) and Autosomal Recessive (ARPKD). Patients with PKD grow large fluid filled cysts on their kidneys which causes several side effects due to the crucial role that the kidneys have in maintaining body homeostasis. Namely, the cyst grow so big that they destroy the kidney tissue, eventually leading to complete kidney failure. One major side effect of PKD that patients have high blood pressure.
Using both zebrafish and rodent models of, we aim to understand how the immune system contributes to disease development, progression and high blood pressure. By identifying the molecular pathways involved in disease progression we may be able to design therapies to stop disease early in its progression.

### Can Zebrafish be used to screen for new drugs to treat kidney disease?

Zebrafish develop cystic changes in a way that is similar in humans. This gives us the unique opportunity to screen new compounds that may be beneficial in stopping or slowing the progression of PKD development. Zebrafish embryos are transparent and develop outside the body, so we can use sophisticated microscopy techniques to monitor their development in real time.

### Why do cells dye in human kidney disease?

We use new technology called tubules on a chip (TOAC) to understand the crosstalk between cells of the kidney and the immune system.
In this cell culture technique, we take cells from human kidneys, which have been surgically removed from patients with kidney cancers or PKD, and grow epithelial cells in one chamber, endothelial cells in another. We then add immune cells and culture everything under physiological flow, meaning that this culture method closely represents what occurs in the human kidney. Using Bulk RNA sequencing, we can determine the cellular changes that occur under different conditions, giving us insight into the cellular changes associated with disease progression.

### How has telehealth changed the way care is delivered to kidney transplant patients?

This qualitative study will expand on our recent work that looked into how kidney transplant recipients feel about using technology in their post-transplant care. The results of this previous study was used to lobby for government changes into telehealth services across Australia. Now, we want to gain insight into the physicians point of view and determine if the mode of healthcare delivery affects patient outcomes.

Lab Head: Dr Brooke Huuskes (b.huuskes@latrobe.edu.au)

Lab members:
Emily Major, Sean Barton, Emily Dixon.

Fields of Study:
Kidney disease, Hypertension, Genetics, Public Health, Patient-centered

Capabilities and Techniques:
Animal models of kidney disease (including rodents and zebrafish), molecular biology techniques, human cell culture, live-cell imaging, histopathology, immunohistochemistry, confocal microscopy, renal function, qualitative data collection

Translational Opportunities:
Understanding the mechanisms involved in kidney disease allows us the opportunity to identify new therapies for kidney disease. Through qualitative research, there is opportunity to impact current practices in government processes and policy.

# Cerebrovascular Disease Group

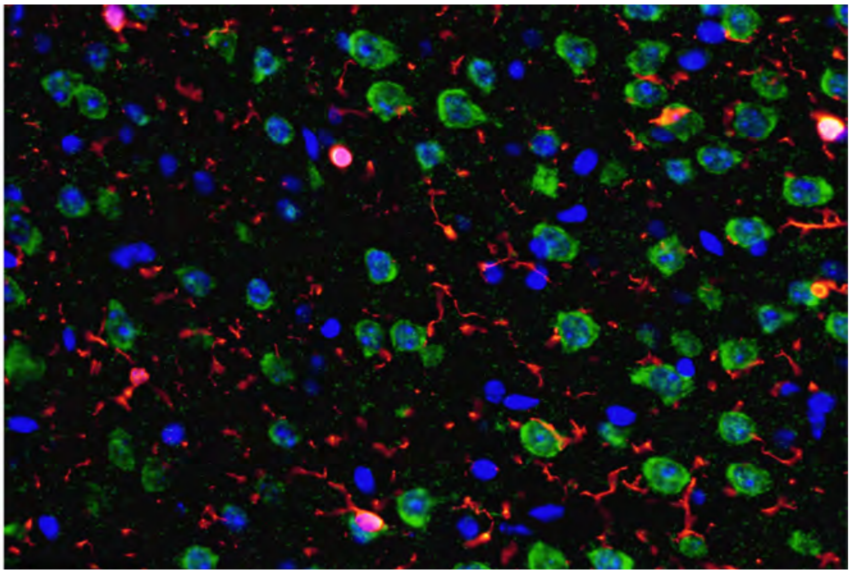
Cerebrovascular diseases (stroke, dementias) are a major health concern in Australia and throughout the world. The brain is and its circulation are particularly sensitive to disease. Cardiovascular diseases disrupt the function of cerebral arteries which leads to a dysregulation of cerebral blood flow. This may lead to altered blood flow to the brain which may starve neurons of the continuous supply of oxygen and other nutrients essential for their function. Insufficient delivery of oxygen and nutrients to the brain is a major factor in neuronal dysfunction and may contribute to the development of cognitive impairment (e.g. loss of memory). Our research focuses on the effects on cardiovascular diseases (e.g. hypertension, ischaemic stroke, metabolic syndrome) on the brain and its circulation. We utilise animal models of disease as well as state of the art imaging, molecular and behavioural testing techniques to determine the impact of disease on the brain and identify potential targets for therapy.

### Targeting estrogen signalling to reduce dementia risk

It was recently reported that postmenopausal women with hypertension to have the greatest reduction in brain health between ages 60-80. This decline is greater than in groups regarded as "unhealthier" (e.g. males with multiple cardiovascular diseases). Loss of protection by estrogen after menopause is a likely contributor. We have shown that activation of the G protein-coupled estrogen receptor (GPER) is protective in cardiovascular disease models, including hypertension and stroke. Importantly, selective activation of GPER avoids unwanted effects that result from activation of classical estrogen receptors. In this project we will study menopause-accelerated brain atrophy and cognitive decline in female mice with hypertension and if these changes to brain health can be prevented by pharmacological targeting of GPER.

### Comorbidities and stroke

Stroke patients are typically older and have one or more cardiometabolic diseases. Despite this, most preclinical research is performed in young, healthy animals.



Staining for neurons and microglia in the prefrontal cortex. (Photo credit: Tarunpreet Rajput)

This has likely contributed to the failure to translate drugs identified in preclinical studies to clinical use. Hypertension is the major risk factor for stroke and we recently found that hypertension worsens memory after stroke. The combination of hypertension and stroke altered the transcriptomic profile of the brain, with changes to genes associated with neuroinflammation and neuronal function. This project aims to understand how hypertension, or other cardiometabolic diseases, worsens stroke outcomes.

### Human amniotic epithelial cells and cognitive function

Cardiovascular diseases are known to promote brain injury and may therefore, result in impairment of cognition. The complex mechanisms that underly these diseases mean that a single therapeutic agent is unlikely to be effective. Human amnion epithelial cells (hAECs) have many properties (eg. anti-inflammatory, antifibrotic, regenerative and immunologically inert) that make them attractive candidates for a cell-based therapy for disease. This project will determine whether hAECs can treat cardiovascular disease-induced brain injury and cognitive impairment.

Lab Head: Dr Michael De Silva (tdesilva@latrobe.edu.au)

Lab members:
Dr Quynh Nhu Dinh; Mr. David Wong Zhang; Mr. Yeshwanth Yeraddu; Mr. Louis Tran.

Fields of Study:
Dementia, stroke, vascular function, brain injury, behaviour.

Capabilities and Techniques:
Animal models of hypertension and stroke; flow cytometry; histopathology; immunohistochemistry; confocal microscopy; genomic sequencing; mouse behavioural/cognitive testing; oxidative stress & inflammation assessment; vascular reactivity/compliance.

Translational Opportunities:
New drug targets: Pre-clinical dementia/stroke.

# Developmental Genetics Group

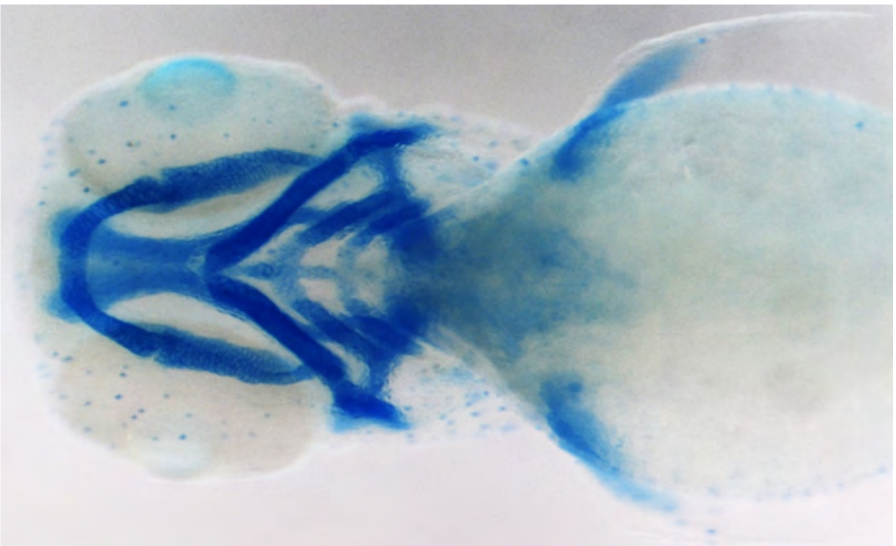
Understanding the cellular behaviours, particularly in the craniofacial region and neural tube, and the molecular pathways by which these behaviours are regulated, forms the cornerstone of understanding embryonic development. Using genetically-modified mouse and zebrafish models, our group identify critical genetic networks that underpin formation of the head (brain, skull and jaws) and epithelia of the body. We focus on the roles played by key conserved transcription factors Grhl3 and PLAG1 in regulating organ formation and behaviour in vertebrates. Our group also aims to identify supplements that may overcome the severity and/or incidence of birth defects due to genetic deficiency.

### Novel genetic pathways in skull, jaw and epithelial formation

Congenital anomalies affecting the formation of the head, skull and jaws (craniofacial defects), are mainly caused by genetic mutations. We focus on the Grainyhead like (Grhl) genes, a key family that regulates craniofacial formation in flies, zebrafish, mice and humans. We developed mouse and zebrafish models with impaired Grhl function, that identify new genetic pathways affecting skull, hard palate and lower jaw formation. Our animal models also identify the role these genes play in establishment and maintenance of healthy epithelia and ensuring correct organ function.

### Environmental factors that affect embryonic development

Environmental factors (smoking, alcohol intake and bacterial/viral infection) can cause human birth defects. Supplements (folic acid, magnesium, zinc, vitamin B and iodine) reduce birth defect severity. We use zebrafish embryos and mouse palate explants to identify ways to reduce epithelial and craniofacial defects incidence and severity. We also study the effects of prolonged agricultural organophosphate insecticides exposure on adult behaviour and embryonic development.



Craniofacial skeleton in a zebrafish (Photo credit: Seb Dworkin)

### Establishing zebrafish models of human craniofacial defects

Using both germline deletion and transient knockdown approaches, we establish zebrafish lines to model structural human craniofacial skeleton birth defects. By identifying genes that are known to cause birth defects in humans and inhibiting or inactivating the respective zebrafish orthologues of these genes, we study how and why mutations in these genes lead to defects.

### Animal models of neurocognitive and behavioural disorders

Using time-lapse microscopy, animal tracking software and mouse and zebrafish behavioural analyses, we study how genetic compromise during embryogenesis can lead to subsequent learning, memory and behavioural issues in later life. Using mouse models deficient for two genes – PLAG1 and Grhl3 - we study the habenula brain region that acts as a "handbrake" to guard against socially-inappropriate or overt risk-taking behaviours. Understanding how this neural center is established and maintained at the genetic level may lead to new therapies.

**Lab Head:** Assoc Prof Seb Dworkin (s.dworkin@latrobe.edu.au)

**Lab members:**
Dr Jemma Gasperoni; Mr Jarrad Fuller; Mr Zachary Di Pastena, Ms April Lewis, Ms Maya Salama.

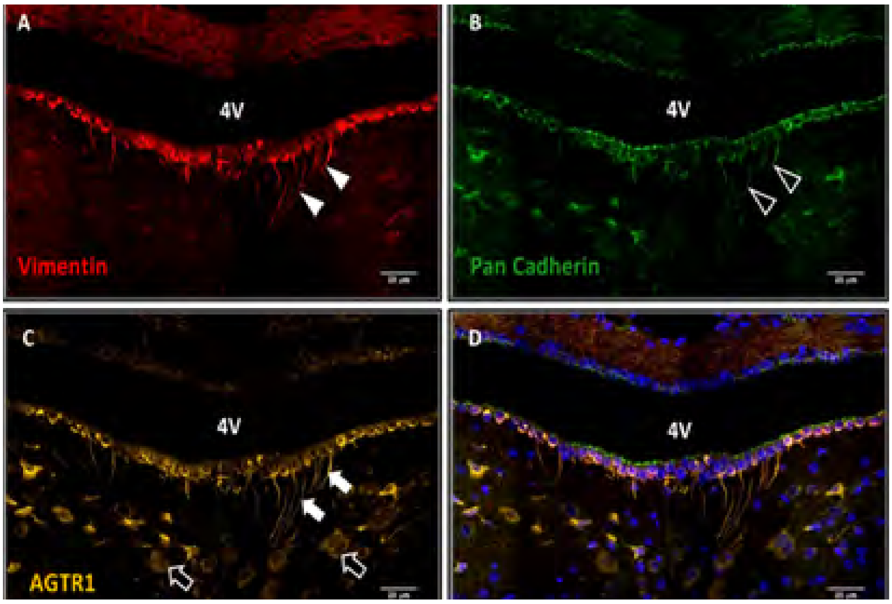
**Fields of Study:**
Embryology; Genetics; Craniofacial Biology; Neurodevelopment; Animal models of disease.

**Capabilities and Techniques:**
Zebrafish model system; confocal and fluorescent microscopy; in-situ hybridisation; cartilage & bone staining; PCR & DNA/RNA molecular biology techniques; micro-injection; immunohistochemistry and basic histology; genetically-defined models (mouse, zebrafish) and mouse palate cultures.

**Translational Opportunities:**
Genetic counselling; Gene mutation identification for pre- and peri-natal healthcare to ameliorate craniofacial defects and behavioural disorders.

# Diabetes Development and Prevention Group

The Diabetes Development and Prevention research group is involved in broad range of research activities which includes experimental, clinical trials and community-based research. The primary aim of our group is to explore risk factors which increases the incidence of diabetes and identifies measures that can be undertaken to prevent the development of this disease and thereby reducing the development of cardiovascular complications. The group uses innovative high-performance clinical and analytical techniques to assess the levels & activity of enzymes, hormones and trace elements in various biological samples in both animal model and human model. The research group has established collaborations with local, national, and international research teams aiming for better prevention and early management of diabetes mellitus and related co-morbidities. The group is also investigating barriers pertaining to diabetes management and wellbeing in people from Culturally And Linguistically Diverse (CALD) communities living with type 2 diabetes Australia. The lab has three main research foci:




Immunofluorescence labeling of vimentin (A), pan cadherin (B), AGTR1 (C) and combined (D) in coronal sections of rat brain (Photo credit: Hayder Al-Aubaidy)

### The antioxidant, anti-inflammation and hypoglycaemic effects of selected nutraceutical supplements

This research project aims to investigate the effects of a series of nutraceutical supplements (including citrus bioflavonoids and phytosterols) on the levels of oxidative stress, inflammation and glycaemic index in prediabetes and type 2 diabetes mellitus. This project involves research collaboration from local (Professor Grant Drummond, Associate Professor Colleen Thomas, Dr Maria Jelinic), national (Dr Glenn Jacobson – University of Tasmania, Professor Catherine Itsiopoulos – Murdoch University) and international (Dr Lynne Chepulis – Waikato University, NZ).

### Indicators of poor glycaemic control

This project aims to highlight the interplay of several biochemical markers associated with poor diabetes outcome which may precipitate the development of diabetes complications including cardiovascular disease. In collaboration with research staff from Charles Sturt University and Khalifa University, UAE, the research team introduced the oxidative stress and inflammation assessment as a routine clinical test of diabetes screening program in rural areas.

### Improve diabetes management in developing countries

This research project focuses on improving the current measures used in early detection and management of type 2 diabetes in developing countries. It has established collaboration with several clinicians and medical researchers from international universities in both Iraq and India to look for better ways to increase awareness of the risks of diabetes and its complications, through early diagnosis of prediabetes and type 2 diabetes mellitus. These research project involves – Dr Jency Thomas, Dr Sabrina Gupta (Local), Dr Ramesh M (JSS university, India), Associate Professor Amani Alhazmi (King Khalid University, Saudi Arabia) & Dr Clarice Tang (Victoria University, Australia).

Lab Head:
Assoc Prof Hayder Al-Aubaidy
(halaubaidy@latrobe.edu.au)
**Lab members:** Dr Jency Thomas; Dr Sabrina Gupta; Dr Dina Jamil; Ms. Deniz Heydarian; Mr Rahul Puvvada; Mr Anwar Althubyani; Ms. Chandana Deekshith; Mr Abdulsatar Jamal; Mr Jad El-Rassi.

Fields of Study:
Diabetes Mellitus; Cardiovascular Disease Prevention, Diagnosis and Early Management; Nutrition; Public Health; Clinical Sciences.

Capabilities and Techniques:
Ultra-Performance Liquid Chromatography-Mass Spectrophotometry; Enzyme Linked Immunosorbent Assay; Fluorometry; Molecular Biology; Epigenetics; Immunohistochemistry, Semi-structured interviews, Qualitative and Quantitative data analysis.

Translational Opportunities:
Ultra-Performance Liquid Chromatography-Mass Spectrophotometry, Enzyme Linked Immunosorbent Assay, Fluorometry, Molecular Biology and Epigenetics. Quantitative and Qualitative research methodologies, Semi structured interviews, Randomised Control Trials (RCTs) & Community engagement.

# Environmental Microbial Genetics Group

We study horizontal gene transfer (HGT), which is the mechanism of gene-swapping between bacteria of unrelated species. HGT provides opportunities for bacterial evolution over long and short timespans. HGT has contributed to antimicrobial-resistance amongst diverse, clinically significant, bacterial species, a situation that now threatens the usefulness of antimicrobials in the treatment of bacterial infections. We study plasmids, transposons and bacteriophages which are vital components of HGT. Our research group uses molecular genetic techniques, transmission electron microscopy, next generation sequencing, microbiological techniques and CRISPR/cas9 gene editing. We also have state of the art equipment, e.g. Illumina MiSeq, Nanopore sequencing facility, bioprocessing fermenter and other equipment to perform genetic analysis.


Transmission Electron Microscope Image of Patescibacterium *Mycolasynbacter amalyticus* infecting *Gordonia pseudoamarae* (Photo credit: Steve Petrovski)

### Bacterial horizontal gene transfer in *Pseudomonas aeruginosa*

Bacteria are evolving and are becoming resistant to antibiotics. Understanding how bacteria gain resistance can enable us to control the spread of resistance. *Pseudomonas aeruginosa* is a bacterium that thrives in environments including in humans where it can be part of the normal flora or an opportunistic pathogen that causes serious infections. *Pseudomonas* infection treatment is challenging because it is naturally resistant to antimicrobial agents and can carry plasmids that confer antibiotic resistance. We focus on the genetic elements in *P.* aeruginosa that contribute to the spread of antimicrobial resistance, particularly broad-host-range plasmids which are transmissible between diverse types of Gram-negative bacteria and serve as vehicles for HGT. We study the distribution and evolutionary relationships of these elements as well as the mechanistic basis of their mobility. Our aim is to prevent or limit the spread of antibiotic resistance and our research could also lead to new molecular biology tools that genetically manipulate bacteria.

### Population dynamics and biocontrol of wastewater foams

Activated sludge processes remove excess nutrients from wastewater prior to release into other water bodies (oceans and/or lakes) but often fail due to microbiological foams. The brown scum surface foam in aeration tanks contains Candididatus '*Microthrix parvicella*' or "Mycolata" bacteria. We apply lytic bacteriophages directly to activated sludge plants to reduce the bacterial cell numbers below the foaming threshold. We have isolated >100 mycolata bacteriophages and have shown that we are able to reduce their growth. We also study bacteriophage interactions to identify their population dynamics.

Patescibacteria, or Candidate Phyla Radiation, are diverse bacteria mostly uncultivated and known as microbial dark matter. Our lab has developed a method to isolate and culture these ultrasmall microbes from wastewater treatment plants. They have reduced genomes and parasitise hots bacteria I.e. *Gordonia amarae.* The mechanism of their growth and cell cycle are largely unknown. We are investigating their lifecylces to understand Patescibacteria's unique biology and aim to control problematic bacterial growth in wastewater treatment plants by manipulating their growth.

**Lab Head:** Assoc Prof Steve Petrovski (steve.petrovski@latrobe.edu.au)

**Lab members:**
Dr Mark Chan; Mr Jayson Rose;
Ms Liana Theodoridis; Ms Mikaela Whitty;
Ms Jessica Owen, Mr Jed Chafer;
Ms Caroline Xavier; Ms Laura Viola.

**Fields of Study:**
Microbiology; Genetics; Microbial Ecology; Evolution; Biosensors.

**Capabilities and Techniques:**
Electron microscopy; Next Generation Sequencing; Microbial assays; Molecular Biology.

**Translational Opportunities:**
Developing potential bacteriophage cocktails to be applied to wastewater treatment plants to control bacterial proliferation that cause foaming and bulking; Developing novel pharmaceutical products containing bacteriophages; Developing Phage biosensors detection tools for use by Australian Defence Force.

# Healthy Brain Ageing & Dementia Research Group

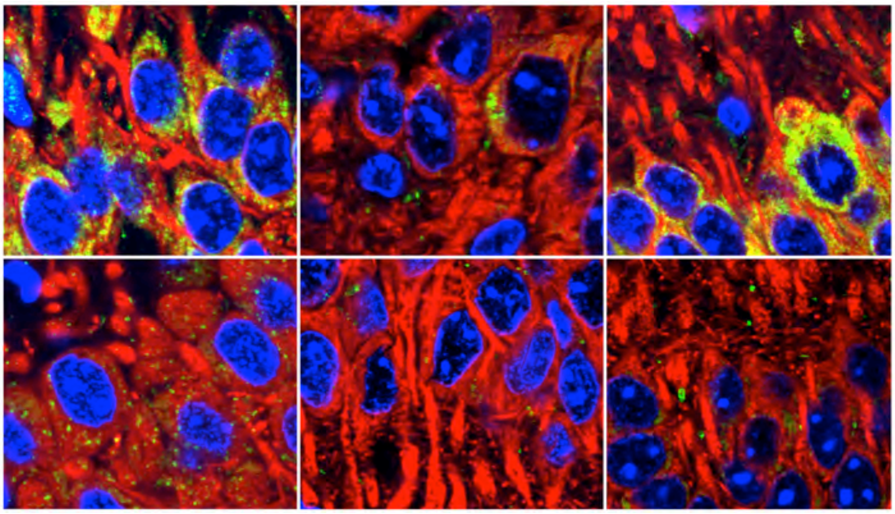
Our group aims to identify the epigenetic and molecular mechanisms involved in the injury process of vascular dementia (VaD) in order to develop new therapies for its treatment. Through our research, we have discovered many potential targets and have utilized a range of pharmacological agents.

### The Hypoxisome in Neuronal Resilience and Cell Death

Our research has uncovered that both hypoxia, which occurs due to oxygen deprivation at the tissue level, and cerebral ischaemia, which results from insufficient blood flow to the brain, activate five signalling pathways that converge on the hypoxisome - a nuclear multi-protein complex that is associated with DNA. The hypoxisome controls genes that dictate the fate of neurons. Our primary focus is toinvestigate the effect of hypoxisome on cell death following ischaemic stroke, specifically in cases of severe injury where the hypoxisome up-regulates proteins that trigger and execute neuronal death programs. Additionally, we are studying the hypoxisome during the post-stroke remodelling phase, where it up-regulates adaptive stress response genes encoding proteins that promote neuronal survival. By understanding the role of the hypoxisome in both detrimental and beneficial post-stroke processes, our research aims to develop new therapeutic strategies for treating ischaemic stroke.

### Uncovering the Mechanisms of Sterile Neuroinflammation in Stroke and Vascular Dementia (VaD)

Neuroinflammation is known to cause neuronal tissue damage, impairments, and disabilities. However, the mechanisms that initiate neuroinflammation in vascular dementia (VaD) remain poorly understood. Our research has revealed that cerebral hypoperfusion activates innate immune receptors, which then trigger signalling cascades that activate protein kinases, leading to an inflammatory response. This activation of intracellular signalling pathways results in an increased production of inflammasomes, which are multi-protein complexes that contribute to tissue injury and cell death. In our animal model of VaD, we have observed that inflammasomes play a critical role in neuronal tissue



Immunofluorescence images of inflammasome activation in the hippocampus in Vascular Dementia (Photo credit: Garrie Arumugam)

damage and behaviour. Specifically, we are investigating how immune receptors recognize self-ligands in neurons undergoing metabolic stress, and activate inflammasomes and caspase-1, ultimately leading to neuronal injury or death. Additionally, our research focuses on how blocking the inflammasome signalling pathways weakens the initiation and amplification of inflammatory cell responses, thereby improving functional outcomes. Our findings provide a novel avenue for the development of potential therapeutic targets for the treatment of VaD .

### Intermittent Metabolic Switching and Epigenetics

Recent studies have revealed that individuals with metabolic diseases have an elevated risk for age-related neurological disorders. Intermittent fasting, a dietary protocol characterised by alternating periods of feeding and fasting, has been shown to mitigate or prevent cellular dysfunction and degeneration in various cardiovascular disease models, including dementia. However, the precise mechanisms by which intermittent fasting modifies the expression of proteins involved in these protective effects remain to be elucidated. Our research demonstrates that intermittent fasting provides protection against both ischaemic stroke and VaD. Previous investigations have shown that epigenetic germline inheritance of diet can lead to obesity and insulin resistance. In our own work, we have observed epigenetic changes in animals following intermittent fasting, which may underlie the beneficial effects seen in a range of disease conditions. We seek to identify specific intermittent fasting-induced epigenetic changes that promote expression of protective genes and ultimately improve outcomes in ischaemic stroke and vascular dementia.

**Lab Head:**Prof Thiruma V. Arumugam (Garrie) (g.arumugam@latrobe.edu.au)
**Lab members:** Dr Irene Cheng; Dr Vernise Lim; Dr Vanessa Johanssen; Ms Nishat Tabassum; Mr Yibo Fan; Mr Xiangyuan Peng; Mr Xiangru Cheng; Ms Aayushi Arora; Mr Marconi Fung; Ms Jyotsnna Ranjithkumar.

**Fields of Study:**
Neurobiology; Pharmacology; Molecular Biology; Epigenetics; Neurodegeneration; Ageing.

**Capabilities and Techniques:**
Ischaemic stroke and vascular dementia animal models; Molecular Biology; RNA sequencing; Genomics; Proteomics; Flow Cytometry; Bioimaging; Cognitive Testing.

**Translational Opportunities:**
Our research on the hypoxisome and inflammasome has revealed novel mechanisms of cell death and potential therapeutic targets for ischaemic stroke and vascular dementia. Our findings hold promise for clinical translation and have already played an instrumental role in initiating three clinical trials for stroke treatment.

# Hypertension and Diabetes Research Group

Cardiometabolic disease claims 40,000 Australian lives per year due to events such as heart attack and stroke. While current medications, which include blood pressure- and cholesterol-lowering agents, reduce the risk of a deadly event in some patients, they are not effective in all cases. Many patients remain at risk of a heart attack or stroke despite receiving best available care. Clearly, there are disease mechanisms at play that current medicines don't address. Our group is focused on identifying what these unknown mechanisms are and using the knowledge to identify new biomarkers for early disease detection and to develop more effective therapies. We use animal and cell culture models of cardiometabolic disease, as well as physiology, immunology, molecular biology, genomic and imaging techniques.

### The NLRP3 Inflammasome and hypertensive end-organ disease

Hypertension (high blood pressure) affects 40% of adults and is the leading risk factor for heart disease and stroke. It also promotes kidney disease, dementia and retinopathy (vision impairment). Drugs that increase urine production, dilate blood vessels and/or reduce heart rate are used to reduce blood pressure; but, over half of all patients still cannot control their blood pressure with these medications. Hypertension also affects the immune system. We discovered that an immune complex called the NLRP3 inflammasome, contributes to the development of hypertension. Knocking out the genes that code for the NLRP3 inflammasome, or its cytokine product interleukin-18 (IL-18), reduces blood pressure, kidney injury and heart failure in mice with hypertension. Our current focus is on developing and screening novel drugs that block IL-18 or its receptor and determining their effectiveness at treating hypertension and its downstream consequences of kidney disease and heart failure

### Deciphering the gut phageome and its role in hypertension

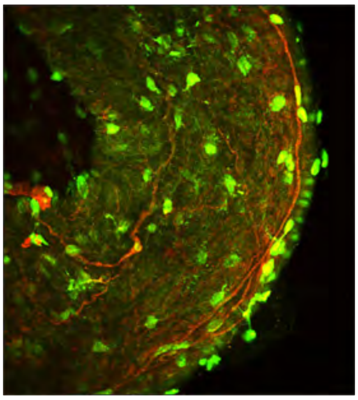
An imbalance in the gut bacterial communities can contribute to hypertension and related end-organ damage. However, an understudied yet vital organism in the gut are phages - viruses that infect and kill bacteria. We have discovered several phages that are highly abundant during experimental hypertension that are known to kill the 'good' bacteria of the gut. These phages may be prime targets for new treatments to improve gut health and high blood pressure.

### Understanding the cellular and molecular drivers of heart attacks

Heart attacks are a major cause of global death and disability. They occur when the coronary arteries – which supply blood to the heart – become blocked by fatty deposits called atherosclerotic plaques. Early detection and therapies that slow or halt their development could prevent blockages. This project will comprehensively explore human atherosclerosis biology using powerful multiomic approaches that include single-nucleus RNA sequencing, spatial transcriptomics, and imaging mass cytometry (through collaborations with the University of Sydney) tools to human coronary artery specimens. This study will likely identify: (1) candidate biomarkers for early detection of atherosclerotic plaques; and (2) crucial disease pathways that could serve as targets for future therapies to halt/ reverse atherosclerotic plaque development.

### Comparing the effects of intermittent fasting and sex in metabolic syndrome

Intermittent fasting is an effective and natural strategy for weight control. It can also reverse metabolic disturbances such as hyperglycemia, hypertension, and unhealthy levels of fat in the bloodstream. Many studies have shown the beneficial effects of intermittent fasting in the setting of metabolic syndrome, but very few studies have considered the effect of sex, which our work will now investigate..



Inflammatory macrophages (green) accumulating in blood vessels from a pre-clinical model of high blood pressure

**Lab Heads:**
Assoc Prof Antony Vinh (a.vinh@latrobe.edu.au) and
Dr Maria Jelinic (m.jelinic@latrobe.edu.au)

**Lab members:**
Dr Courtney Judkins; Dr Hericka Bruna Figueiredo Galvao; Dr Vivian Tran; Ms Flavia Wassef; Ms Buddhila Wickramasinghe; Ms Tayla Gibson Hughes; Mr Jake Robertson; Ms Ghaida Moria; Mr Roberto Iaconis; Mr Patrick Francis; Mr Vinh Nguyen Son Ngo.

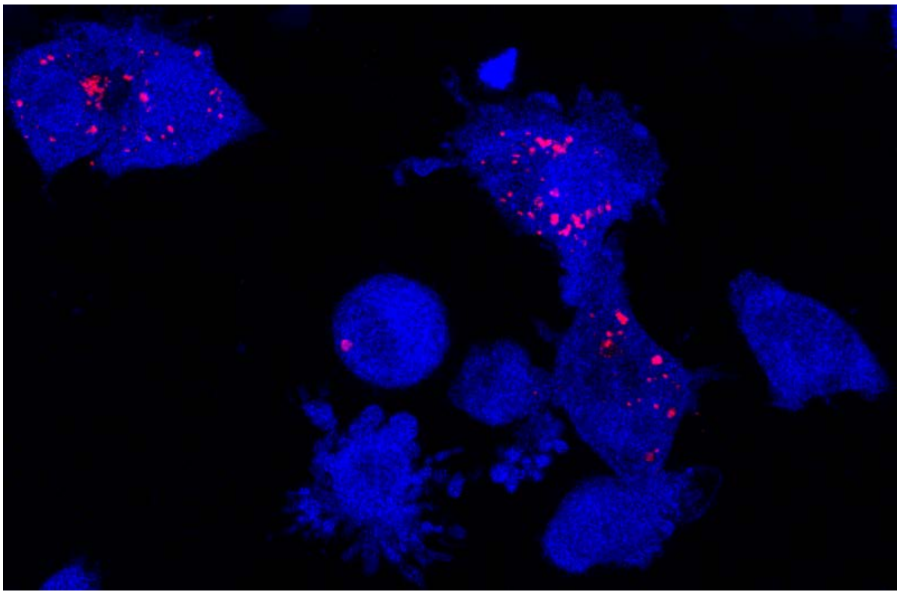
**Fields of Study:**
Hypertension; Diabetes; Obesity; Immunology; Pharmacology

**Capabilities and Techniques:**
Animal models of hypertension, diabetes and obesity; flow cytometry; histopathology; immunohistochemistry; biomedical imaging; confocal microscopy; genomic sequencing; spatial transcriptomics; in vivo cardiovascular/renal function; oxidative stress & inflammation assessment; vascular reactivity/compliance.

**Translational Opportunities:**
Drug discovery, validation; pre-clinical chronic kidney/liver/vascular disease drug assessment; hypertension/diabetes therapy and dietary interventions.v cdf

# Inflammasomes and Innate Immunity Group

Inflammation is the body's defense against injury or infection, but when it becomes excessive or prolonged, it can lead to diseases like autoimmune disorders and chronic conditions. The innate immune system, our first line of defense, triggers inflammation to fight pathogens and heal tissues. Inflammasomes, protein complexes in immune cells, detect harmful stimuli and activate inflammation to protect and repair the body. However, excessive or chronic activation of Toll-like receptors (TLRs) and Inflammasomes can lead to diseases such as neurodegenerative, pulmonary, metabolic, and gastrointestinal diseases, even cancer. Our research focuses on how the innate immune system recognises pathogens, activates immune sensors like Toll-like receptors and inflammasomes, and aims to develop therapies to reduce harmful inflammation and provide relief to patients



Inflammasome activation in macrophages challenged by viral aggregates (red). (Photo credit: Ashley Mansell)

**Inflammasomes and mucosal immunology**
Inflammasomes are crucial in the immune response to bacterial and viral infections. Our group has identified their role in infectious diseases and the benefits of targeting inflammasomes to reduce inflammation in pathogen-related diseases. In collaboration with researchers at the Hudson Institute and UNSW, we are studying inflammasomes in acute and chronic inflammatory diseases using human patient stem cell-derived organoids. We aim to assess the therapeutic potential of NLRP-targeted treatments. These studies will explore inflammasome activation in the pulmonary and intestinal mucosal barriers during chronic inflammation and pathogen-related diseases. Further research will evaluate the effectiveness of targeting inflammasomes to treat these conditions. Additionally, in partnership with the Helbig lab, we are examining the role of inflammasomes in viral infections like Dengue and Zika, and their potential as therapeutic targets to reduce inflammation. Drawing on our previous identification of viral aggregate proteins as a novel class of inflammasome activators, we are also identifying and characterising new viral aggregates that drive the inflammation associated with these viral infections.

**Inflammasome Drug Development**
In conjunction with the Dutton group, we are leveraging our previous characterisation of the world's only dual inflammasome inhibitor, to intelligently design and validate new lead drug candidates with improved drug-like properties to treat the inflammation associated with inflammasome-related diseases.

**TLR Signal Transduction and Immunometabolism**
Immunometabolism describes the interplay between immunological and metabolic processes which are critical to the immediate innate immune response to infection. Dysfunctional metabolism underlies many inflammatory diseases, the identification of key regulators of selective metabolic programs providing the framework for next generation therapeutic agents for function-specific immunometabolic targeting. With colleagues at the Hudson Institute, we identified a role for the critical immune modulator STAT3 in regulating the immunometabolic programming of TLR-activated macrophage mitochondria.

Our studies aim to understand the mechanisms of action of mitochondrial STAT3 and regulation of the Electron Transfer Chain and mitochondrial respiration.

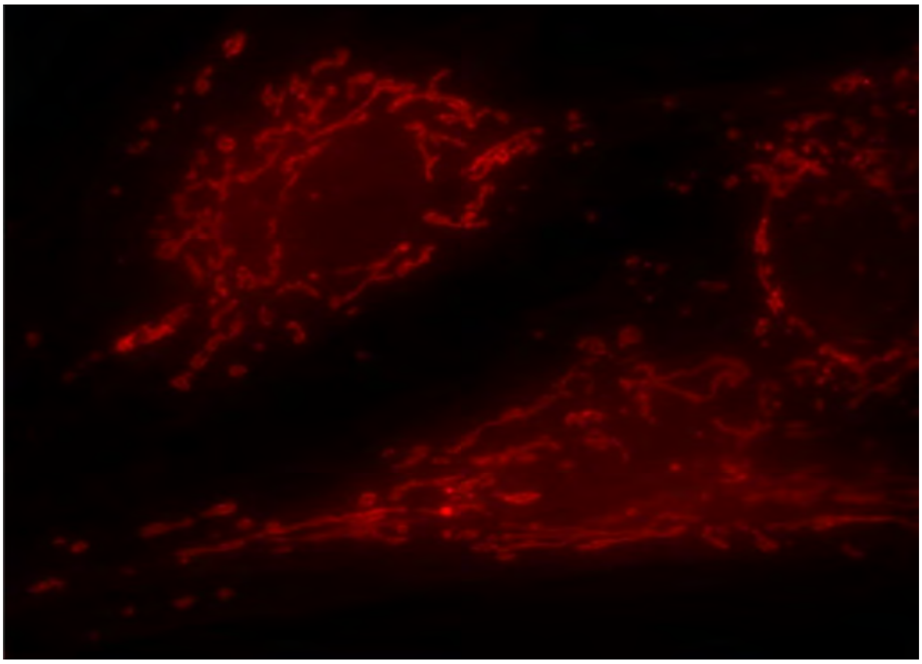
**Lab Head:** Assoc Prof Ashley Mansell (A.Mansell@latrobe.edu.au)
**Lab Members:** Mr Ethan Reidy; Mr Kye Vahland; Mr Cameron McDonald.

**Fields of Study:**
Innate Immunology, Inflammation, Drug Development, Infectious Diseases, Mucosal Immunology.

**Capabilities and Techniques:**
*In vivo* and *in vitro* models of disease, microscopy, live-cell imaging, inflammation screening, drug screening, cell biology.

**Translational Opportunities:**
Inflammasome and TLR drug screening platform, drug development, pre-clinical disease models

# Molecular Cell Biology Laboratory



Fibroblast mito. (Photo Credit: Sarah Annesley)

My laboratory investigates diseases that affect the central nervous system and collectively represent a significant proportion of the burden of disease in adults worldwide. I focus on three main disorders, Parkinson's Disease, Myalgic Encephalomyelitis/ Chronic Fatigue Syndrome (ME/CFS) and Long COVID. My laboratory aims to characterise these disorders, investigating the mechanisms of the disease process at the cellular and molecular level. We aim to discover how these mechanisms can be manipulated for treatment and to identify biomarkers which can be developed into world-first diagnostic tests.

Parkinson's Disease
Parkinson's Disease (PD), is the second most common neurodegenerative disorder worldwide. Most cases of PD are sporadic with no known genetic cause but a small percentage of patients (5-10%) are due to inherited genetic mutations. We use blood cells from patients with sporadic and genetic forms of PD. Our main objectives are to increase our understanding of the underlying disease mechanisms and pathways, identify biomarkers of the disease, identify patients early in the disease process prior to clinical diagnosis and test the effectiveness of various substances. We do this via analysing mitochondrial and lysosomal function, activity levels of proteins, measurement of calcium responses and analysis of gene expression changes.

Myalgic Encephalitis/Chronic Fatigue Syndrome (ME/CFS)
ME/CFS is a debilitating chronic condition characterised by a disabling fatigue and a post-exertional malaise which is a worsening of symptoms after a mental or physical exertion. The disease is triggered by a range of bodily insults, most commonly a viral infection. Currently there is no cure and no clear treatments or diagnostic tests are available. My laboratory is working to unravel the underlying disease mechanisms with a focus on immunometabolism, gut microbiota and immune function.

By understanding the underlying disease mechanisms we aim to develop viable treatment options. We have also identified biomarkers of the disease and are working towards validating these biomarkers in larger and more varied cohorts with the ultimate aim of developing a much needed diagnostic test.

Long Covid
Beyond the immediate acute effects of the virus responsible for the COVID-19 pandemic a large number of people are experiencing ongoing symptoms many weeks and months beyond the original infection. The illness afflicting these patients is termed Long COVID and it shares many similarities with ME/CFS. My laboratory has i dentified biomarkers of Long COVID and are working with a large team of researchers to further validate these in a large cohort. This work aims to develop a multibiomarker panel which will have high diagnostic potential. My laboratory is also investigating the underlying disease mechanisms and the overlap with ME/CFS.

Lab Head: Dr Sarah Annesley
(s.annesley@latrobe.edu.au)

Lab Members:
Dr. Daniel Missailidis; Ms Oana Sanislav; Dr. Claire Allan; Mr Benjamin Arnold; Ms Tina Katsaros; Mr Eric Okrah; Ms Zoe Whitehouse; Ms Kayla Kurt

Fields of Study:
Cell Biology, Metabolism; Molecular Biology; Molecular Genetics.

Capabilities and Techniques:
All techniques of molecular biology; Seahorse respirometry assays; enzyme activity assays; immunofluorescence microscopy; diverse FRET-based; fluorometric and luminometric assays of cellular functions; transcriptomics; proteomics.

Translational Opportunities:
We have identified biomarkers for Long COVID, ME/CFS and Parkinson's Disease and have published these results. We are now working at validating these biomarkers in larger and more varied cohorts. This is the first step in development of world first diagnostic tests for these diseases.

# Musculoskeletal Research Group

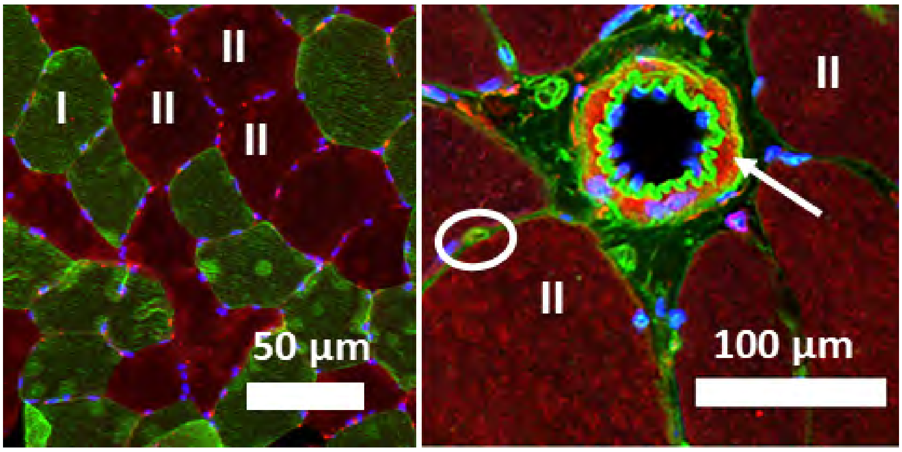
Skeletal muscle tissue (the largest mass in the human body) accounts for 45% of total body weight and is essential for human health adapting in function and metabolism in response to increased physical activity and changes to metabolic demands. Loss of skeletal muscle mass leads to devastating consequences causing permanent disability and mortality in many conditions, including cancer, chronic heart failure, burn injury, kidney disease, diabetes, ageing, disuse, and numerous genetic disorders such as muscular dystrophy. We aim to understand the cellular mechanisms that regulate muscle plasticity and adaptation, so that we can identify new targets or develop treatment options for conditions with compromised skeletal muscle health. We study skeletal muscle adaptation and plasticity via a translational research approach using pre-clinical laboratory models including cell culture and multiple animal models of muscle adaptation and plasticity that are complemented with clinical models of exercise in humans.

### Identifying novel supplements for muscle health

Endurance athletes consume supplements to minimize exercise-induced stress and enhance recovery and performance. Many supplements claim to positively influence exercise induced muscle adaptation but are poorly investigated regarding in vivo activity and efficacy in humans. We aim to understand supplement effects on healthy skeletal muscle function.

### Improving muscle regeneration

Skeletal muscle sports injuries are frequently associated with significant morbidity and prolonged loss of function. After injury, skeletal muscle regeneration has distinct phases: inflammation, degeneration and regeneration. These phase transitions are not fully understood. We use complementary cell culture experiments and muscle injury and regeneration animal models to study new muscle repair improvement therapies.




Fluorescent staining of myosin heavy chain and blood vessel in skeletal muscle (Photo credit: Nicole Stupka)

### Characterizing genetic models of myopathy

Effective treatments for myopathies are difficult to find because the molecular changes underlying clinical phenotypes are poorly understood. Few mammalian models are available to study disease progression from juveniles to adult and finally in elderly mammals. Ageing effects are important for muscle related disorders as age-related changes in normal muscle protein expression, muscle strength and fibre-type composition can impact animal model responses to therapeutic strategies and pre-clinical therapeutic drug testing. We characterize and define age related changes in skeletal muscle phenotype in new muscle pathology models. We characterize new RyR1 myopathy models to test therapeutic strategies and drugs.

Lab Head:
Dr Chris van der Poel
(c.vanderpoel@latrobe.edu.au)

Lab Members:
Dr Travis Dutka; Dr Andy Govus;
Dr Brett Gordon.

Fields of Study:
Skeletal Muscle; Sports Medicine; Cell Physiology.

Capabilities and Techniques:
Muscle injury models (chemical, stretch, and ischaemia-reperfusion); Skeletal muscle contractile function testing (in vitro, in situ); histology; immunohistochemistry; cell culture; biochemistry.

Translational Opportunities:
Muscle strength; Inflammatory Myopathies; Genetic Myopathies; Sarcopenia; Sports Supplements; Skeletal muscle health; Adaptation to exercise.

# Pain and Childbirth Group

There is an urgent need to improve approaches to supporting women through childbirth, to promote normal birth and positive experiences for women.

The pain associated with labour is unique and complex. While typical occurrences of pain tend to be associated with injury or disease, labour pain is different. It arises during a natural process in which it plays a role in driving the hormonal events of labour.

Despite the unique context and function of labour pain – which differentiates it from the pain associated with injury or disease – labour pain is most commonly treated as a pathological pain, associated with suffering. Rates of birth trauma, fear of birth and medical intervention during childbirth are escalating in developed countries, leading to increased exposure to risks and poorer health outcomes for women and babies. Compounding the issue, women exposed to high intervention rates who also perceive intrapartum care to be poor, are more likely to experience acute trauma symptoms.

Dr Laura Whitburn leads an innovative research program to better understand the experience of childbirth based on contemporary pain science and consciousness theories. This work looks at the neurobiological mechanisms behind childbirth and how these influence women's conscious state and perceptions during labour. This includes the role of the nocebo effect, where negative experiences can be elicited through verbal and non-verbal cues.

This aim of this program is to enhance the care provided to women during this transformative event, to improve the health of mothers and their babies and reduce rates of birth trauma.

Persephone's Birth (Photo credit: Jason Lander)

Current projects:

- Labour pain assessment: Evaluating a new woman-centred approach
- The language of labour pain: Understanding how words influence women's experiences of labour pain
- Midwives' views and experiences of supporting women to manage labour pain

Lab Head: Dr Laura Whitburn (l.whitburn@latrob.edu.au)

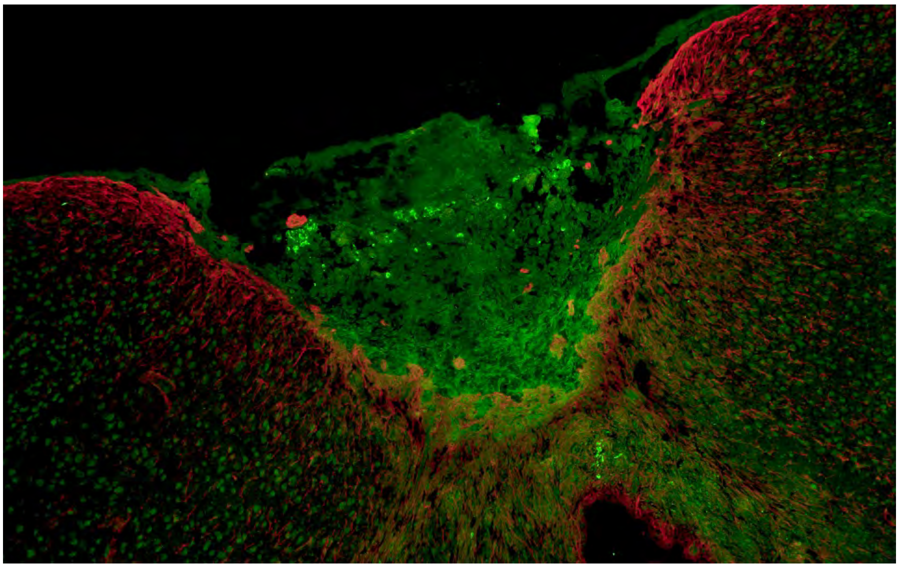
Fields of Study:
Medical and Health Sciences; Midwifery; Physiotherapy; Obstetrics; Gynaecology.

Capabilities and Techniques:
Qualitative research methods, particularly phenomenology; Longitudinal cohort studies.

Translational Opportunities:
The outcomes of this research aim to influence current practices in supporting women in labour, including policy and models of care.

# Stroke and Brain Inflammation Group

Our research group aims to understand the fundamental injury and repair mechanisms which occur during stroke. A stroke triggers a series of damaging events following its onset, including inflammation and systemic infection that lead to cell death and changes in mobility. Our team has introduced routine immunological approaches that are now widely used in this field to tackle inflammation. Our key research focuses on whether immunotherapies – that is therapies which either suppress or activate the body's immune response - can be used to reduce brain inflammation and consequently reduce the burden of stroke. The team has extensive expertise using rodent studies, as well as new approaches to analysing large data sets to identify new relationships in stroke pathology. Our team aims to address gaps in existing research by addressing key risk factors such as advanced age and sex in our work.



Immunofluorescence image of glial scar surrounding the infarct area after stroke (Photo credit: Samoda Rupasinghe)

**Targeting inflammation in stroke**
Stroke, from insufficient blood flow to the brain, is treated by clot-buster drugs or surgical clot removal to restore blood flow. However, these interventions are only suitable for 20% of patients and must be used quickly requiring advanced neuroimaging facilities. Brain cells may rapidly die from lack of oxygen or later from inflammation. We study acute and chronic stroke treatments that target and neutralise local inflammation. We assess brain injury, inflammation, motor function and cognition impairment in animal models of stroke, and examine immunotherapies as a treatment for stroke.

**Amniotic cell therapy in stroke**
We have found that treatment with human amnion epithelial cells (hAECs) is neuroprotective when administered within the acute phase of experimental stroke. That work has been translated into a Phase I clinical trial of hAECs in 8 acute stroke patients. We are also identifying how long after a stroke that hAEC therapy might still be beneficial. We routinely incorporate aged mice of both sexes into our preclinical studies to better simulate the clinical scenario.

**hAEC-derived extracellular vesicles in stroke**
We are extending our work on hAECs by exploring the potential of tiny particles (extracellular vesicles) released by the cells as another attractive stroke therapy. Extracellular vesicles (40-120 nm in size) can act as signalling mediators between cells, and those released by hAECs contain material that supports blood vessel development and tissue healing. We predict that extracellular vesicles from hAECs may be protective after stroke when simply administered intravenously or intranasally. Purified extracellular vesicles are more drug-like than hAECs and can be readily stored and quickly prepared for use.

**Estrogen receptor signalling in stroke**
Clinically, pre-menopausal women have a lower incidence and better outcome after stroke than men and post-menopausal women. Pre-clinical studies have reported a neuroprotective role of estrogen. We have previously found that drugs selectively targeting a novel estrogen receptor (GPER1) can substantially influence stroke outcome in a sex-dependent manner. Using mice deficient in GPER1, our research aims to gain a better understanding of sex difference in outcome after stroke, in terms of brain injury and inflammation. Furthermore, we aim to elucidate the importance of GPER1 of estrogen signalling using a selective antagonist, G-15, and agonist, Tamoxifen.

**Lab Head:** Dr Helena Kim
(h.kim2@latrobe.edu.au)
**Lab members:** Dr Richard Zhang;
Mr Satar Jamal; Mr Tymon van Diemen.

**Fields of Study:**
Stroke; Brain inflammation; Neuroprotection; Cell therapy; Immunotherapy.

**Capabilities and Techniques:**
Ischemic stroke animal models; Animal behavioural testing; Immunofluorescence; Flow cytometry; Molecular biology; RNA sequencing; Genomics; Big data analysis.

**Translational Opportunities:**
Our findings hold promise for clinical translation and have already played an instrumental role in initiating three clinical trials for stroke treatment.

# The Bay Group - Microbial Ecology, Biogeochemistry & Global Change

### Mission
We advance research on the microbial ecology of terrestrial and aquatic ecosystems, tackling global challenges including environmental degradation, food security, and climate change. We mentor future leaders and scientists in an inclusive and collaborative setting that fosters innovation and a deeper understanding of complex systems.

### Biodiversity, Function & Activity
Microbes thrive in diverse and extreme habitats like deserts, salt lakes, caves, and the deep ocean, defying the notion that these environments are too extreme for life to persist. Our research reveals that many bacteria are metabolically flexible, capable of dormancy, and can utilize various organic and inorganic energy sources, including atmospheric trace gases, to survive and grow. Studying these microbes and their diversity, ecology, and function enhances our understanding of how life persists, and biodiversity is maintained in the face of climate risks such as desertification and nutrient depletion.

### Soil Fertility & Environmental Resilience
Soil biomes are complex ecosystems rich in microbial diversity, which play a crucial role in soil productivity. These microbes facilitate nutrient cycling, decompose organic material, and support plant health. By studying the structural and functional aspects of microbial biodiversity in soils, we can gain insights into their contribution to ecosystem services. This understanding can inform strategies to improve soil health, resilience to disturbance and enhance productivity, contributing to sustainable agricultural and environmental practices.

### Atmospheric Change & Global Cycles
Microorganisms are essential in driving global biogeochemical cycles, encompassing carbon and various nutrient cycles. They regulate greenhouse gases like methane, carbon dioxide, and nitrous oxide, which are vital for climate regulation. Our research indicates that soil bacteria are instrumental in cycling these gases through a range of ecosystems. Understanding these microbial processes across different ecosystems and land use types is critical for devising effective climate change mitigation strategies.

### Impact
Our research provides fundamental insights into the biogeochemistry of environmental microbiota. This provides a basis for to enhance environmental stability, food security and mitigate climate change.


Lab Head:
Dr Sean K. Bay (s.bay@latrobe.edu.au)

Lab Members:
M. Nayeli Luis-Vargas (PhD candidate),
Alyza Lynch (MSc Candidate),
Phil Bottomly (B.Hons. Candidate).


Fields of Study:
Environmental Microbiology; Computational Biology; Biogeochemistry;
Microbial Ecology.

Capabilities and Techniques: Bioinformatics, Multi-omics, Gas chromatography, Microbial activity studies, Isotope studies, Nutrient budgets, Soil physicochemistry, GIS.

Translational Opportunities:
Microbial biodiversity of soil and aquatic systems, Atmospheric gas, carbon and nutrient budgets. Monitoring soil fertility and environmental degradation.


Contact:
If you are interested in joining us, collaboration or learning more about our research, please contact us directly on:
E - s.bay@latrobe.edu.au
P – 03 9479 1501

# About La Trobe University

## Our Mission

Advancing knowledge and learning to shape the future of our students and communities.

## Our Vision

To promote positive change and address the major issues of our time through being connected, inclusive and excellent.

## Our Values

Our early reputation as a radical and challenging institution continues to influence the way we enrich the experience of our students and engage with our partners and communities.

We were founded half a century ago to broaden participation in higher education in Melbourne's north and, later, in regional Victoria. We have succeeded for many thousands of students who would otherwise have been excluded from the opportunities provided by a university education.

We continue to support access, diversity and inclusivity while undertaking world-class research that aims to address the global forces shaping our world and make a difference to some of the world's most pressing problems, including climate change, securing food, water and the environment, building healthy communities, and creating a more just and sustainable future.This approach is based on our values of:

- inclusiveness, diversity, equity and social justice
- pursuing excellence and sustainability in everything we do
- championing our local communities in Melbourne's north and regional Victoria
- being willing to innovate and disrupt the traditional way of doing things.

Of all Australian universities, we are the most successful at combining accessibility and excellence, and have become a place where social inclusion and globally-recognised excellence come together for the benefit of our students, our staff and our communities.

Our academics and researchers achieve national and international recognition, our public intellectuals demonstrate an enduring social conscience and influence, and our alumni achieve extraordinary success and impact in government, industry and not for profit organisations.

We strive to be exemplars for the sector in our commitment to gender equity and to inclusivity for marginalised groups; and we work with indigenous peoples and organisations to support their social, cultural and economic aspirations.

We embrace sustainable practices across all our campuses because we are committed to improving environmental, social and economic outcomes for our communities.

We contribute to economic development for our local communities, and our future activity will increasingly be international as we become a globally connected university in everything we do.

## Our Culture

### La Trobe Cultural Qualities

Our cultural qualities underpin everything we do. As we work towards realising the strategic goals of the University we strive to work in a way which is aligned to our four cultural qualities:

**Connected**

- We are Connected: Connecting the students and communities we serve to the world outside

**Innovative**

- We are Innovative: Tackling the big issues of our time to transform the lives of our students and society

**Accountable**

- We are Accountable: Striving for excellence in everything we do. Holding each other to account, and working the highest standards

**Care**

- We Care: We care about what we do and why we do it, because we believe in the power of education and research to transform lives and global society.

# About
# Victoria and Melbourne

## Experience Melbourne

Melbourne is the capital of the state of Victoria, and Australia's second largest city. It's a multicultural hub with 4.5 million people from over 153 countries. It's one of the world's best sporting cities, and is Australia's art and culture capital. Melbourne is a safe, well-serviced city in which to live. The main campus of the University at Bundoora is close to many world class hospitals, schools, research centres, shopping centres, bike paths and parklands. Melbournians enjoy, affordable healthcare, world-class education, reliable infrastructure, business opportunities and a healthy environment. In Melbourne you'll find just about every cuisine: French, Italian, Spanish, Greek, Chinese, Malaysian, Indian, Thai, Japanese, Moroccan and lots more. Melbourne has over 100 art galleries as well as theatres, international and local opera, ballet, comedy and live music.

Each year Melbourne hosts major international sporting events like the Australian Open Grand Slam tennis tournament, the Formula One Grand Prix, the Rip Curl Pro surfing championship, the Australian Masters golf tournament, the Melbourne Cup and the Grand Final of Australian Rules Football. As well as over 2500 festivals and events including the Melbourne International Arts Festival, Melbourne International Film Festival, Melbourne International Comedy Festival and the Melbourne Spring Racing Carnival.

Find out more: https://liveinmelbourne.vic.gov.au/discover

## Victoria: The Garden State

Victoria has many notable gardens and 36 national parks covering two and a half million hectares. Victoria's many attractions include the Great Ocean Road, (stunning coastal views and the world-famous Twelve Apostles), the Grampians and the High Country.

Find out more visitvictoria.com

## La Trobe University Campuses in Australia

Each of our seven campuses (Melbourne, Albury-Wodonga, City, Bendigo, Shepparton, Midura and Sydney) is a unique expression of place, people and history that play an important role in social, cultural and economic life. We are located in Victoria's major regional cities, creating a unique network of research, industry and innovation expertise that can be accessed across the state.


## Melbourne Campus

La Trobe's Melbourne Campus has 27,000+ students and is surrounded by bushland. Students from across the world take advantage of state-of-the-art facilities, including our AgriBio Research Centre, the La Trobe Institute for Molecular Science and our very own Wildlife Sanctuary.

## Albury-Wodonga Campus

La Trobe's Albury-Wodonga Campus has 800+ students and is home to our leading regional research centre, the Centre for Freshwater Ecosystems which focuses on water science and policy of the Murray-Darling basin. Here, undergraduate students work alongside Honours and research students on local issues.

INDEX

# Baker Cardiovascular Research Translation and Implementation

# Biochemistry & Chemistry

# Ecological, Plant and Animal Sciences

# Ecological, Plant and Animal Sciences (continued)

# Microbiology, Anatomy, Physiology and Pharmacology

School of Agriculture,
Biomedicine and
Environment,
La Trobe University,
Corner Plenty Road and
Kingsbury Drive,
Bundoora, Victoria, 3086
Australia