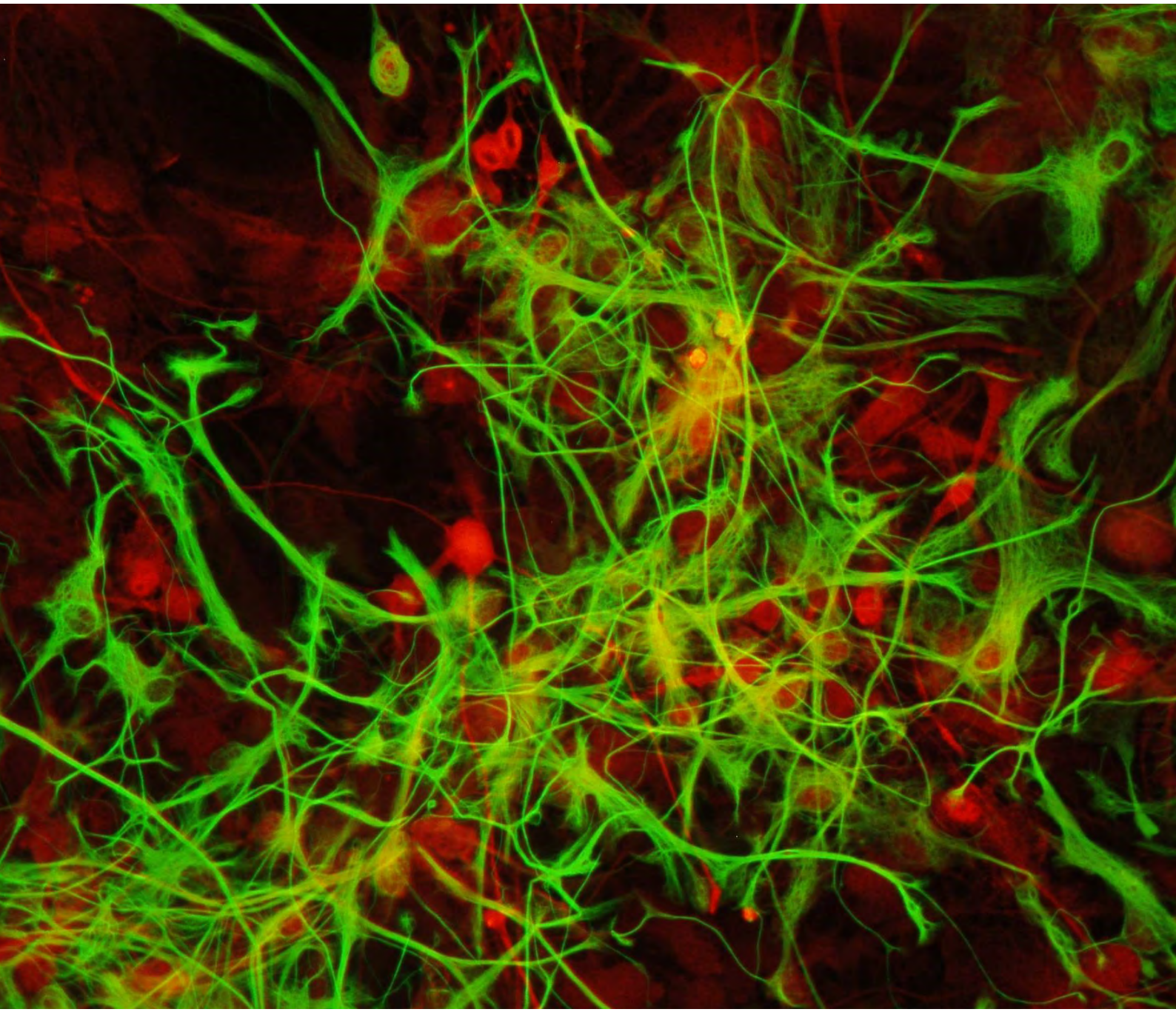
LA TROBE
UNIVERSITY • AUSTRALIA

School of Agriculture, Biomedicine and Environment

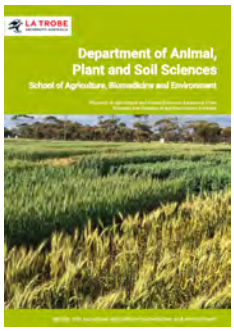
Scientists working across animal, plant and soil science, biochemistry and chemistry, ecology, environment and evolution as well as physiology, anatomy and microbiology.



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

School of Agriculture, Biomedicine and Environment

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



Department of Animal, Plant and Soil Sciences

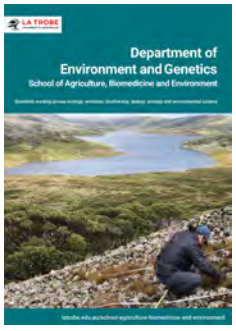
Research in Agricultural and Animal Sciences, Agronomy, Plant Sciences and Genetics at AgriBiosciences Australia
pp. 3-25

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. 26-67

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. 68-85



Department of Environment and Genetics

Scientists working across ecology, evolution, biodiversity, botany, zoology and environmental science
pp. 86-114

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. 115-140

About the School of Agriculture, Biomedicine and Environment

The School of Agriculture, Biomedicine and Environment is one of the largest at La Trobe University, with more than 170 continuing and fixed term staff across multiple campuses. Over the last three years 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 270 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 School is a major contributor to research strengths in both the Biological and Agricultural Sciences, achieving the highest possible rating '5 - well above world standing' from the Australian Research Council in the fields of Ecology, Zoology, Plant Biology, Physiology, Microbiology, Biochemistry and Cell Biology, Crop and Pasture Production, Genetics, Soil Science, and Veterinary Science, and rated as '4 - above world standing' in Ecological Applications.

The 5 departments in the School are:

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

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

- La Trobe Institute of Sustainable Agriculture and Food (LISAF)
- ARC ITRH (Industry Transformation Research Hub) for Medicinal Agriculture
- ARC CoE (Centre of Excellence) in Plants for Space
- 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 Molecular Cancer Prevention
- La Trobe Institute for Molecular Science
- Research Centre for Future Landscapes (collaboration with the Arthur Rylah Institute of DELWP)
- Centre for Freshwater Ecosystems (formerly the Murray-Darling Freshwater Research Centre)
- Research Centre for Applied Alpine Ecology

- Mallee Regional Innovation Centre (MRIC)(a joint venture with The University of Melbourne)

Professor Shaun Collin
Dean, School of Agriculture, Biomedicine and Environment, Co-Director of AgriBio

Department of Animal, Plant and Soil Sciences

School of Agriculture, Biomedicine and Environment

Research in Agricultural and Animal Sciences, Agronomy, Plant Sciences and Genetics at AgriBiosciences Australia

Crops (Photo Credit: James Hunt)

Contents

Department of Animal, Plant and Soil Sciences

The Department of Animal, Plant and Soil Sciences consists of 17 continuing and fixed-term academic staff, an ARC DECRA Fellow approximately 20 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 (https://www.latrobe.edu.au/research-infrastructure/research-facilities/genomics-platform).

The Department has a dynamic higher degree by research program that reflects the disciplinary interests of the staff. We are currently training 34 PhD students and typically host an additional 10-15 MSC and Honours (4th year Research) students from Australia and overseas.

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.

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 Plant Biology, Soil Sciences, Animal Production, Crop and Pasture Production, and Veterinary Sciences and also contributes to similar ''well above world standard' ratings in the areas of Biochemistry and Cell Biology.

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

The Department maintains a diverse portfolio of research programs encompassing the full range from fundamental to highly applied, with particular strengths in plant biology, plant energy metabolism, cell wall biology, medicinal agriculture, soil science agronomy, and animal immunology, health and disease (https://www.latrobe.edu.au/animal-plant-and-soil-sciences).

Members of the Department are also key contributors to La Trobe's new 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*, and *Resilient Environments and Communities*'.

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

- La Trobe Institute for Sustainable Agriculture and Food
- ARC Industrial Transformation Research Hub for Medicinal Agriculture
- ARC Centre of Excellence in Plants for Space

Department of Animal, Plant and Soil Sciences Research Centres

ARC Industrial Transformation Research Hub for Medicinal Agriculture

The ARC MedAg Hub is the first of its kind in Australia. The $24+ million initiative, supported by Australian government, industry and university funds, aims to transform the production of high quality, plant derived therapeutics into an integrated, Australia-wide industry that spans primary producers and manufacturers.

Based at La Trobe University's Melbourne Campus, the ARC MedAg Hub is the first of several initiatives arising from the $50 million commitment to the La Trobe Institute for Agriculture and Food (LIAF) a state-of-theart research and education training institute which holds a central position in the university's research and innovation precinct.

The ARC MedAg Hub comprises agricultural and biomedical researchers along with existing and new industry partners. In the collaboration with industry, this multi-disciplinary research hub addresses cultivation, germplasm generation, novel extraction technologies and chemistries, through to the discovery and functional characterisation of novel lead compounds metabolites (cannabinoids and terpenes) and peptides.

By bringing together exceptional research capabilities and industry expertise, the resulting knowledge from the ARC MedAg Hub will be applicable across related industries, drive better health outcomes through leading innovation in medicinal agriculture and build the specialised workforce needed to underpin Australia's developing medicinal agriculture industry.

Theme 1:
Improving the profitability and sustainability for primary producers.

Theme Leaders:
Associate Professor Monika Doblin;
Associate Professor Mat Lewsey;
Associate Professor Tony Gendall.

Program 1.
Enhanced agronomy for production.

Program 2.
Improving indoor cultivation practices.

Program 3.
Improving medical plant varieties.

Cannabis

Theme 2:
Adding value for pharmaceutical manufacturers and end-users.

Theme Leaders:
Professor Travis Beddoe;
Professor Jim Whelan;
Professor Marilyn Anderson.

Program 1.
Develop novel extraction and synthesis technologies.

Program 2.
Bioprospecting of novel plant-derived proteins/peptides/compounds.

Program 3.
Novel non-invasive high throughput analysis, measurements and monitoring technologies.

Director:
Professor Tony Bacic, FAA

Research Director:
Professor Jim Whelan, FAA

Co Deputy Directors:
Associate Professor Monika Doblin and Associate Professor Mat Lewsey

Senior Director:
Dr Veronica Borrett

15+ Post-docs
4 Administration staff
20+ Research students
10+ Research assistants

Email: medaghub@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: Dr Kim Johnson (k.johnson@latrobe.edu.au) and Professor Mat Lewsey (m.lewsey@latrobe.edu.au)

La Trobe Institute for Sustainable Agriculture and Food

The La Trobe Institute for Sustainable Agriculture and Food (LISAF) has been established with the expertise and financial backing to apply world-class research to meet global food challenges in coming decades.

La Trobe is making further investment in agri-food to drive sector growth, improve health outcomes and commercialise new food products.

Our goal is to find solutions that enable sustainable agriculture that will provide food of the quality and quantity to meet global food challenges in coming decades.

Provide sustainable food production to generate enduring profitability for growers and deliver real benefits for the community and economy.

We work with industry and research partners to cultivate new ideas and find ways to add value to existing products.

We have established partnerships with world renowned researchers, growers, health and nutrition specialists, and leading national and international food producers to enable the research underpinning higher yielding and more nutritious farm produce.

LISAF innovations are aimed to provide impact across all elements of the value chain, and are also underpinned by expertise in agrifood business, supply chains, provenance and agrifood tech.

Greenhouse at the AgriBio Building

Capabilities:

- 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

Director: Professor Tony Bacic, FAA.

Research Director:
Associate Professor Monika Doblin.
Senior Director: Dr Veronica Borrett.

Domain 1
Farming Systems, Soil Science and Agronomy.
Leader: Professor Caixian Tang.

Domain 2
Protected Cropping.
Leader: Professor Tony Bacic.

Domain 3
Fit for Purpose Seeds.
Leader: Professor Mat Lewsey.

Domain 4
Food, Nutrition & Health.
Leader:
Associate Professor Monika Doblin.

Domain 5
Food Business and Food Security.
Leaders: Professor Aron O'Cass (Dean La Trobe Business School) and Professor Wei Xiang (Cisco Chair of AI and Internet of Things, Dept of Mathematics and Engineering).

Email: lisaf@latrobe.edu.au

Department of Animal, Plant and Soil Sciences 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, themost 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

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.

Key projects:

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.

Photo credit: James Hunt

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 Heads:
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.

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.

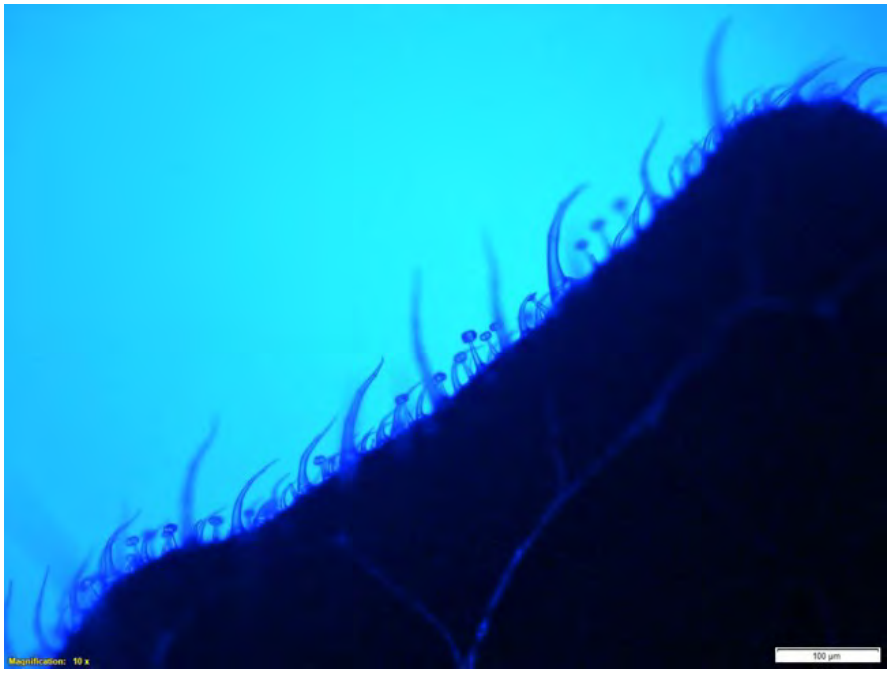
Genome Regulation Lab

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: Associate Professor 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.

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.

Left: chickpea plant with nodules.

Right: cowpea plant roots with nodules.

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

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.

LabHead:
Associate Professor Penelope Smith (psmith3@latrobe.edu.au) and Dr Dugald Reid (dugald.reid@latrobe.edu.au)

Lab Members: 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.

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.

Neuroecology Group

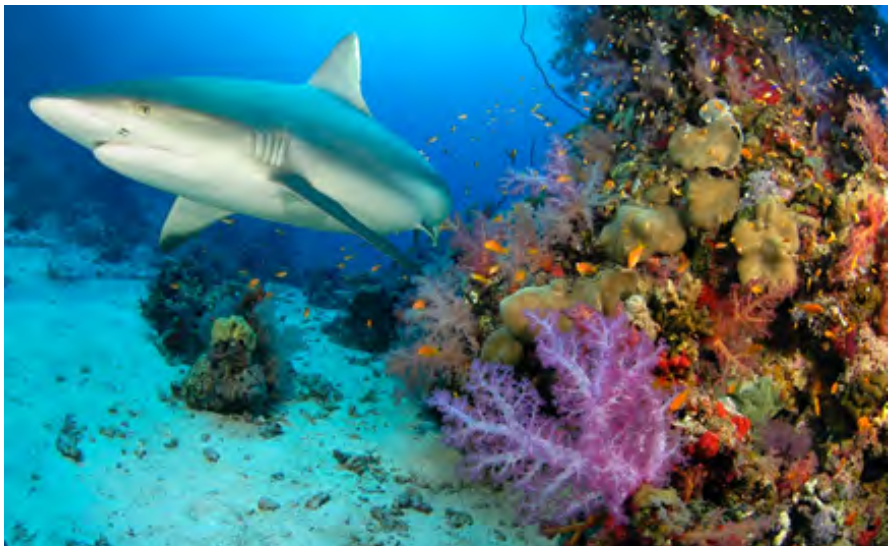
Neuroecology bridges the gap between our knowledge of the neural bases of behaviour in the context of an animal's habitat and ecology. Our collaborative research involves local, national and international partners using neurobiological techniques (molecular genetics, bioimaging, electrophysiology, anatomy 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.

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 (e.g. manta rays and white sharks) 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.



Grey reef shark at home reef (Photo credit: istock/strmko)

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 approaches to improving aquaculture and fisheries management

We study aquacultural feeding behaviour (visual, olfactory, and gustatory), to reduce stress and improve growth rates and artificial food uptake. We also advise on sensory pollution reduction for captive animals in aquaculture and public aquaria.

Brains frozen in time: vertebrate neural adaptations to invading land

The focus is on early vertebrate brain morphology to uncover the functional and phylogenetic significance of new changes, their timing and environmental context using 3D-preserved fossil fish and tetrapod skull materials significant to transition.

Lab Head: Prof Shaun Collin (s.collin@latrobe.edu.au)
Lab members: Ms Caroline Kerr; Dr Jenna Crowe-Riddell; Ms Hope Robins; Ms Paola Talarico, Mr Myoung Hoon Ha.

Fields of Study:
Neurobiology; Behaviour; Ecology; Evolution; Development.

Capabilities and Techniques:
Electron microscopy (scanning and transmission); Electrophysiology; MRI; micro Computed Tomography (µCT); Behavioural testing; Molecular Biology.

Translational Opportunities:
Shark mitigation; Aquaculture stress/ welfare; Mine de-watering effects on local freshwater fauna; species conservation; environmental and sensory pollution; biomimetics; climate change and animal behaviour effects; deep-sea exploration; the blue economy.

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)

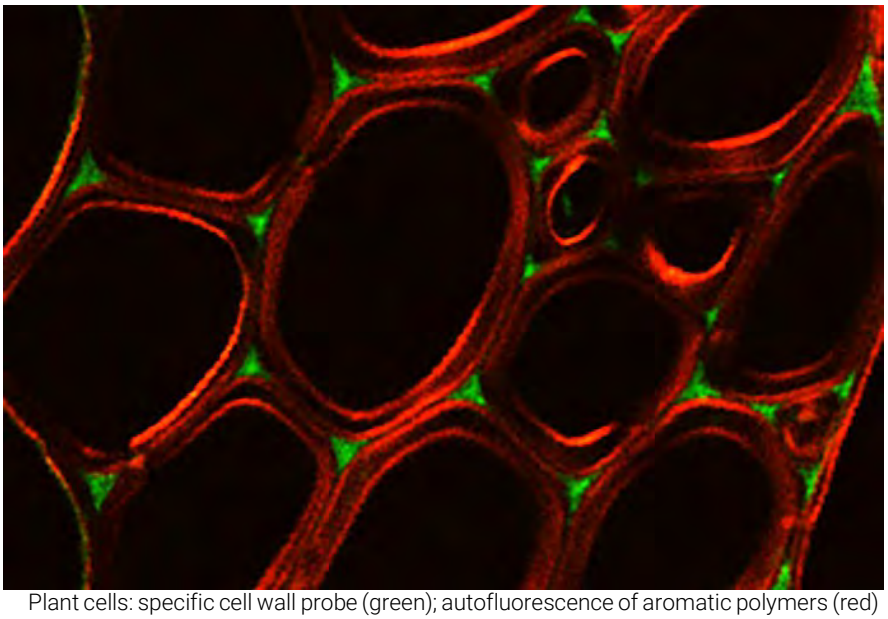
Most plant biomass consists of a carbohydrate-rich matrix present in cell walls. Cell walls, a major carbon sink, are our most renewable bio-resource and determine the products (food, fibre and fuel). Primary cell wall components are a key source of soluble fibre products. Secondary cell walls are the 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, A/Prof Monika Doblin (m.doblin@latrobe.edu.au), Dr Kim Johnson and Dr Wei Zeng (Zhejiang A&F 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; 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

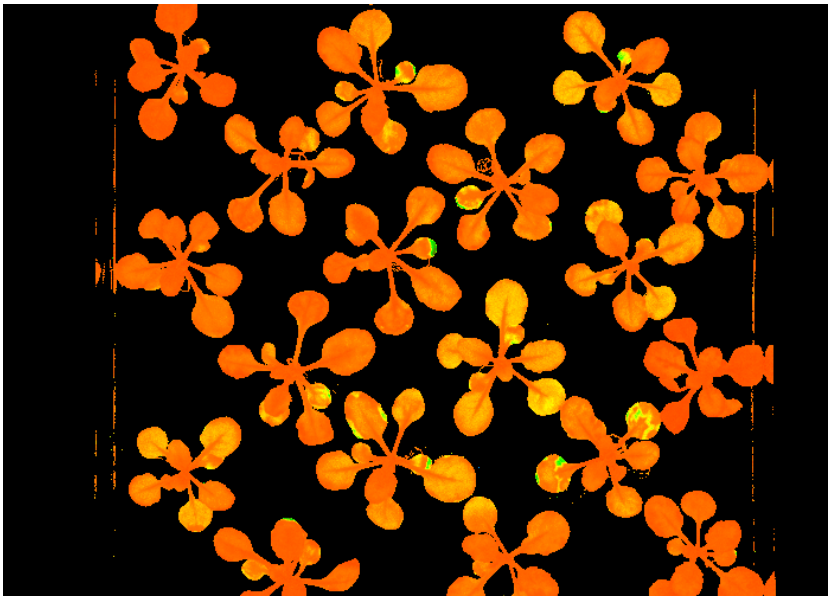
A major area of interest in the lab is the regulation of ion homeostasis by a family of intracellular Na+/H+ antiporters in the model plant *Arabidopsis*. Overexpression of many of these family members leads to increased salt tolerance, but the mechanisms for this resistance is poorly understood.

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.

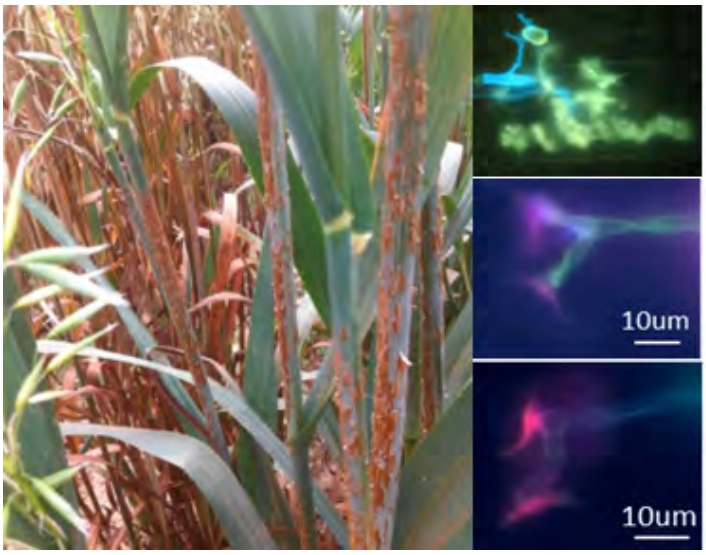
Capabilities and Techniques:
Confocal microscopy; in vitro plant analysis; plant genetics.

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.



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)

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.

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 Reproductive Development Group

The laboratory is located in AgriBio and has access to state-of-the-art facilities including growth rooms, environmentally controlled glasshouses, PC2 laboratories, cold rooms, confocal and light microscopy etc.
The two major areas of research include the characterisation of the genetic mechanisms/pathways regulating development of the seed coat and of the anther.

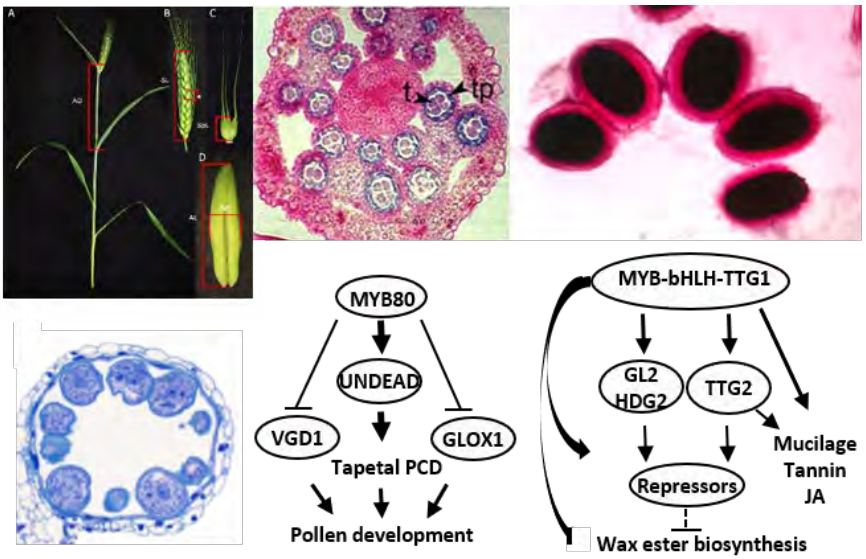
Heat stress and anther development

Wheat

Many self-pollinating crops such as wheat are especially sensitive to abiotic stresses at the reproductive stage. Abiotic stress at the time of meiosis results in pollen sterility and consequently a sever reduction in grain number (i.e. yield). Heat is a key abiotic stress and its effect on grain yield is as important as drought and frost. In order to study the effects of heat on anther and pollen development in wheat we established an accurate and efficient method to determine the various anther developmental stages (Browne et al., 2018). Fifteen developmental stages were identified and described. We have compared the effects of heat on pollen development in heat tolerant and heat sensitive wheat lines. RNAseq analysis has identified genes whose expression levels are severely reduced by heat in the heat sensitive but not the heat tolerant anthers. These genes are involved in various processes essential for normal pollen development (e.g. hormone synthesis, PCD) and should provide wheat breeders with markers.

Arabidopsis thaliana

We identified a key transcription factor gene MYB80, which plays a critical role in tapetal and pollen development. We identified many genes that are directly activated or repressed by MYB80, including UNDEAD and UNDEAD-like genes coding for aspartic proteases, and GLOX genes coding for gloxal oxidases. We are studying the roles of UNDEAD and UNDEAD-like genes in tapetal development and identifying genes which may confer heat stress tolerance.



Wheat ears; anther X; pollen grains; major gene pathways; heat stressed pollen grains

Hybrid seed production technology

Food security is becoming a major global challenge as a consequence of climate change. The key in producing hybrid seeds is to prevent self-fertilization of female plants by creating male sterility in these plants, which can then be easily reversed to produce seeds. We are developing a novel inducible male fertility system for hybrid seed production.

Seed coat development in *Arabidopsis*

The seed coat provides a protective layer for the embryo and also contributes to seed dormancy, dispersal and germination. The *Arabidopsis* seed coat produces large amounts of pectinaceous mucilage (mostly pectin) and proanthocyanidin (PA). Seed coat cells undergo programmed cell death (PCD) during the later stages of seed maturation. Pectin biosynthesis in the *Arabidopsis* seed coat provides a powerful system to study the synthesis of the cell wall. We have shown that a transcription factor complex (MYB-bHLH-TTG1) regulates mucilage and PA biosynthesis via multiple tiers of transcription factors and also regulates seed coat programmed cell death. We are working on the TTG1 target genes in mucilage biosynthesis and the genes regulating seed coat PCD.

Lab Heads:

Professor Roger Parish, (r.parish@latrobe.edu.au) Dr Song Li

Fields of Study:

Cell and Molecular Biology; Plant Development; Plant Breeding; Plant Biotechnology.

Capabilities and Techniques:

RNA-seq; chromatin immunoprecipitation; qRT-PCR; TUNEL assay for PCD; confocal microscopy; scanning electron microscopy; analysis of T-DNA insertion mutants; promoter-reporter constructs; and plant transformation.

Translational Opportunities:

Development of heat tolerant crops and hybrid varieties; Improvement of seed quality.

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 work with 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 reintroduction. Our research focuses on maternal mate choice to improve both conception rates and offspring fitness in captive breeding programs. We also assess predator recognition, behavioural, personality and cognitive traits linked to survival success post release. Candidates for release are often chosen based on age, sex and health status, however, individual behavioural type also relates to fitness and survival success. Wildlife behavioural trait studies used to assess suitability for captivity are less used for release selection. Personality trait studies within and between animal populations are often not applied to reintroduction programs. To be effective insurance and source populations, captive threatened species populations must retain essential survivalbehaviours.

Lab Head: Dr Kylie Robert
(k.robert@latrobe.edu.au)

Lab Members:
Dr Amy Edwards; Dr Stephen Griffiths;
Ms Danielle Eastick; Ms Lauren Tworkowski;
Ms Alicia Dimovski; Ms Emily Scicluna;
Ms Kelly Wiliams; Ms Candice Sexton;
Ms Kushini Kularatne.

Fields of Study:
Animal Behaviour; Conservation; Ecology; Anthropogenic disturbance; Reproduction.

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

Sleep Ecophysiology Group

Sleep is something we all do. We are asleep 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 it's 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 inactive for long periods of time is less obvious. Our group studies sleep behaviour and neurophysiology in animals, including mammals, reptiles, 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 in birds; (iv) effects of human 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, including foraging and caching in birds, and the maintenance of structurally complex and cognitively demanding structures (bowers) in bowerbirds.

Disruptive effects of pollution on sleep

Globally, humans have modified natural landscapes to contain sleep-disturbing pollution (e.g. artificial lights and urban noise). 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)
Lab Members: Miss Shauni Omond; Miss Erika Zaid, Miss Sophia Lee.

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

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.

(Photo credit: Caixian Tang)

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. We also study soil properties effects on the long-term degradation of insecticide 'dieldrin' in pasture soils.

Management of soil constraints

Subsoil acidity and sodicity limit crop production in Australia, and are costly and often impractical to fix. We have 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; Ms Yunyun Zheng; Ms Zahra Latifi; Ms Rachel Davis; Mr Dominic Lauricella.

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.

Wildlife Endocrinology Lab

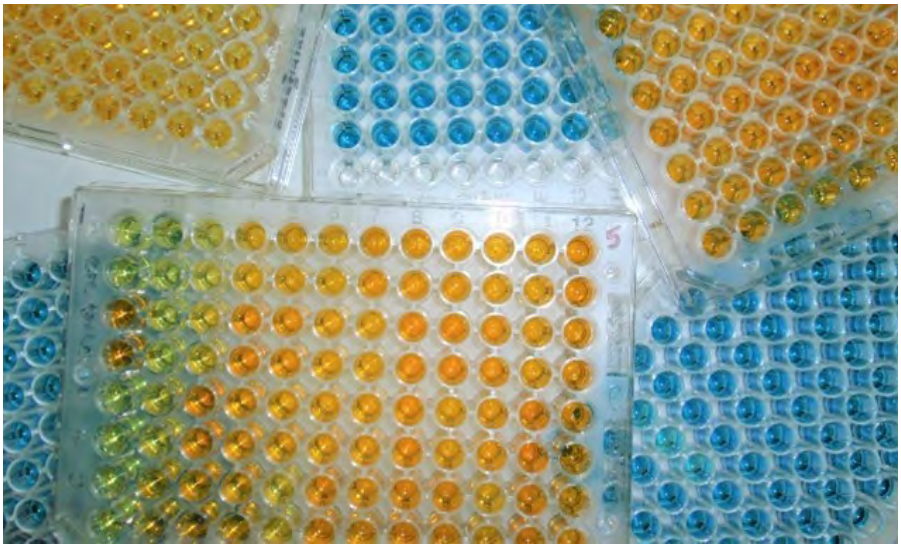
The Wildlife Endocrinology Laboratory examines the complex interactions between stress and reproduction in a wide range of species. Our research lies at the interface of endocrinology, reproductive physiology, animal behaviour, conservation, and animal welfare. We are international leaders in the field of non-invasive hormone monitoring, and the only lab in Victoria to specialize in this technique. Using a multi-disciplinary approach, our group aims to develop a broad understanding of hormone function, including steroid biosynthesis, receptor dynamics, and gene expression. We have a strong partnership with Zoos Victoria, and we also work with conservation biologists, ecologists, and medical researchers.

Stress and reproductive function

Everyone is familiar with the notion that stress suppresses reproduction, but we still have a poor understanding of the underlying physiological mechanisms. 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.

Individual variation in stress coping styles

Individual animals vary widely in how they respond to stressful events. Until recently, biological research has focused on averages ("the golden mean"). However, the variation around the mean is just as interesting, if not more so. Our lab is interested in the ecological and evolutionary implications of different types of stress coping styles. We are particularly interested in how this individual variation impacts conservation biology, such as animal reintroductions and captive breeding programs.



Enzyme immunoassays (Photo credit: Kerry Fanson)

Anthropogenic impacts

Humans have dramatically altered the global landscape, and it is important to understand the impacts that our actions have on other species. Our group tackles this question from a variety of different angles. Examples of questions we are interested in include: How do zoo visitors affect animal welfare and behaviour? How does artificial light at night affect animal physiology? How do pollutants affect endocrine signalling and reproductive function?

Lab Head: Dr Kerry V. Fanson (k.fanson@latrobe.edu.au)

Lab members:
Ms Hannah Roberts; Mr Zachary Di Pastena; Ms Kayla Davis; Ms Lauren Sandy.

Fields of Study:
Endocrinology; Reproduction; Ecology; Conservation; Welfare.

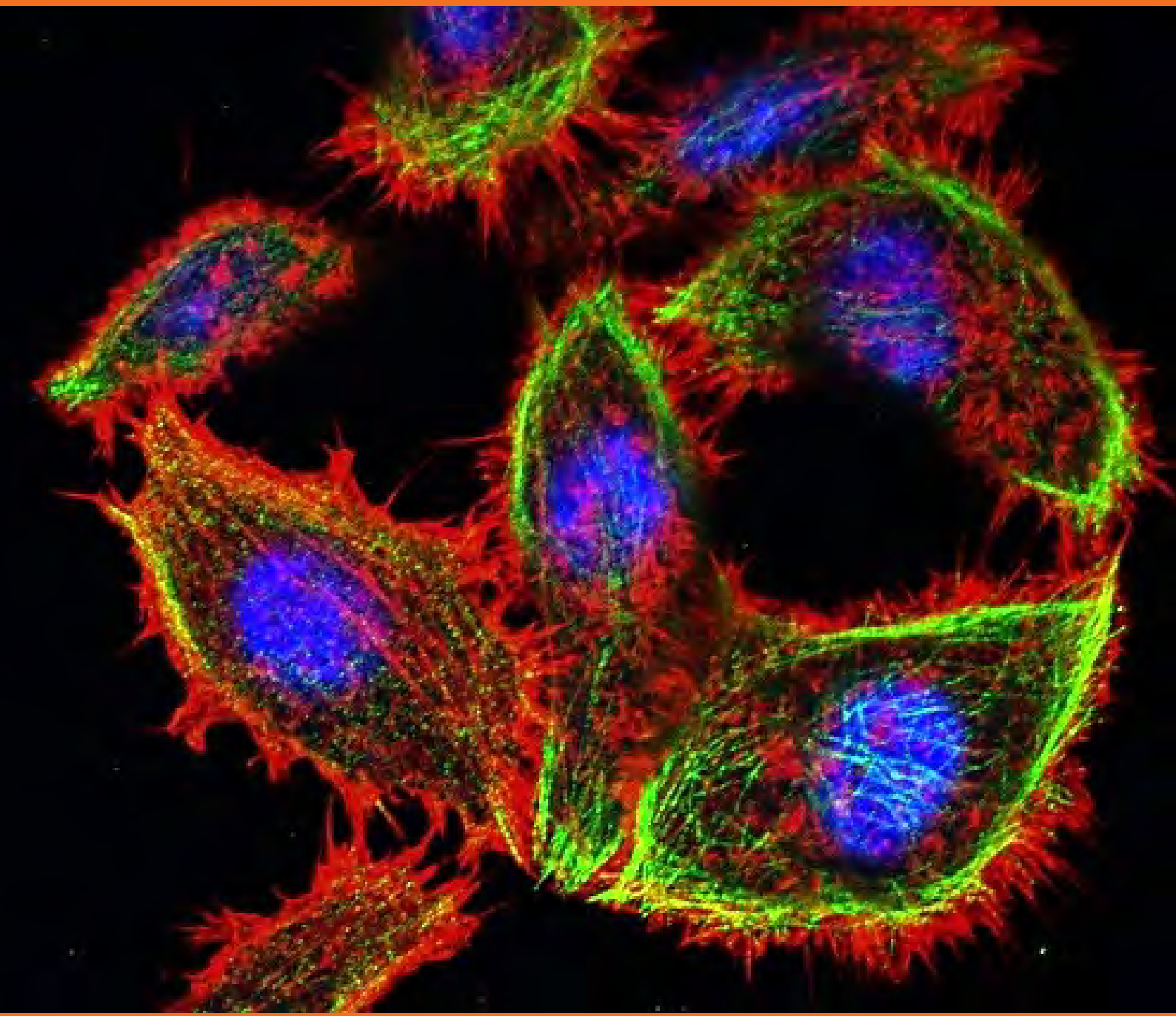
Capabilities and Techniques:
Non-invasive hormone monitoring; enzyme-immunoassays; behaviour assessments; histology; immunohistochemistry; GC-MS; qPCR.

Translational Opportunities: Understanding infertility in humans and animals and identifying potential treatments; conservation; captive breeding programs; improved assessment of animal welfare; anthropogenic effects on wildlife.

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



Immunofluorescence of the cytoskeletal network in human PC3 prostate cancer cells (Photo credit: Guneet Bindra)

Contents

Department of Biochemistry and Chemistry

The Department of Biochemistry and Chemistry is the largest academic department in the School of Agriculture, Biomedicine and Environment at La Trobe University. The Department consists of more than 75 continuing and fixed-term academic staff, including two NHMRC Senior Research Fellows, two ARC Future Fellows, two ARC DECRA Fellows, one Victorian Cancer Agency Research Fellow, and one Tracey Banivanua Mar Fellow. Professor Mark Hulett serves the role of Head of Department.

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, our department has several embedded biotech companies including Hexima Limited, Adalta Limited, and Immunexus. 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, and cardiovascular disease. 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)
- Research Centre for Molecular Cancer Prevention

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

Department of Biochemistry and Chemistry Research Centres

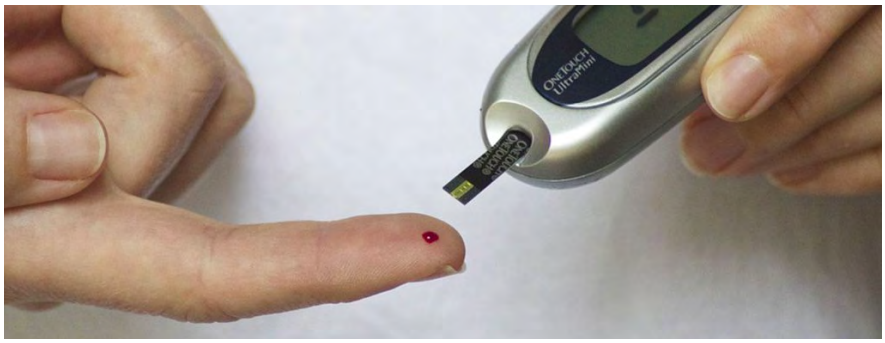
Biomedical and Environment Sensor Technology (BEST) Research Centre

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:
Professor Conor Hogan
(c.hogan@latrobe.edu.au)

Strategic Partners:
Advanced Molecular Technologies; Metrohm AG; MiniFab Pty Ltd; Universal Biosensors.

La Trobe Institute for Molecular Science

The La Trobe Institute for Molecular Science (LIMS) brings together La Trobe University's leading researchers to work on some of the most critical problems facing our world today. The research agenda of LIMS is supported by a state of-the-art facility where scientists in different disciplines work together in well equipped, shared work-spaces to achieve outcomes that would not be possible in traditional academic settings. The Institute's vision is achieved through excellence in four thematic areas of research strength: Cancer, Infection and Immunity, Molecular Design and Nanoscience.

Cancer

The Cancer theme investigates the mechanisms of cancer initiation and progression, the crosstalk between cancer cells and the surrounding environment, and the potential of novel therapeutic approaches for combating disease.

Infection and Immunity

The Infection and Immunity theme studies the molecules used by viruses, bacteria, parasites and fungi to infect humans, animals and plants, and the immune response associated with this.

Molecular Design

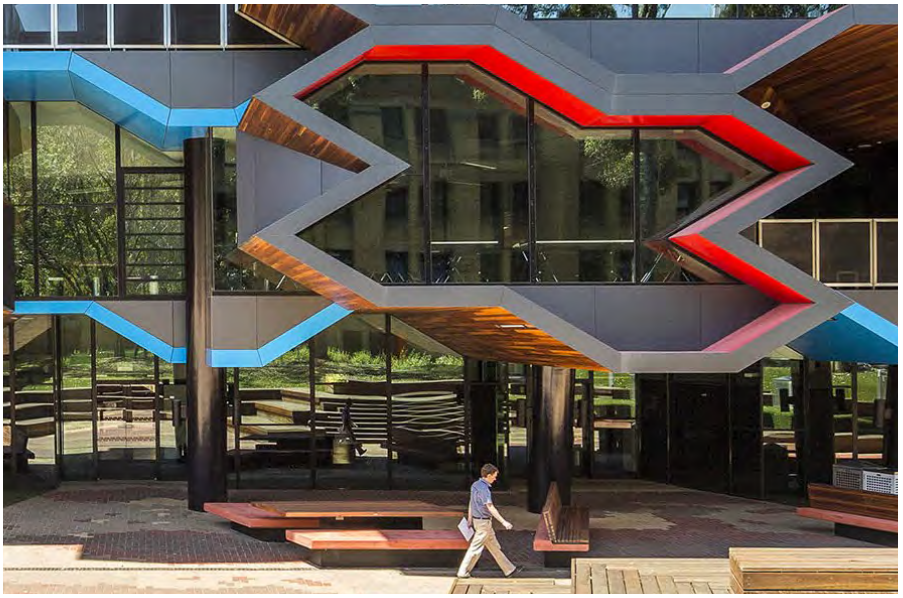
The Molecular Design theme uses molecules to solve real world problems across a broad range of disciplines.

Nanoscience

The Nanoscience theme uses a broad range of methods to characterise molecular structure and function, and to identify and quantitate key chemical and biochemical species in the environment and in the human body.

LIMS Facilities

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



LIMS has in-house facilities for bioinformatics, flow cytometry, microscopy, genomics, nuclear magnetic resonance (NMR), and mass spectrometry. It additionally houses inductively coupled plasma (ICP) equipment, atomic absorption spectrometer (AAS), X-Ray diffractometer, crystallography, and laser research. As well as a comprehensive Proteomics Platform, suite of Surface Science and Surface Analysis equipment and a Histology Facility.

Embedded Biotech Companies

LIMS also has several embedded biotech companies including: **Hexima Limited,** which is developing plant-derived proteins and peptides for applications such as human therapeutics and the genetic modification of crops; and **AdAlta Limited,** which is developing the next generation antibody platform, the i-body, to deliver high affinity and specific biologics against a variety of therapeutic and diagnostic targets. **Imunexus** is the latest biologics company to join LIMS. LIMS has outstanding links with the **Australian Synchrotron**. Several of the Institute's physicists design and build synchrotron components.

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

LIMS Fellowships

The LIMS Endowment Fund was established to create new and sustainable opportunities for scientists with outstanding potential via the inaugural Bruce Stone Fellowship in Chemical Biology and Nicholas Hoogenraad AO Fellowship in Molecular Sciences.

LIMS Fellows Society

The LIMS Fellows Society fosters support, communication and career development for postdocs at LIMS and La Trobe University's partner institutions, such as Olivia Newton-John Cancer Research Institute, AdAlta and Hexima.

Director:

Professor Patrick Humbert
(p.humbert@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.

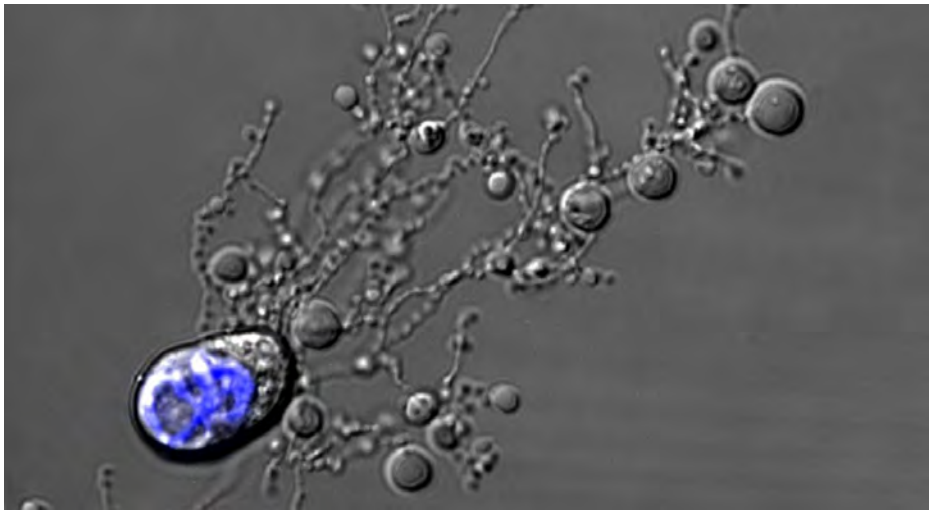
We do this by:

- 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.

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.



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

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 Suresh Mathivanan
(S.Mathivanan@latrobe.edu.au)

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 Centre for Molecular Cancer Prevention

The Research Centre for Molecular Cancer Prevention (RCMCP) is a research program for the discovery and implementation of molecular cancer prevention strategies. We are based in the School of Molecular Sciences and collaborate with key local, national and international researchers and conduct multidisciplinary research. Our objective is to lead innovative research and research training in molecular cancer prevention.

We do this by:

- integrating the expertise and capabilities at La Trobe University into new and innovative research programs, enabling molecular targeted cancer prevention therapies that benefit and impact society.
- providing cross-discipline education, training and career development opportunities in cancer prevention research and related skills.

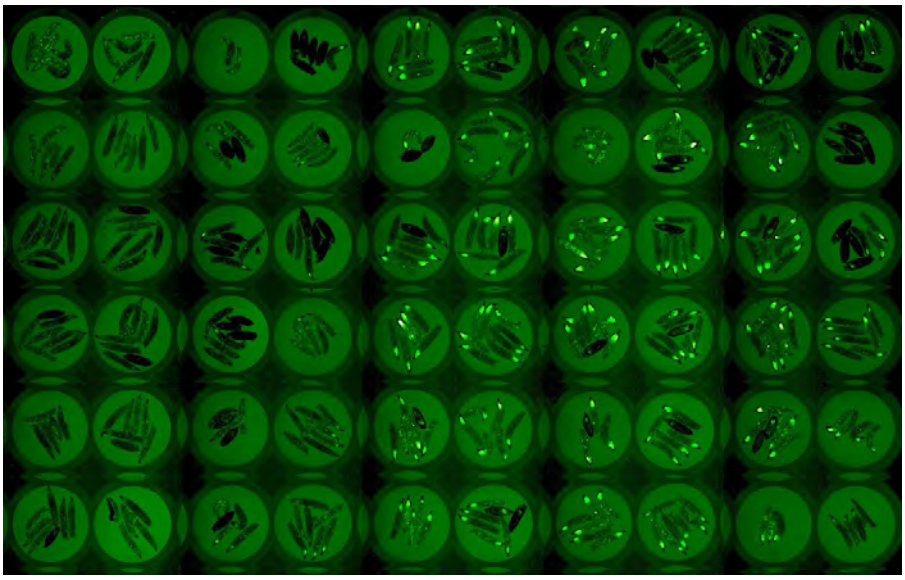
Why study cancer prevention?

There is a 1 in 2 lifetime risk of developing cancer. Breast and prostate cancers are the most common cancers and by age 50, the majority of Australians will already carry silent, premalignant lesions.

Evidence-based economic and health burden studies show preventative approaches to cancer therapy are cost-effective and improve patient wellbeing. However, a major hurdle for new cancer prevention strategies is that we do not understand the biology of cancer initiation.

We need to develop new and improved preventative therapies, specifically designed to target the early biology of breast and prostate cancer. We also need to develop effective strategies for the uptake and implementation of promising molecular prevention therapies.

We are studying the earliest cellular events in cancer to develop new chemo-preventative strategies for breast and prostate cancer. Our research will involve proof of principle basic and pre-clinical studies.



Ultimately, we want to undertake human clinical trials of novel therapeutic agents to implement early intervention and prevention of cancer.

Cancer initiation and the microenvironment

To identify and test biomarkers, we are studying the first molecular changes in cancer cells and the immune surveillance systems that protect us from cancer.

Precision Medicine

To generate specific targets for drug discovery, our researchers will also probe the molecular mechanisms that underlie lifestyle factors such as diet and nutrition that may alter cancer risk.

Barriers to molecular cancer prevention

Uptake of molecular treatments and delivery to the community are barriers to cancer prevention programs. We are developing new implementation models and guidelines to overcome this.

New cancer prevention therapies

We will translate our findings to patients via clinical trials of candidate and newly identified preventative therapies.

Director:

Professor Patrick Humbert
(p.humbert@latrobe.edu.au)

Strategic Partners:

Our centre promotes cross-disciplinary networks and research in the scientific and wider communities. The relationships include:

La Trobe University

School of Cancer Medicine
School of Psychology and Public Health
School of Allied Health, Human Services and Sport

National

Olivia Newton John Cancer Research Institute Olivia Newton John Cancer Wellness and Research Centre
Peter MacCallum Cancer Centre
Victorian Comprehensive Cancer Centre (VCCC)
Royal Melbourne Hospital
The Royal Women's Hospital
Austin Hospital
Community members and cancer survivors.

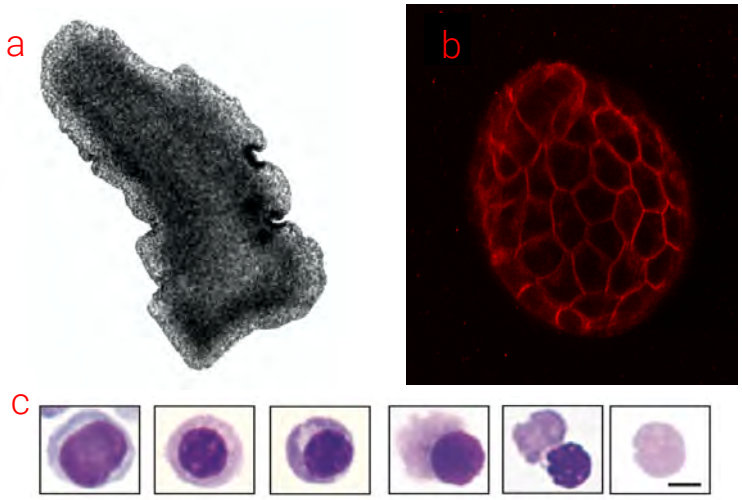
International

International Centre for Genetic Engineering and Biotechnology, Trieste, Italy
University of Veterinary Medicine Hannover, Foundation (TiHo), Germany
University of California San Francisco, USA
University of California Santa Cruz, USA

Department of Biochemistry and Chemistry 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

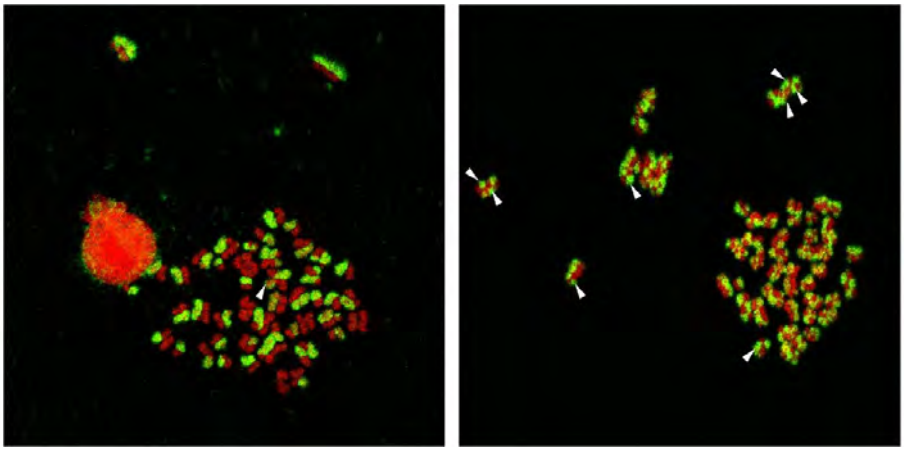
Fields of Study:
Cell development, proliferation and death; Cellular interactions; Cancer cell biology; Space Sciences; Cell Polarity; Erythropoiesis

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.

Cancer Cell Death Group

Cells can die, or be killed, by physical or biochemical damage. Some cell death mechanisms are "programmed" (cell death is caused by the cell's own proteins, encoded in its own genes). This enables the elimination of dangerous cells that could wreak havoc in the individuals that habour them. Apoptosis, necroptosis and pyroptosis are regulated processes that destroy surplus and dangerous cells. Excessive apoptosis has been linked with degenerative diseases, while defects in apoptosis can promote cancer, infection and autoimmune disease. Necroptosis can eliminate infected or cancerous cells that are unable to undergo apoptosis. Pyroptosis is primarily implicated in the destruction of cells following bacterial, viral or protozoal infection. By understanding the proteins that control cellular self-destruction pathways, and their aberrations in cancer and infectious diseases, we are pursuing diagnostic and therapeutic approaches to target these conditions.



untreated cisplatin treated

DNA repair in chemotherapy-treated cells (Photo credit: Mark Miles)

Yeast systems for identifying new drugs and proteins that regulate cell death
Researchers have been mapping the biochemical pathways that control cell survival and susceptibility to apoptotic, necroptotic or pyroptotic cell death. We reconstituted these pathways in yeast, a simple, single-celled organism that shares many features of cellular structure and biochemical pathways with more complex species like humans. Our yeast systems enable rapid, high-throughput screening for novel drugs that can either enhance or suppress apoptotic, necroptotic or pyroptotic cell death pathways. We use these platforms to characterise or identify proteins from host cells or pathogens that regulate or perturb these cell death pathways.

Animal models of sarcomas
We developed multiple mouse models of bone and soft tissue cancers that typically arise during teenage years, including osteosarcoma and Ewing sarcoma. Our model faithfully emulates "metastatic disease", the dangerous phase in which tumours spread from their original sites (e.g. bone or muscle) to other organs in the body, (e.g. lungs). This transition heralds poor outcomes for patients; current anti-cancer treatments are often powerless to cure these metastatic cancers. We developed a technique that allows cancer cells injected into the blood of mice to form tumours in their lungs, mimicking metastatic bone and soft tissue cancers. We use these models to evaluate potential new drug treatments that we hope will improve cancer survival rates.

Smac mimetics/IAP antagonists
Drugs resembling the cellular protein "Smac" can disable other proteins (called "IAPs") within cancer cells that allow some tumour cells to withstand stimuli that would otherwise destroy them. These "Smac mimetics" or "IAP antagonists" are promising anti-cancer agents. We have discovered that a subset of these drugs are able to control and sometimes eliminate bone cancers growing in the lungs of mice, modelling an often-fatal manifestation of this type of cancer.

Curing cancer without causing cancer About 20% of cancer survivors develop new tumours, many of which are caused by cancer therapies. Chemotherapy and radiotherapy cause DNA damage in cancerous cells. Cells respond by triggering apoptosis, which hopefully eliminates the cancer. Other cells can be damaged during chemotherapy or radiotherapy treatment, if these cells survive, they can form new cancers. Recent research has been focused on the development of drugs that directly kill cancer cells, rather than provoking DNA damage to indirectly induce tumour cell death. Some new drugs have shown robust anti-cancer activity in animal experiments and clinical trials. As direct apoptosis inducers do not need to damage DNA to kill tumour cells, we hypothesised that they may provoke fewer mutations in surviving cells, so may be less likely than current therapies to cause secondary cancers. We found that drugs that trigger necroptosis failed to provoke mutations in surviving cells, in contrast to highly mutagenic chemotherapy drugs. It is hoped that cancer survivors treated with necroptosis-inducing agents will have a lower risk of developing therapy-related cancers.

Lab Head:
Associate Professor Christine Hawkins (c.hawkins@latrobe.edu.au)
Lab members: Mr Yanhao Ji; Mr Michael Harris; Ms Matilda Mikic; Ms Seirian Hart; Mr Dushan Peiris.

Fields of Study:
Biomedicine; Cancer; Molecular Genetics; Biochemistry.

Capabilities and Techniques:
Animal models; Cell Biology; Fluorescence microscopy; Flow cytometry; Microbiology; Molecular Biology; Biochemistry.

Translational Opportunities:
Oncology; Biotechnology; Pharmaceuticals.

Cell Death and Survival Group

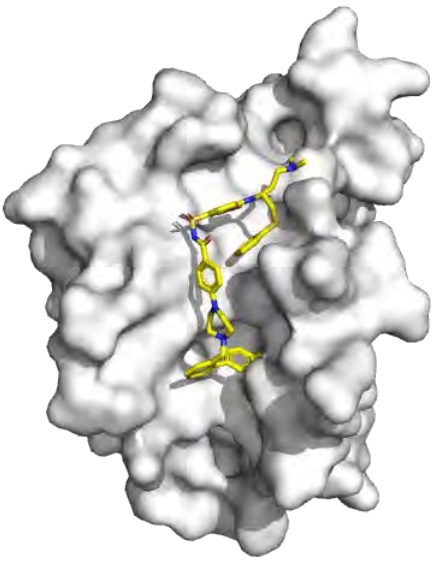
Our group is uniquely positioned at the cross-roads of SABE and the School of Cancer Medicine (Olivia Newton-John Cancer Research Institute). Our research investigates how our cells determine their fate. In particular, we aim to understand what goes wrong in this decision-making process in disease and 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.

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 and AbbVie.

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.



BH3-mimetic drug (yellow) bound to its target protein (BCL-XL; white).
Photo credit Doug Fairlie and Erinna Lee.

Mechanisms of novel cancer drugs

Drugs that inhibit the growth or survival of cancer cells can be developed without necessarily knowing their precise molecular targets or mechanism of action. However, in many cases these mechanisms involve the apoptosis and/or autophagy pathways. As a consequence of our long-term interest in these areas, we have developed relationships with a number of pharmaceutical companies to evaluate drugs they are developing and establish the mechanisms underlying their anti-cancer effects. This work provides further insights into novel approaches for targeting cancer cells and important data to support clinical approval of these compounds by regulatory bodies.

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:

Dr Laura Jenkins;
Ms Sharon Tran;
Ms Julie Juliani;
Ms Tiffany Harris;
Mr Kristian Caracciolo.

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 Polarity, Cell Signalling and Cancer Group

Our group uses the vinegar fly, *Drosophila,* to model cancer to understand how regulators of cell shape (polarity) impact on cell signalling and cancer development. We also aim to understand the signalling pathways in the tumour microenvironment that dictate whether polarity-impaired mutant cells live or die. *Drosophila* is a great organism to model cancer due to the high conservation of critical genes and signalling pathways between flies and man, its low genetic redundancy, short life cycle and cheap maintenance costs. We seek to translate our findings from *Drosophila* to mammalian systems by collaboration with Professors Patrick Humbert and Marc Kvansakul at LIMS.

Genetic analysis using the Drosophila adult eye validates Tsp29Fb as a tumour suppressor

Determining how cell polarity proteins control signalling pathways
We discovered that the cell polarity regulator, Lgl, regulates the Notch signalling pathway by effecting vesicle acidification and γ-secretase activity. Using mass spectrometer analysis we identified proteins involved in linking Lgl to the vacuolar-ATPase (v-ATPase), which regulates vesicle acidification. We also found that Lgl and the v-ATPase are involved in regulating the Hippo negative tissue growth control pathway by using genetic, cell biological and biochemical approaches. These studies will potentially provide new avenues for targeting polarity-impaired human cancer.

Modelling Cooperative Tumourigenesis: Determining the link between cell polarity, signalling, tissue growth and tumourigenesis.
We identified novel tumour suppressors that cooperate with oncogenic Ras (Ras^{V12}) in cancer progression in a genetic screen. These novel tumour suppressors include membrane proteins, autophagy, vesicular trafficking, cytoskeletal and metabolic regulators. We aim to determine how knockdown of these tumour suppressors results in cooperative tumourigenesis with Ras^{V12}. We found that knockdown of autophagy genes cooperates with Ras^{V12} to promote hyperplasia of the *Drosophila* eye tissue. Also, autophagic gene knockdown together with Ras^{V12} leads to an upregulation of Reactive oxygen species (ROS) and the JNK signalling pathway, which is crucial for the cooperation. We also studied the tumour suppressor role of a Tetraspanin, Tsp29Fb/TSPAN6, (a four-pass membrane protein) and found it regulates EGFR-Ras signalling in *Drosophila* and mammalian systems. We now wish to study the involvement of the novel tumour suppressors that we discovered in Ras-driven human cancers.

Analysis of a surveillance mechanism involved in preventing cancer initiation.
Cell competition is a surveillance mechanism that acts to remove less-fit cells in an epithelium. We have shown that a phosphatase, PTP61F (ortholog of mammalian PTPN1/PTPN2) is involved in the elimination of polarity-impaired cells in the *Drosophila* developing eye epithelium by inhibiting JAK-STAT signalling in mutant cells. It also has a role in the surrounding normal cells where it functions non-cell autonomously to limit elimination of the mutant cells. We also study the receptor phosphatase, PTP10D (ortholog of mammalian PTPRB/PTPRJ), in cell competition of cells with impaired polarity or with cytoskeletal defects. These studies will reveal new approaches for targeting pre-cancerous lessons by identifying ways in which to augment the cell competition process.

Discovery of novel anti-cancer drugs using Drosophila tumour models.
We established a screening platform using *Drosophila* larvae carrying Ras-activated polarity-impaired tumours marked by green fluorescent protein (GFP). The effect of different drugs on tumour development were revealed by quantifying the amount of GFP. We found that a MEK inhibitor (Ras signalling pathway blocker), Tramtinib, was highly potent in reducing tumourigenesis. Our screen revealed compounds that target diacyl-glycerol kinase, are synergistic with low doses of Trametinib, and specifically kill Ras-driven polarity-impaired tumours in *Drosophila* and human epithelial cells. Using a modified system, we will screen for novel compounds that normalize or kill polarity-impaired cells and senescent cells, which are early defects that occur in cancer initiation. We aim to develop a therapeutic cancer 'de-tox' treatment, similar to the HPV-vaccine for cervical cancer.

Lab Head:
Associate Professor Helena Richardson (h.richardson@latrobe.edu.au)
Lab members: Dr Eddie La Marca; Mr Peter Burke; Ms Natasha Fahey Lozano.

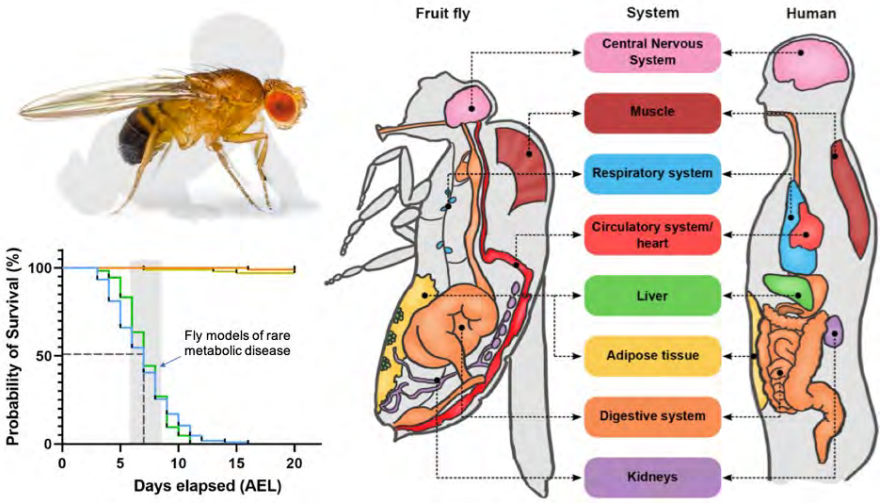
Fields of Study:
Cell Biology; Genetics; Biochemistry.

Capabilities and Techniques:
Drosophila model organism expertise; Immunofluorescence techniques; Confocal microscopy; PCR and Molecular Biology techniques; Genetic analysis; In vivo compound screening.

Translational Opportunities:
In vivo compound screening to identify and develop novel anti-cancer drugs.

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:
Ms Grace Jefferies;
Ms Sabah Jbara;
Ms Sarah Mele;
Ms Jiayi Lin;
Ms April Lewis

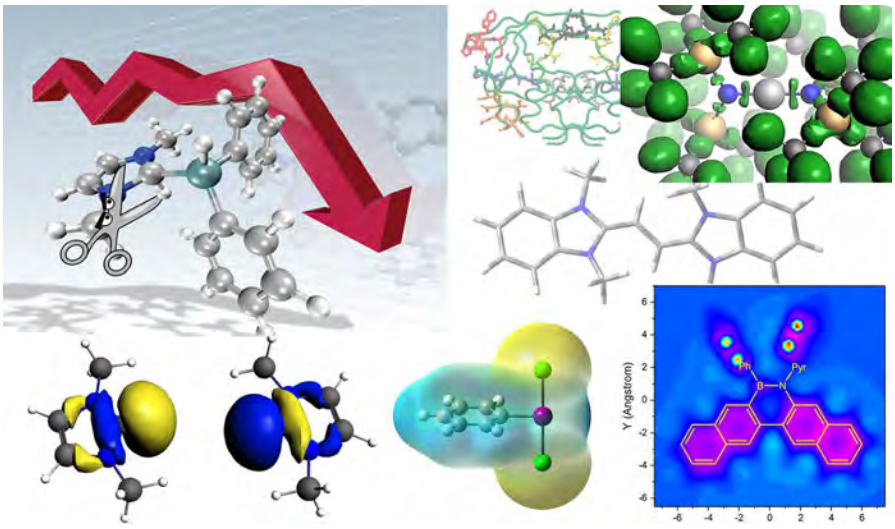
Fields of Study:
Genetics; Molecular Biology; Cell Biology; Developmental Biology; Disease models.

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.

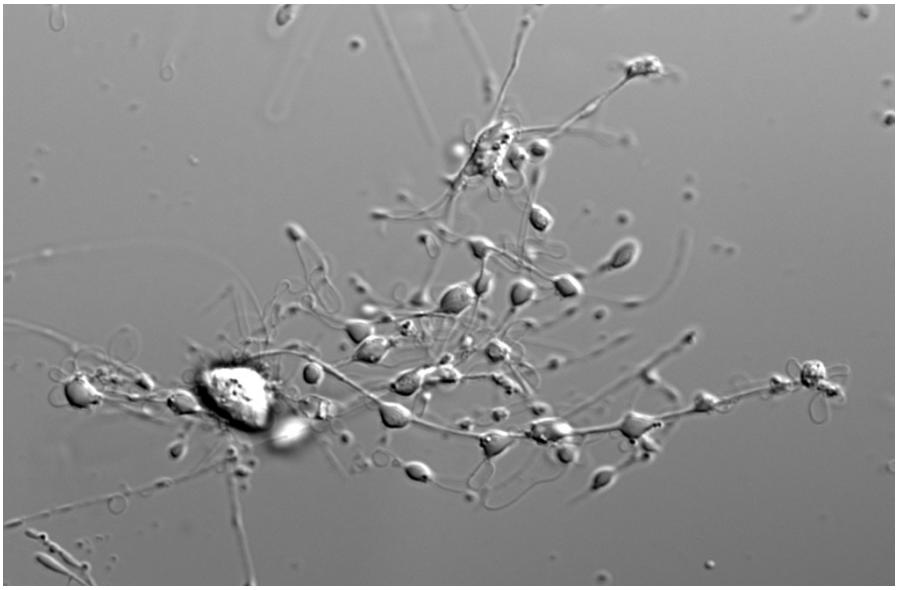
Fields of Study:
Theoretical and Computational Chemistry.

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

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

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: Associate Professor Ivan Poon (i.poon@latrobe.edu.au)

Lab members:
Dr Amy Baxter; Dr Kha Phan; Dr Georgia Atkin-Smith; 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

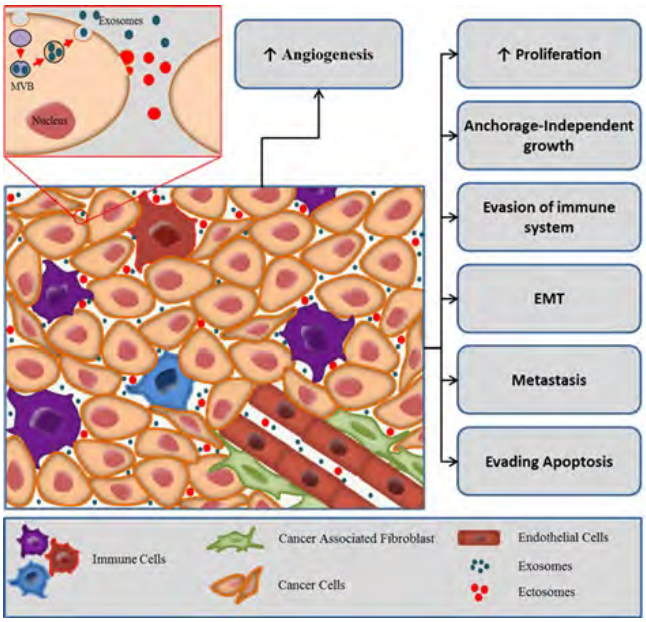
Our major research interests are in exploring the role of extracellular matrix components (soluble secreted proteins and extracellular vesicles) in cancer and intercellular communication. Our lab integrates proteomic, genomic and bioinformatics methodologies to study cancer progression. In addition to 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.

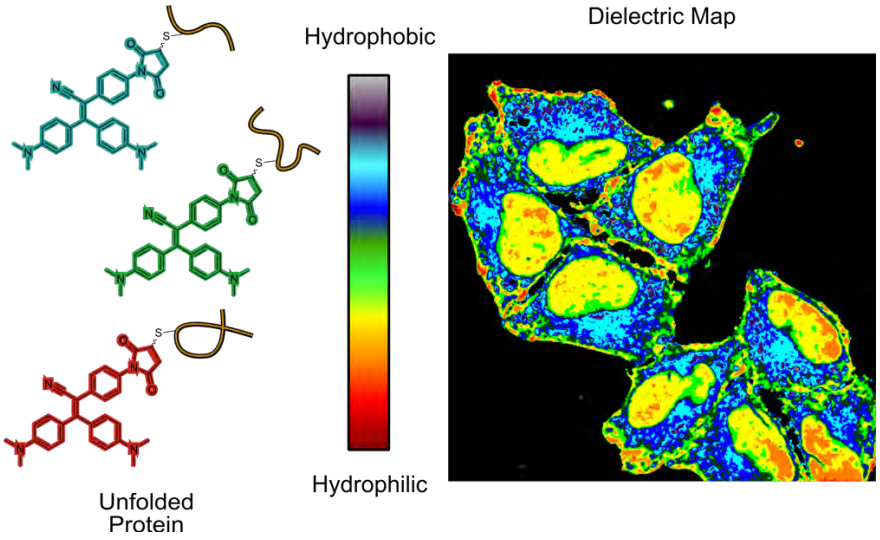
Fields of Study:
Exosomes; Cancer; Extracellular Vesicles; Proteomics; Bioinformatics

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.

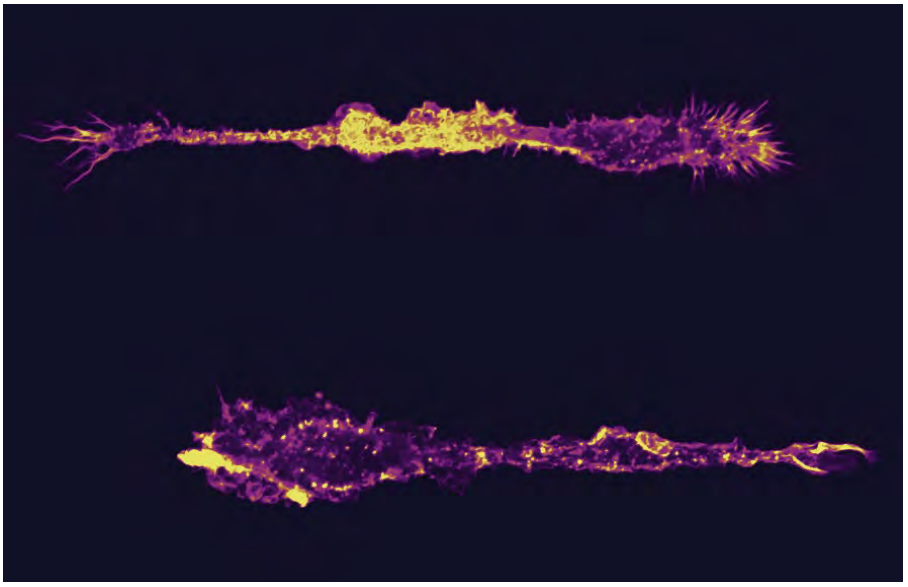
Translational Opportunities:
Material transfer; Early detection of neurodegenerative diseases; Disease treatment evaluation; Assay kits/device development based on our materials.

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;
Mr Christopher Chong;
Mr Michael Osbourne; Ms Emily Field;
Mr Shohan Johnson.

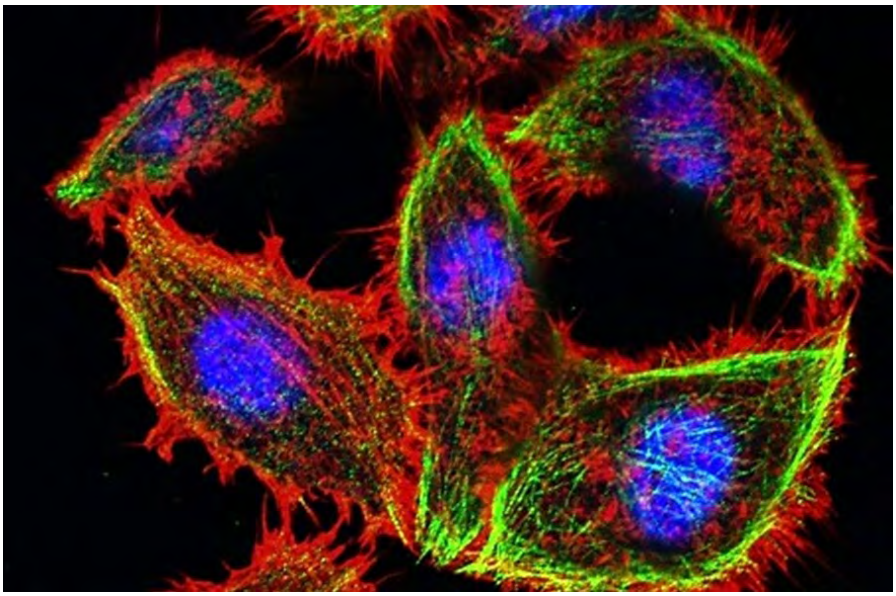
Fields of Study:
Immunology; Cell Biology; Metabolism; Biochemistry; Molecular Biology.

Capabilities and Techniques:
Primary cell culture; infection assays; metabolism analyses.

Translational Opportunities:
Biomedical therapies for infection 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; Ms Guneet Bindra; Ms Tien Nguyen; Mr Scott Williams; Mr Matt Hein; Ms Zoe Day; Ms Serenay Dimir.

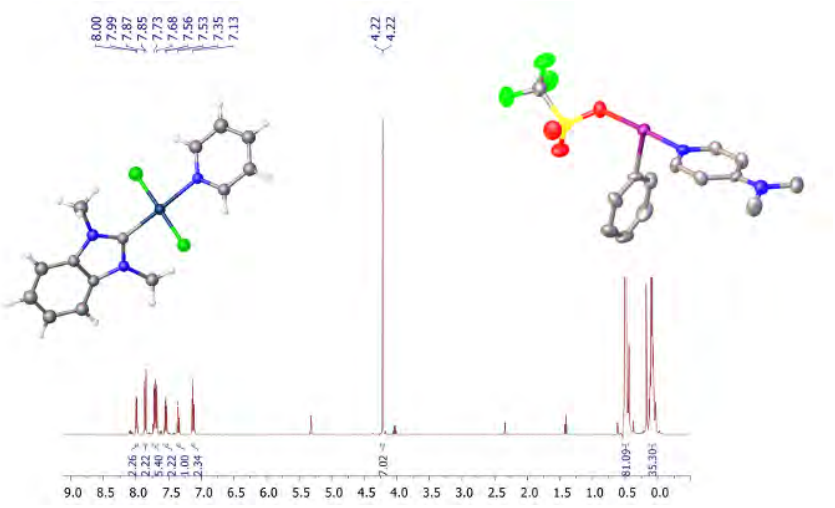
Fields of Study:
Biochemistry; Cell biology; Innate immunity; Inflammation; Cancer biology; Cardiovascular disease.

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.

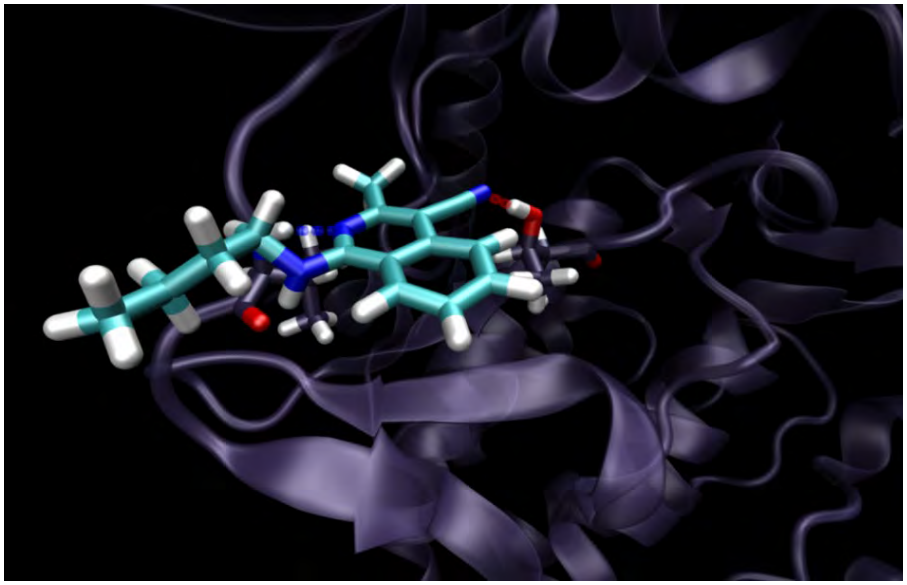
Capabilities and Techniques:
We have expertise in electrochemistry, biomaterials, nanomaterials, and surface modification with a strong focus on interfacing materials with biological systems.

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

Medicinal and Biological Chemistry Group

Medicinal chemistry involves the design, synthesis and development of the molecules we need in order to understand, prevent and treat disease. Our research uses chemical synthesis, purification and characterisation techniques to make novel heterocyclic compounds. We partner with collaborators in order to study how these small molecules interact with complex biological systems, allowing us to develop our understanding the structure-activity relationships of our novel compounds with the target of interest. We are then able to use chemical modifications to optimise the pharmacodynamic and pharmacokinetic properties of promising lead compounds for further evaluation as potential therapeutics.



Small heterocyclic compound binding to protein target. (Image credit: M.Buskes)

Exploring FBDD to interrupt bacterial signaling between SRP and FtsY

The bacterial signal recognition particle (SRP) is an essential ribonucleoprotein complex responsible for the delivery of membrane and secretory proteins to the plasma membrane in bacteria. Interrupting the interactions of SRP with the SRP receptor (known as FtsY) represents a promising strategy for the development of novel antibiotics. This project aims to expand fragments obtained from a screening library into high affinity compounds using the approach of fragment-based drug design(FBDD).

Design, synthesis and evaluation of Drp1 inhibitors

The mitochondrial protein dynamin-related protein (A) has been implicated in the development of a number of neurodegenerative diseases, including Alzheimer's disease. To date, no direct small molecule inhibitors of human Drp1 have been identified. Our work aims to develop small molecules which can potently and selectively inhibit human Drp1 to provide important research tools to reveal the specific role of Drp1 in dementia and as potential leads for drug development.

Discovery and synthesis and of inhibitors of Bim expression

Beta-blockers such as propranolol are commonly used to treat cardiac arrhythmia and hypertension but have serious side effects; patients have a 5-year survival rate of 50%. New therapeutics for the treatment of these heart conditions are urgently needed. We are currently interested in two classes of compounds which prevent induction of the pro-apoptotic Bim protein but at the same time not affect CREB phosphorylation, a discovery which may be the key to the development of successful cardiac drug treatments.

Targeting protein transport for the effective treatment of motor neurone disease (MND)

Protein transport is critical to supply a motor neuron with components necessary for its maintenance and survival, and to remove waste products. We have identified a compound that enhances decreases ER stress, preventing the formation of inclusions and prevents apoptosis (cell death). We seek to further develop new compounds with this neuroprotective activity, as there is currently no effective therapeutic treatment for MND.

Inhibiting *P. falciparum* in the search for a new antimalarial agent

Malaria is a severe disease burden on the health and economy of the developing world. Enzymes which are important in the life cycle of the malaria parasite could possibly be attractive targets for novel antimalarial agents. We are synthesising analogues of an isoquinoline compound to evaluate against the malaria causing parasite *Plasmodium falciparum* with the aim of identifying a selective and potent inhibitor against a novel enzymatic target.

Lab Head:
Associate Professor Belinda Abbott
(b.abbott@latrobe.edu.au)

Lab members:
Ms Monica Nguyen; Ms Emily Graham;
Mr Jarrod Pontisso; Ms Jordan Matoe;
Mr Nicholas Baricevic.

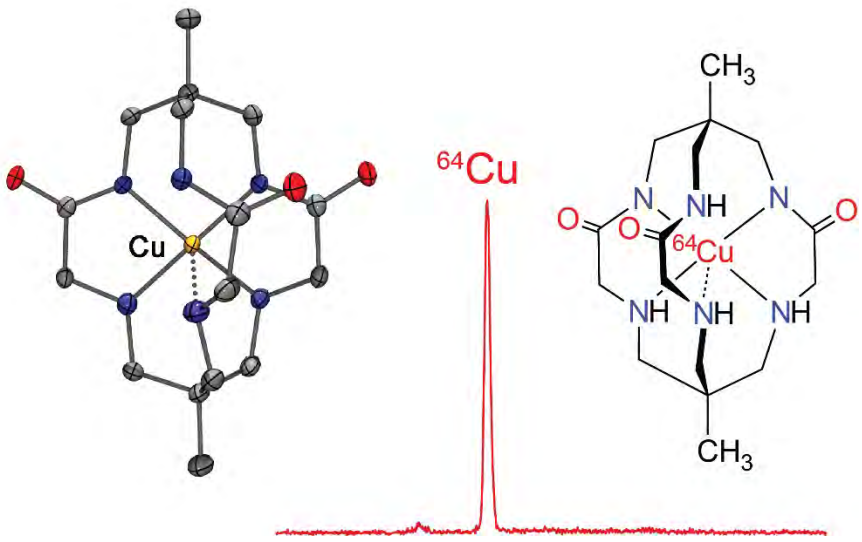
Fields of Study:
Medicinal Chemistry; Biological Chemistry;
Organic Chemistry.

Capabilities and Techniques:
Chemical synthesis; Recrystallisation; Flash Chromatography; RP-HPLC;
NMR spectroscopy; mass spectrometry.

Translational Opportunities:
Small molecule development;
Enzyme inhibitors; Drug discovery.

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.

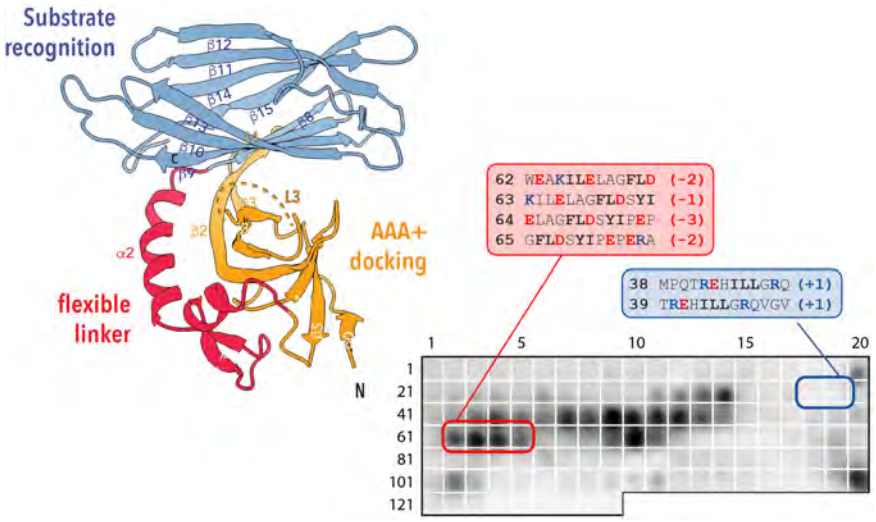
Fields of Study:
Medicinal Inorganic chemistry; Organic Chemistry; chemical luminescence.

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)

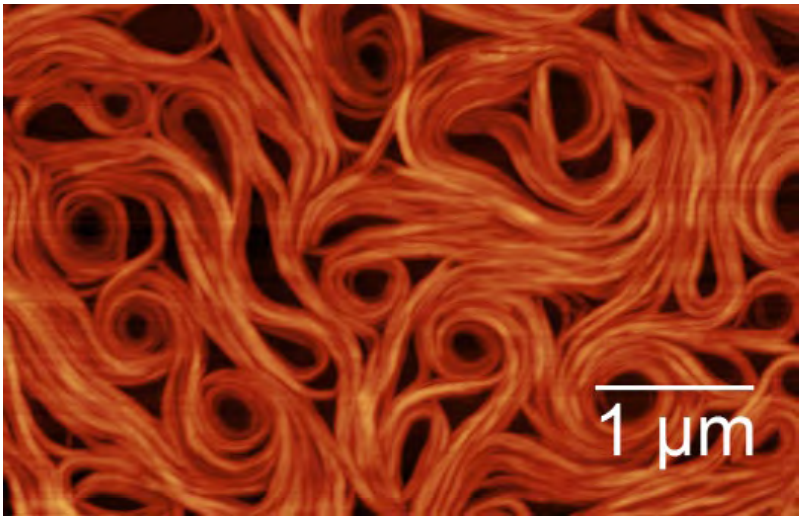
Fields of Study:
Biochemistry; Mitochondrial Biology; Microbiology, Cell Biology.

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)

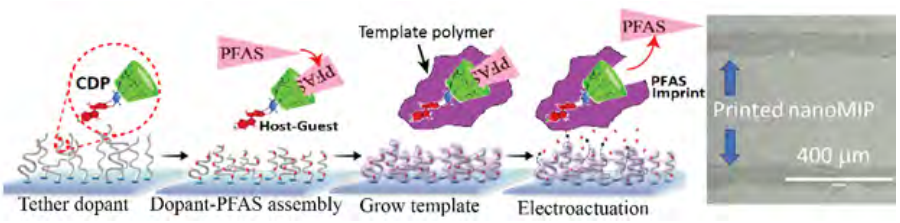
Lab members:
Mr Jose Vilareal-Diaz; Mr Yifan Wang; Ms Zahra Saadatmand; Mr Norton West; Mr Abdalwahab Alshammari.

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

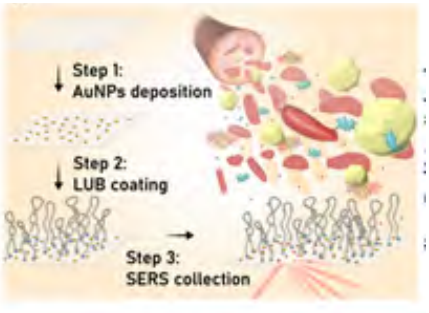
Capabilities and Techniques:
Biomimetic solutions for biomedicine; Delivery and effectiveness of antimicrobial peptides and nanoscales.

Multifunctional and Advanced Interfaces Group

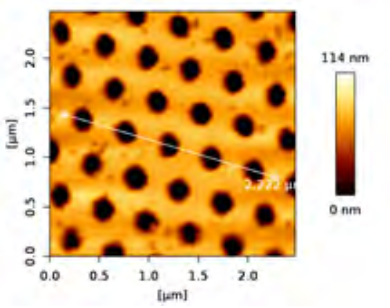
Our lab utilizes the physical chemistry of interfaces to engineer innovative materials and surfaces that exhibit multifunctional and responsive properties. Utilizing a multidisciplinary approach which draws on principles from biology, electrochemistry, inorganic chemistry, and geology, we control intermolecular 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:



Schematic of nanoscale molecularly imprinted conductive polymers



Schematic of non-fouling optical



Nanoimprinted hole array in glass created using pressure solution

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

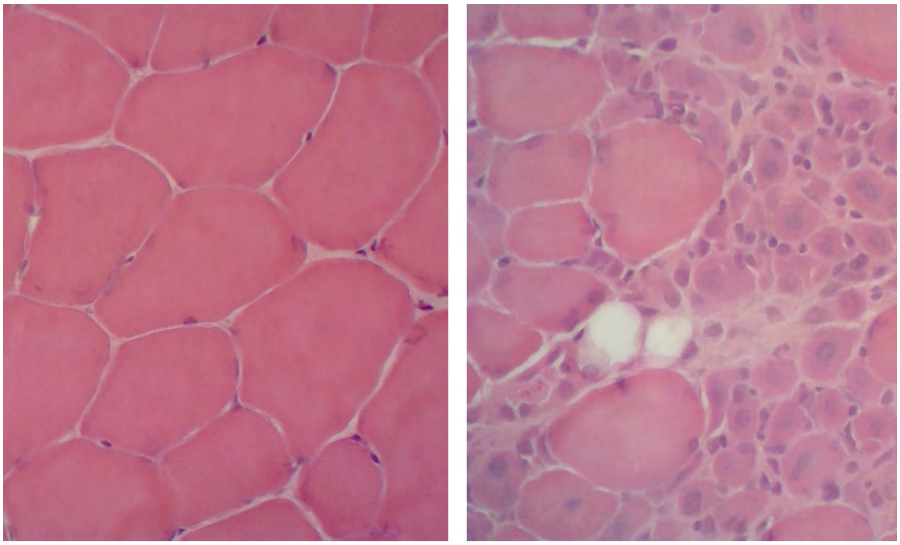
The Muscle Biochemistry Laboratory focuses on understanding aspects of muscle function and biochemistry in both health and disease. The laboratory is situated in the LIMS1 building, with full access to all biochemistry facilities. The overall research interest of the laboratory is in the area of skeletal 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.

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.



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

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.

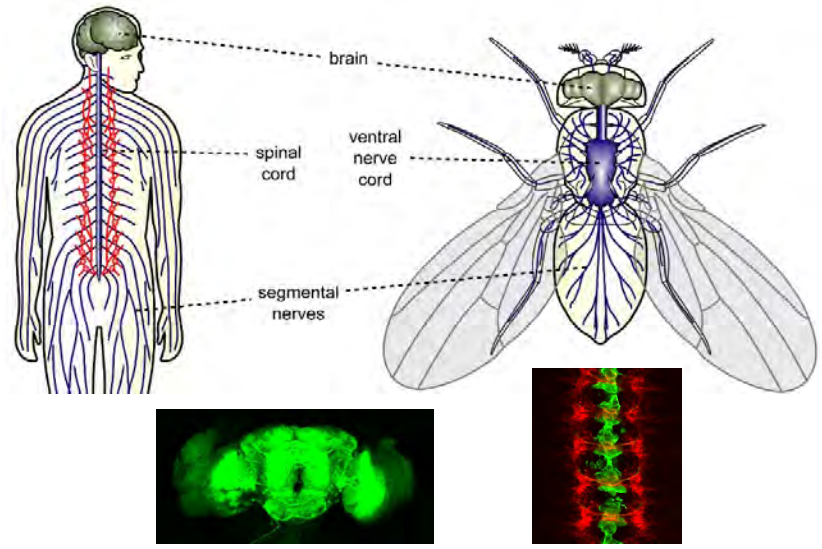
Fields of Study:
Biology with Physiology (cellular, animal and biochemistry); Medical Physiology; Human Movement and Sports Science.

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.

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
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Lab members:
Dr Mackenzie Lovegrove;
Ms Emily Kerton;
Ms Natasha Fahey-Lozano;
Ms Sachini Arachillage Mallika;
Mr Stephen Penrose.

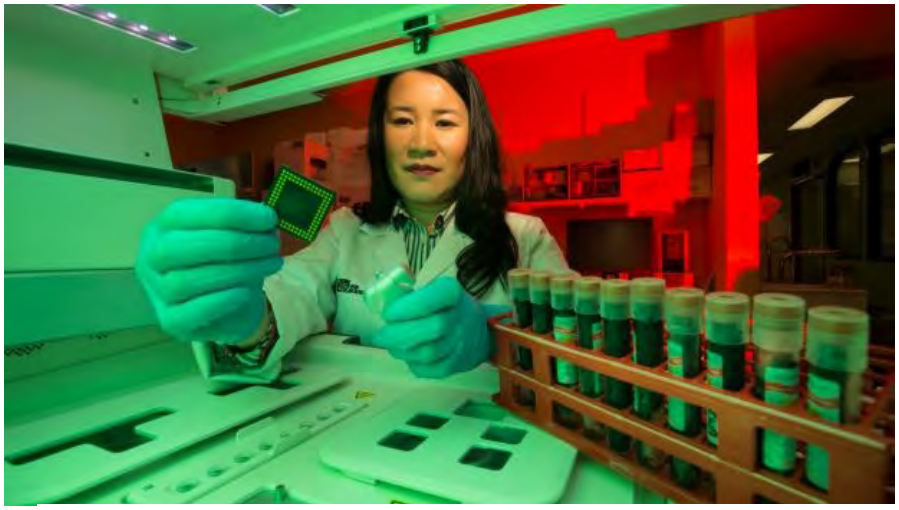
Fields of Study:
Molecular genetics; Cell Biology; Neurobiology; Developmental Biology.

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.

Neurodegeneration Biology and Biomarker Group

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.



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

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; Ms Natasha Vassileff; Mr William Phillips; Mr Christopher Reimann.

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

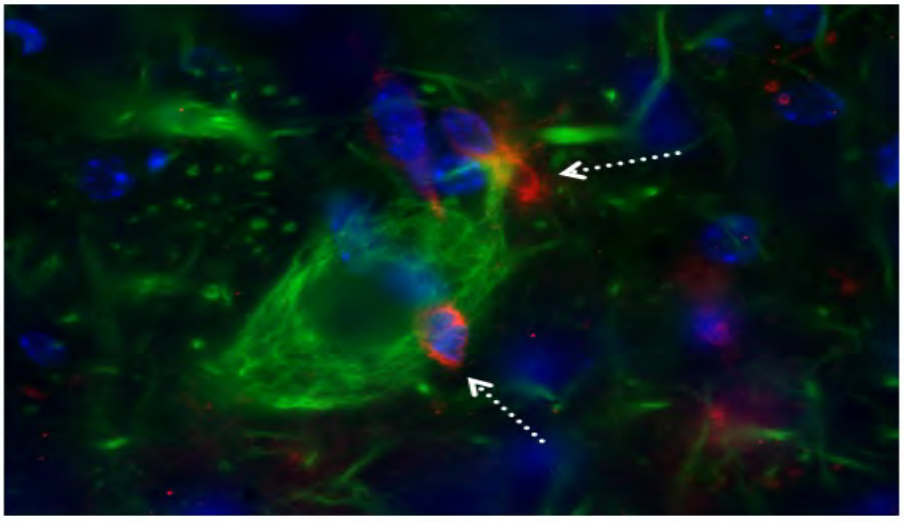
Our laboratory focuses on multiple sclerosis (MS), an autoimmune and neurodegenerative disorder of the central nervous system (CNS). The cause of MS is unknown, but incidence and prevalence of this disease is rising worldwide. Treatment options are unsatisfactory, because of poor understanding of mechanisms 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.

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.



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)

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).

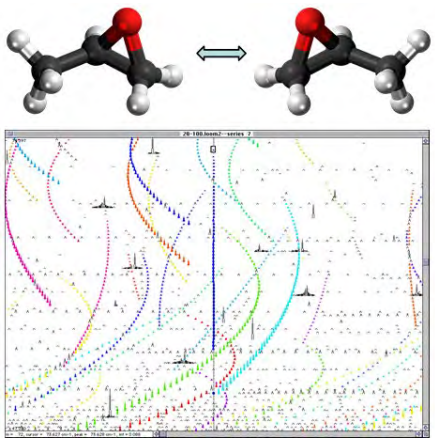
Fields of Study:
EAE models, multiple sclerosis, myelin biology, neuroimmunology, platelets.

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
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Lab members:

Mr Luigi Villani,
Mrs Ishara Peiris,
Mr Kaidan Rolfe.

Fields of Study:

Atmospheres, Astrochemistry, Molecular spectroscopy, Vibrational spectroscopy

Capabilities and Techniques:

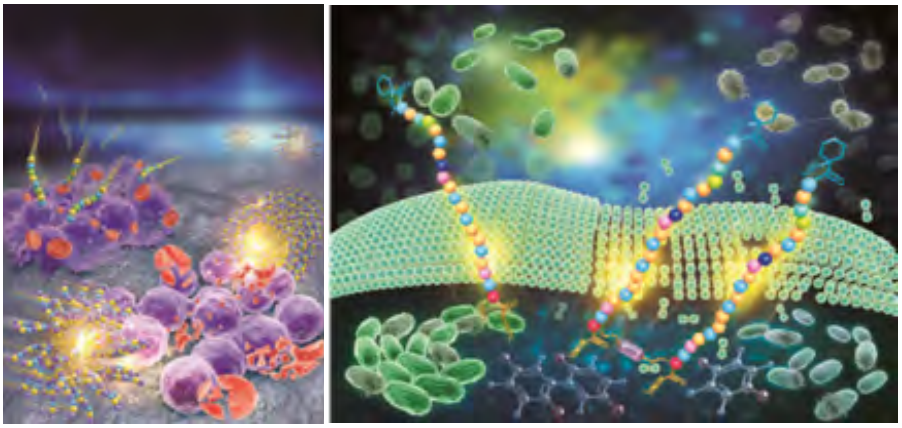
Infrared and Raman Spectroscopy, pulsed ns laser systems, ab initio quantum chemistry, rovibrational analysis.

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.

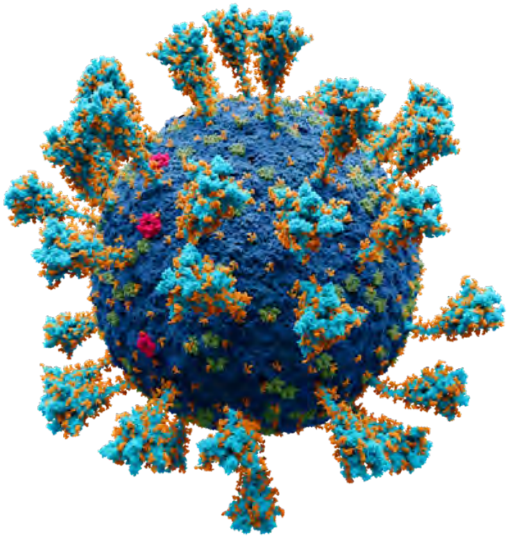
Fields of Study:
Chemical Biology; Peptide chemistry; Antibiotics; Antimicrobial resistance; mode of actions.

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.

Probing materials-biology interactions 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, some involving non-biological structure-property relationships problems in materials.



SARS-CoV-2 coronavirus. (Photo credit: CC BY-SA 4.0 Alexey Solodovnikov)

Machine learning for materials and surface science

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 RMIT, CSIRO, HZG Hamburg, we design catalysts and photo-catalysts for CO2 reduction, hydrogen, water splitting and safe organic corrosion inhibitors for addressing the >$1Tn market for these materials. We also use machine learning and evolutionary methods to design porous materials for environment and energy applications and to model the electrical, optical, and mechanical properties of hybrid 2D materials, recently shown to be superconductive.

Next-generation biomaterials

We work on a large University of Nottingham EPSRC project discovering and designing new materials for medical applications. We use data from high throughput experiments to build models of the biological effects of biomaterials.

Drug treatments for cancer and COVID-19

Working with CSIRO, Mt Sinai School of Medicine we developed novel drugs binding to the thrombopoietin receptor that may be the first disease-modifying treatments for the blood cancer myelofibrosis. We also work with Monash University to find biomarkers for colorectal cancer using sparse feature selection and machine learning. We are using very large-scale computational resources to conduct molecular docking and molecular dynamics studies to discover drugs that can be repurposed for treating coronavirus infections such as COVID-19.

Therapeutic gases

Noble gases like xenon are chemically inert but display a wide range of useful biological effects. We work with Air Liquide Santé International to use large scale computational simulations to understand how these gases produce medically relevant properties.

Safe use of nanomaterials

We are 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).

Lab Head: Professor Dave Winkler (d.winkler@latrobe.edu.au)
Postdoctoral Fellow: Dr Marco Fronzi (UTS).

Collaborators:
Prof Morgan Alexander; Dr Grazziela Figeiredo; Prof Ricky Wildman (Nottingham); Prof Alex Tropsha (UNC Chapel Hill); Dr Ira Katz, Dr Geraldine Farjot (Air Liquide Santé International); 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); Prof Joe Shapter (UQ); Prof Mike Ford (UTS); Prof Amanda Ellis (Melbourne); Dr Tu Le; Dr Nas Meftahi; Prof Andrew Christofferson; Prof Rachel Caruso (RMIT); Dr Aaron Thornton (CSIRO); Prof Nico Voelcker; Dr David Rudd (Monash); Prof Michael Morris (Sydney).

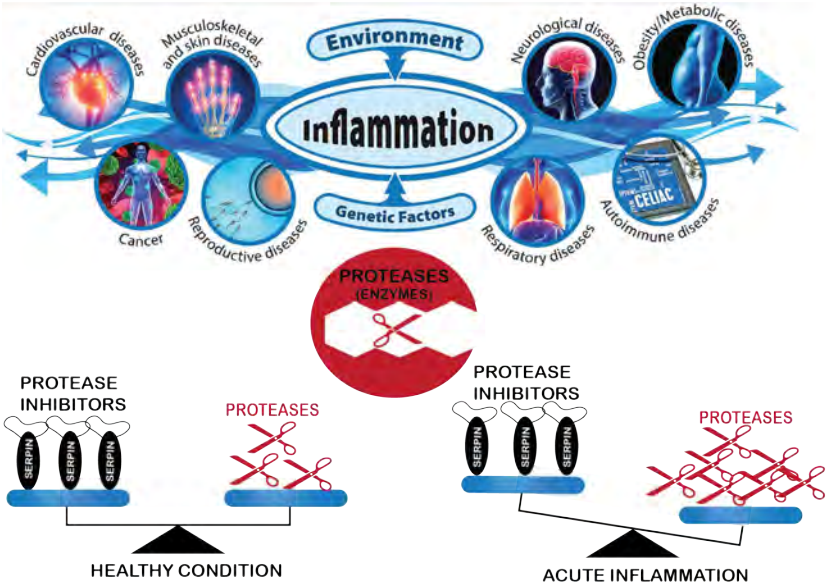
Fields of Study:
Computational chemistry; drug design; AI and machine learning; materials design; complex systems.

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

Translational Opportunities:
Cancer drugs; biomarkers; materials.

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.

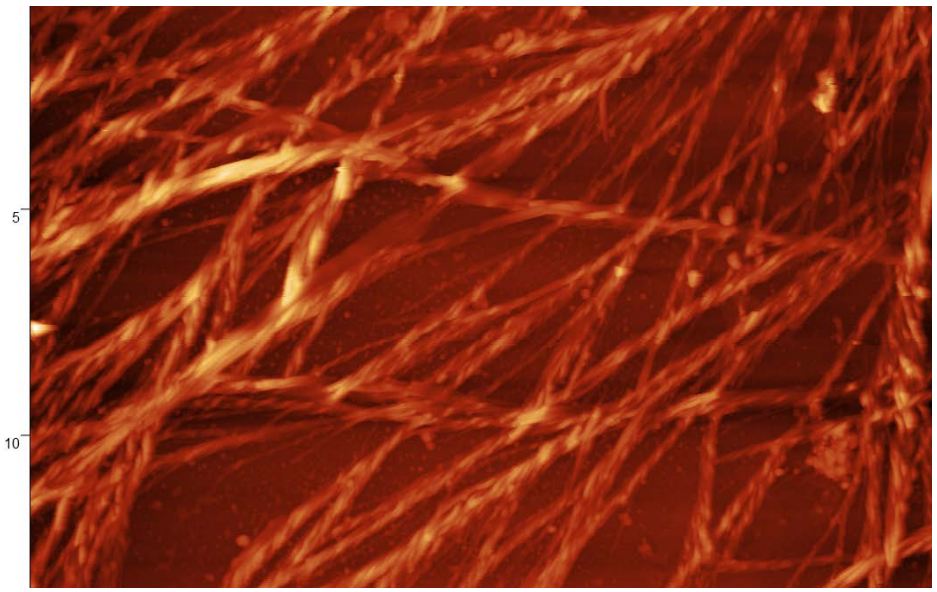
Translational Opportunities:
Development of specific inhibitors.

Self-Assembled Nanomaterials Group

Our group focusses on the design, discovery and characterization of self-assembled nanomaterials. Molecular self-assembly is an evolutionary optimized process where biological molecules with two or more distinct regions (e.g. one part of the molecule may be hydrophilic [water loving] and the other maybe hydrophobic [water hating]) organize themselves to form complex structures with distinct nanoscale morphologies (fibrils, micelles, vesicles etc). Such self-assembling materials have applications in diverse technical fields including tissue engineering, drug delivery, antibacterial materials, biological and environmental sensing and understanding disease.

The goal of my groups research is to develop materials, devices or medicines that have real and tangible benefits to communities in Australia and worldwide. For this to be possible, routes to translate our fundamental research to clinics, facilities and factories must be identified. Thus, I work closely with the MedTech industry, clinicians and government agencies to enable the translation of research outcomes into commercial devices, products and therapies.

Self-Assembled Peptide Nanofibrils as materials for 3D cell culture, bioprinting and tissue engineering
We are exploring the applications of a variety of self-assembling nanofibrillar peptides, and their ability to act as 3D culture materials for a variety of cell types. These materials will help us better understand fundamental biological processes, develop new materials for tissue engineering, new cell-laden inks for bioprinting and regenerative medicine.



Atomic Force Microscopy of Self-Assembled Phenylalanine nanofibrils, the toxic culprit in Phenylketanuria (Photo Credit: Jeremy Engwirda & Claire Buchanan)

Understanding the role of protein self-assembly in diseases
Misfolded protein aggregates known as amyloid fibrils are the molecular hallmark of a number of neurodegenerative diseases including Alzheimer's and Parkinson's. However, protein misfolding and amyloid aggregation also play important roles in a number of other maladies that are not traditionally thought of as amyloid diseases. We are interested in studying the amyloid aggregation processes in some of these less well studied amyloid diseases. Currently, we have active projects investigating the role of amyloid assembly in inborn errors of metabolism such as Phenylketonuria (PKU), and investigating if amyloid assemblies are playing a role in some of the neurological symptoms that occur in COVID-19. These fundamental investigations will help us understand the molecular mechanisms that underpin the progression of these diseases, hopefully revealing new potential therapeutic targets that will aid the development of new drugs.

Lab Head: Dr Nicholas Reynolds (nicholas.reynolds@latrobe.edu.au)

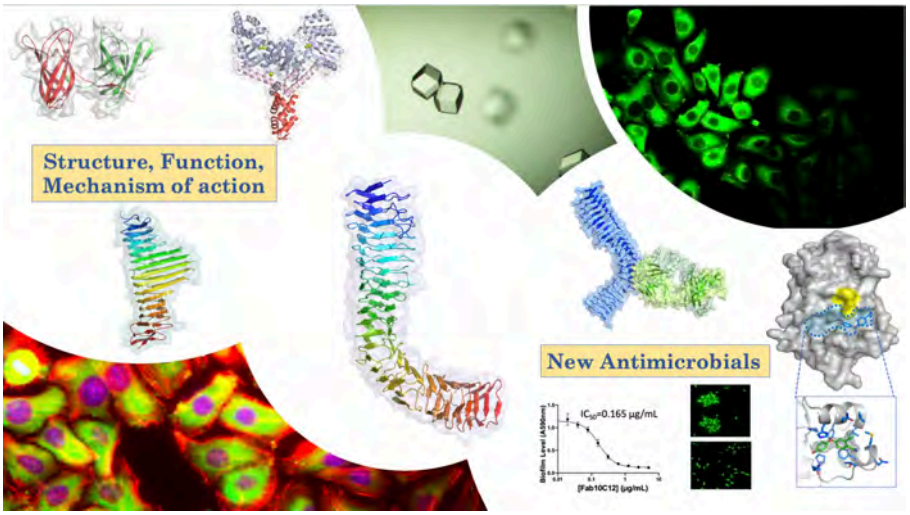
Lab members:
Mr Christopher Chong; Mr Jeremy Engwirda; Ms Bonnie Mclean; Mr Leshy Patchett;
Ms Emily Field; Mr Michael Osborne.

Fields of Study::
Nanotechnology; Biomaterials; Colloid Science; Materials Science; Cell Biology.

Capabilities and Techniques::
Bioprinting; Atomic Force Microscopy; 3D Cell Culture; Biomaterials Characterization; Rheology.

Translational Opportunities:
Long standing relationships and collaborations with Clinicians and Surgeons at St Vincents Hospital Melbourne. We also work closely with the bioprinting company CellInk Ltd.

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.

Structural Biology of Host-Pathogen Interactions Group

Our Group investigates the complex interplay of hosts and their pathogens. All life is shaped by the constant struggle between hosts and microbial threats. The interface between host and pathogens represents a major frontier for biomedical and biotechnological applications. We aim to understand at the atomic level three such molecular battlefields. We hope to understand how viruses hijack cellular defence systems to ensure their own proliferation and survival. Our second major area of interest centers on the role of small proteins that act as a first line of defence against microbial targets such as fungi, and the mechanism that these molecules use to destroy target cell membranes. And lastly, we try to understand how viruses assume control of cell polarity signalling and the impact of this on viral disease.

Crystal structure of an African Swine Fever Virus virulence factor. (Photo credit: Marc Kvansakul, Pippa Hawes)

Antimicrobial peptides in innate immunity

Defensins are small cationic proteins that are involved in innate immune processes in plants as well as humans. In plants, defensins have been shown to deliver significant resistance against plant pathogens such as fungi, however their precise molecular mechanism of action is currently not fully understood. Furthermore, defensins are also able to target cancer cells. We are currently investigating how defensins are able to attack and perforate cell membranes of pathogens as well as cancer cells. Recognition of phospholipids has been shown to be critical for the ability of defensins to attack target cells, and we are interested in understanding the structural basis for phospholipid recognition as well as membrane attack. Using X-ray crystallography we recently showed that defensins form large oligomeric complexes with phospholipids, thus for the first time shedding light onto the detailed molecular mechanism employed by defensins during innate defence.

Viral infections and cell death pathways

The programmed death of cells (apoptosis) is a critically important mechanism that enables multicellular organisms to eliminate damaged, infected or unwanted cells during development, growth and tissue homeostasis. Failure to regulate apoptosis leads to a number of diseases including arthritis, autoimmune diseases and cancer. Viruses have evolved a powerful ability to inhibit host cell apoptosis in response to viral invasion to ensure their own survival and proliferation.

Cell polarity

The establishment of cell polarity, and correct definition of where top and bottom, front and back as well as left and right are in a cell, is critically important for the formation of tissues in multicellular organisms. Dysregulation of this process is associated with the development of birth defects, more mobile and aggressive cancers as well as viral infections. Correct establishment of the different polarity axis is controlled by a network of scaffolding proteins that integrate signals from a host of cellular signalling pathways. We are interested in understanding the molecular mechanism underlying cell polarity regulation using a range of structural biology techniques including X-ray crystallography, cryo-electron microscopy and small-angle X-ray scattering.

Evolution of cell death and cell polarity signaling

Our Group's research is driven by a deep curiosity to discover how the natural world works, and a particular interest of ours centers on the evolutionary origins of some of our favorite cell signaling pathways, including those that control cell death and cell polarity. We are studying proteins that control these pathways from a range of ancient animals including Trichoplax, hydra and sponges, to understand the ancient origins of these critical signaling pathways and how they evolved over time.

Lab Head: Professor Marc Kvansakul (m.kvansakul@latrobe.edu.au)
Lab members: Ms Airah Javorsky; Mr Ben Espinoza; Mr Bryce Stewart; Ms Janesha Maddumage; Ms Shi Xuan Sum.

Fields of Study:
Structural Biology; Biochemistry; Cell Death; Innate Immunity; Cell Polarity.

Capabilities and Techniques:
X-ray crystallography; Cryo-electron microscopy; Protein interaction affinity measurements.

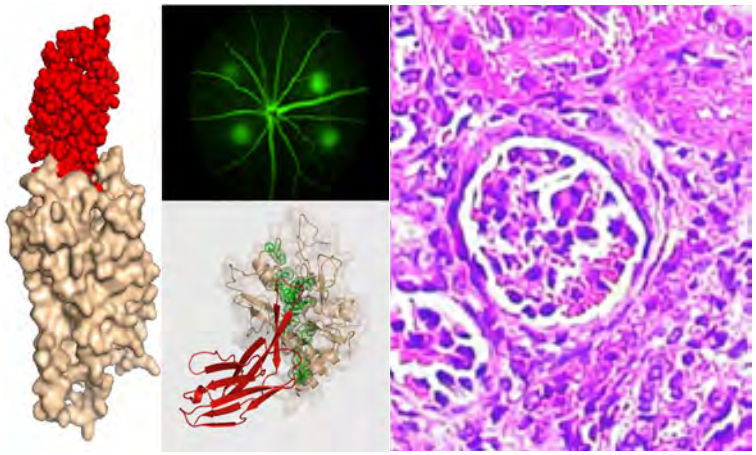
Translational Opportunities:
Drug discovery; vaccine design.

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.

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.



Inflammation in various structures

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: Assoc Prof Hamsa Puthalakath (H.Puthalakath@latrobe.edu.au) and Prof Michael Foley (m.foley@latrobe.edu.au)
Emeritus: Professor Robin Anders
Lab members: Mr Joseph Menassa; Mr Corey Pollock; Ms Valeria Impicheche; Mrs Irvin Jose; Dr Dimuthu Angage; Mr Callum Cairns.

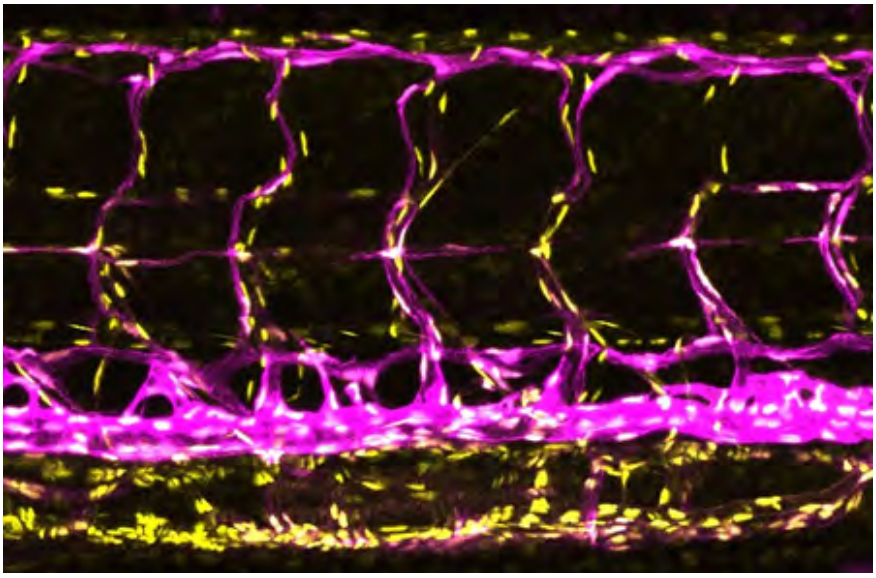
Fields of Study:
Inflammation; Innate immunity; Fibrosis; Antibody development.

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

Translational Opportunities:
Developing biologicals against human inflammatory pathologies.

Vascular 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 small molecules/mRNA therapeutics that will be tested on our zebrafish lymphoedema models.

Anti-lymphangiogenic therapeutics

We have a strong track record of using the zebrafish model to identify novel mechanisms of lymphangiogenesis. These mechanisms could be targeted to inhibit pathological lymphatic 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-lymphangiogenic small molecules. We have already identified several promising leads including 3, 4-Difluorobenzocurcumin. The mechanism of action of these leads will elucidated to potentially identify novel therapeutic targets for anti-lymphangiogenic therapy. We are also testing whether these leads could be novel therapeutics for lymphatic-proliferative diseases such as lymphatic malformations.

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 Heads: Dr Kazuhide Shaun Okuda (k.okuda@latrobe.edu.au)
Lab members: Ms Valeria Impicciche; Mr Bhavya Viradia; Ms Ira Ghosh.

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 that 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 (viral escape). If we were to develop better vaccine and drugs, it is essential to understand the mechanism of viral recognition and viral escape prior to this. Our laboratory combines both the cellular and structural approaches to understand the immune system action when face with a viral infection. Our goal is to deeper our current understanding of T cell activation and recognition mechanism, especially in the context of viral infection 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. Trying 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-19disease

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. In addition, we also aim to study the level of protection from the vaccines against variants, and over time to help inform the need for future booster shot.

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-short vaccine to be developed, instead of having the "jab" every year. Our immune system has killer T cells that are known to be protective against influenza disease, decreasing the quantity of virus (viral load) and disease severity. Understanding how T cells can be protective, what are their characteristics, would help replicate a protective immunity.

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 superior 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 Christopher Szeto; Mr Dhilshan Jayasinghe; Ms Andrea Nguyen; Mr Christian Lobos; Mr Lawton Murdolo; Mr Samuel Liwei Leong; Ms You Min Han; Ms Ha Pham.

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

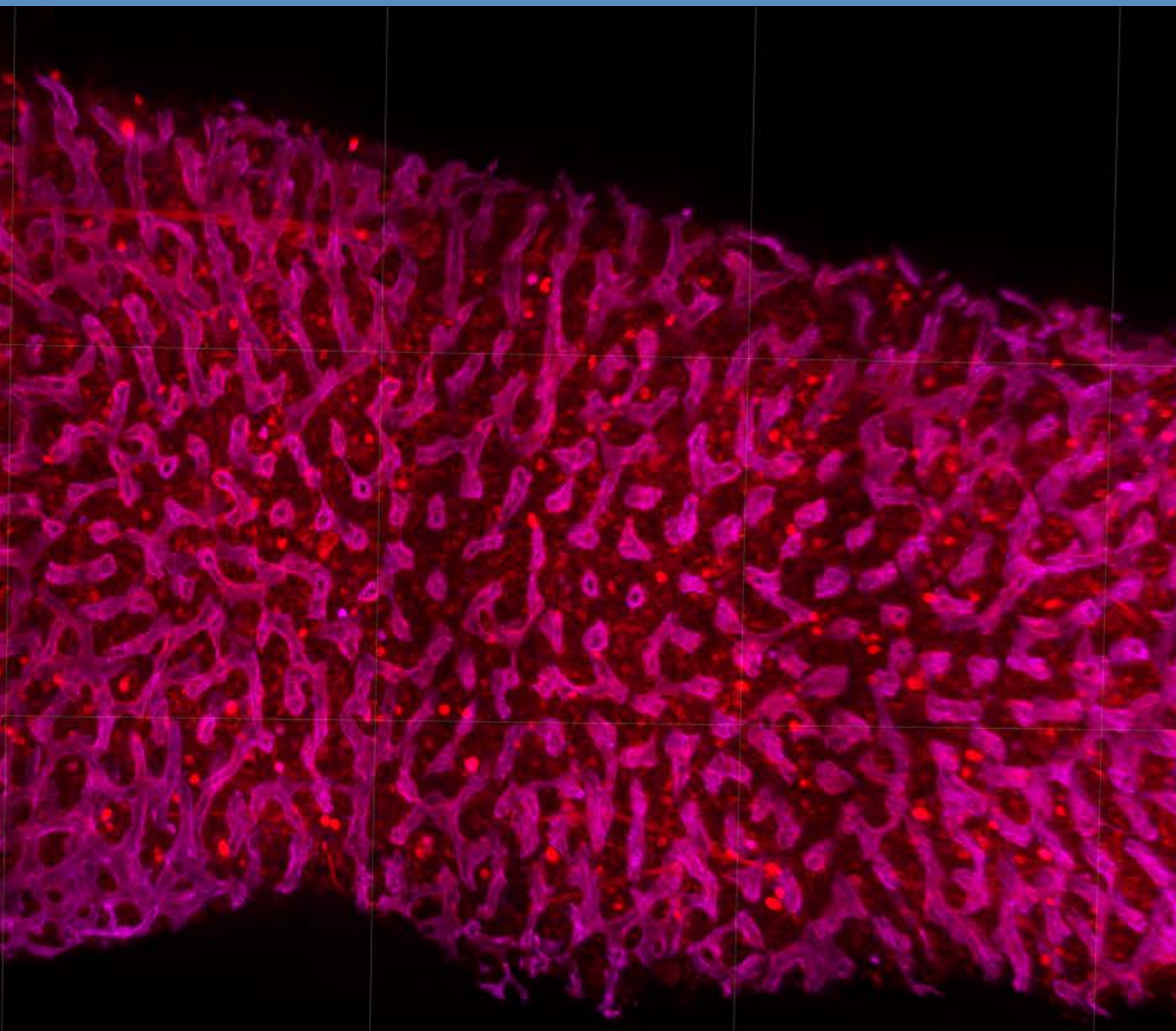
Capabilities and Techniques:
X-ray crystallography; biochemistry; protein affinity and stability measurement; sample biobank (COVID); cellular assay; immunology; T cell activation and repertoire; single cell sequence; flow cytometry.

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

Baker Department of Cardiovascular Research, Translation and Implementation

School of Agriculture, Biomedicine and Environment

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



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

Contents

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.

Baker Department of Cardiovascular Research, Translation & Implementation Research Centre

Centre for Cardiovascular Biology and Disease Research (collaboration with the Baker Heart and Diabetes Institute) / 72

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)
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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 Dementia
(Professor Garrie Arumugam)

Vascular Therapeutics and Regeneration
(Dr Kazuhide Shaun Okuda)

Strategic Partners:
Australian Cardiovascular Alliance,
Baker Heart and Diabetes Institute,
CAD Frontiers, and
Beluga Foundation.

Baker Department of Cardiovascular Research, Translation & Implementation 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.

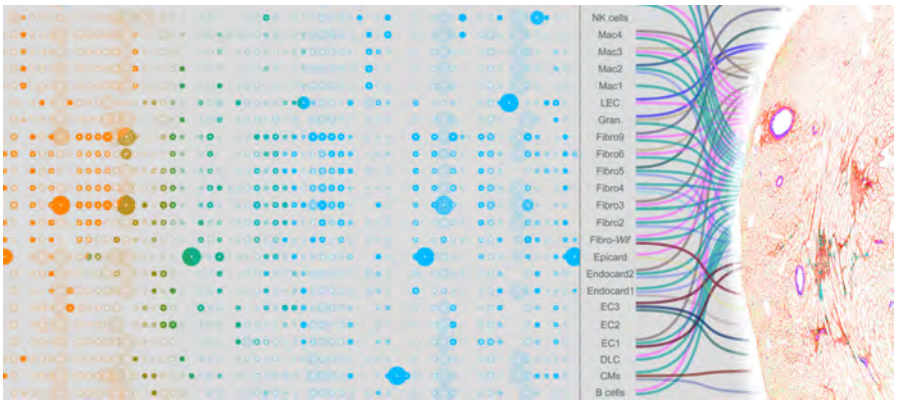
Until recently the cellular composition of the heart was poorly defined.

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.



High-dimensional spatial mapping of the heart.

Overarching goals

1. Determine how pathological changes in cardiac cell networks contribute to the development of heart failure.

2. Determine whether manipulating the cardiac cell network can influence cardiac remodelling and thus be used to prevent or treat cardiac pathologies.

3. Determine how extra-cardiac tissues and circulating factors affect cardiac cell networks.

Key areas of ongoing research

1. Determining the plasticity and elasticity of cardiac cell networks in the context of physiological stressors such as obesity and hypertension.

2. Determining the molecular and cellular drivers of these processes.

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

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

Lab Head: Associate Professor Alex Pinto (a.pinto@latrobe.edu.au)

Lab members: Dr Malathi Imiyage Dona; Mr Ian Hsu; Ms Gabriella Farrugia; Ms Taylah Gaynor; Mr Crisdion Krstevski.

Fields of Study:
Cardiac Cell networks; Cardiology; heart disease.

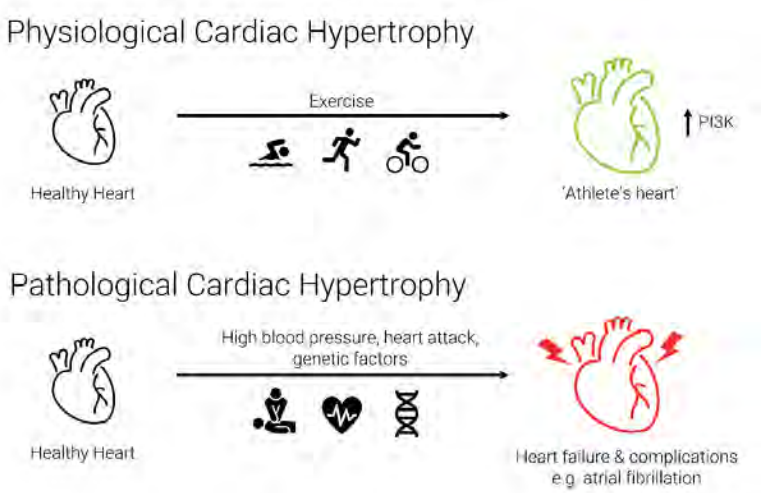
Capabilities and Techniques:
Single cell biology — including single-cell RNA sequencing, high-dimensional flow cytometry and image cytometry;
Multidimensional imaging — including 3D imaging and spatial mapping of cellular interactions;
Mouse genetics — including development of novel cell- and organ-specific genetic tools..

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.

Cardiac Hypertrophy Lab

The Cardiac Hypertrophy laboratory led by Professor Julie McMullen focuses on understanding heart enlargement, cardiac hypertrophy, through comparisons between models of health and disease: examining the enlarged athletic heart (physiological hypertrophy) in comparison to heart enlargement associated with disease (pathological hypertrophy). The team's key research involves:

1. Understanding differences between physiological and pathological cardiac hypertrophy to identify new drug targets and biomarkers for the failing heart.
2. Testing gene therapy approaches, small molecules, and dietary approaches in heart disease mouse models.
3. Understanding and preventing cardiotoxicity.



Physiological hypertrophy compared to pathological hypertrophy

Targeting novel regulators of exercise induced heart growth to treat heart failure and complications

Heart failure (HF) is a major clinical problem, affecting 1–2 per cent of Australians. The number of people diagnosed with HF is on the rise, due to an ageing population and increased rates of obesity and diabetes, posing a significant healthcare burden. Thus, strategies to protect the heart against insults such as high blood pressure, HF and heart attack are becoming more critical. In an effort to treat patients with HF, the majority of investigators have focused on blocking 'bad' genes and signalling pathways in the heart, which largely delays HF. By contrast, the laboratory is examining the possibility of activating 'good' genes and signalling pathways that may normally be activated during the induction of physiological hypertrophy (e.g. in the 'athlete's heart'). The group previously reported that the insulin-like growth factor 1 (IGF-1)-phosphoinositide 3-kinase (PI3K) pathway plays a critical role for the induction of exercise induced heart growth. Thus, activation of PI3K, or novel regulators of this pathway, represents a promising new strategy to treat HF. The ability to profile hundreds or thousands of genes, proteins, lipids and metabolites in tissues and the circulation has opened up the possibility to identify new therapeutic targets and biomarkers.

Defining differences between physiological and pathological atrial enlargement to inform strategies for the prevention & treatment of atrial fibrillation

Atrial fibrillation (AF) is a cardiac disorder. It is the most common type of arrhythmia causing an irregular heartbeat, weakness, fatigue, and dizziness. AF is associated with increased risk of mortality, stroke, and HF. Prior research focused on understanding differences between physiological and pathological enlargement of the ventricles (lower muscular chambers of the heart) to identify new drug targets for heart failure. In contrast, differences in enlargement of the atria (upper chambers) in physiological and pathological settings are largely unknown. This is a key question because atrial enlargement is an independent risk factor for AF, but not under physiological conditions. This represents a knowledge gap in the field.

Understanding cardiotoxicity and targeting PI3K to protect the heart

PI3K is a master regulator of cardiac protection, with an increase in PI3K providing protection in cardiac stress settings against pathological features including cardiac fibrosis, cell death and cardiac dysfunction. However, PI3K is amplified and mutated in a wide range of cancers. Thus, drugs inhibiting components of the PI3K pathway are being actively being developed in the cancer field. There is increasing evidence of cancer therapies increasing the risk of cardiac dysfunction, heart failure and atrial fibrillation. The aim of this research is to understand the cellular and molecular mechanisms by which PI3K protects cardiac cells, and to identify strategies for protecting the heart against cardiotoxicity.

Lab Head: Professor Julie McMullen (j.mcmullen2@latrobe.edu.au)
Lab members: Dr Bianca Bernardo; Dr Jenny Ooi; Dr Aya Matsumoto; Dr Yow Keat Tham; Dr Yi Cheng (Peggy) Chen; Ms Suzan Yildiz; Ms Emma Masterman; Ms Jieting Luo;
Mr Roger Chooi; Ms Teleah Belkin

Fields of Study:
Cardiac Hypertrophy; Heart Failure; Atrial Fibrillation; Biomarker; Cardiotoxicity

Capabilities and Techniques:

- Generating and characterising heart-specific genetic mouse models of health (exercise) and disease (surgically induced).
- Assessment of heart function in mice.
- Therapeutic approaches for improving heart function (gene therapy, AAVs, miRNAs, small molecules, dietary approaches).
- Profiling (genes, proteins, lipids)

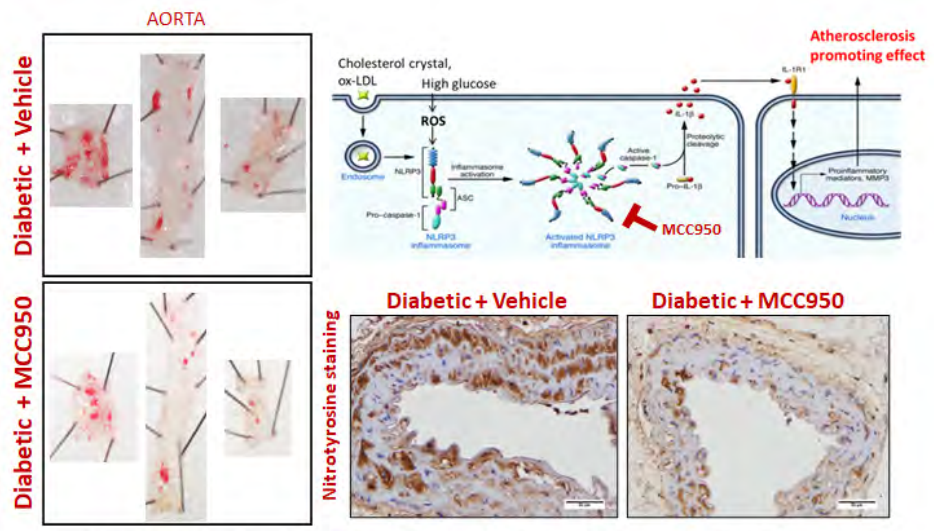
Translational Opportunities:
Gene therapy approaches are tested in large animal models, and lipidomic signatures are being assessed in blood samples from humans to examine whether the addition of circulating lipids to traditional risk factors can improve the ability to diagnose and predict cardiac risk.

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.

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.



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

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.

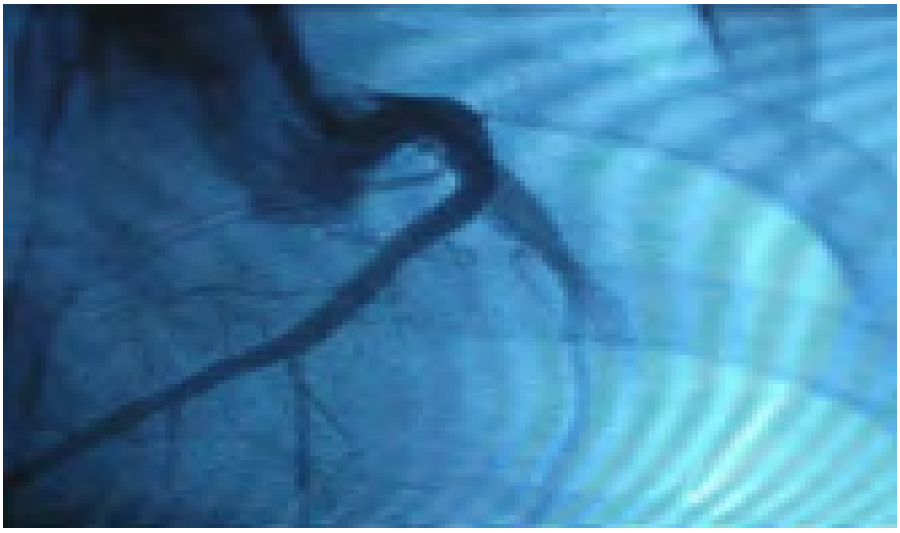
Translational Opportunities:
Data from our studies are translated into healthcare planning by providing robust estimates of disease burden.

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.

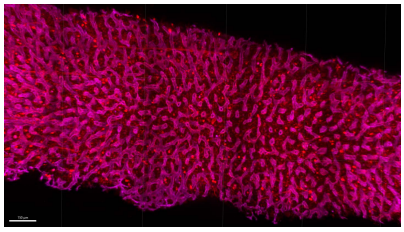
In conjunction with research work the lab is heavily focused on these clinical research studies:

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 dpspobsz!bsufsz!ejtfbtf!cz!qpnzhfojd!boe! n fubcpnjd!sjtl!tdpsjoh!)FEDBE.QNT*!bjn t!up! jefoujgz!x i fu i fs!b!qpnzhfofjd!sjtl!tdpsf!)QST*!dbo!qsfejdu!u i f!qsft fodf!pg!dpspobsz! dbnjdv n !jo!u i f!bsufsjft-!x ijd i !pddvst!x i fo! qnbrvf!jt!qsft fou/!X f!bnt p!x bou!up!gjoe!pvu! x i fu i fs!lopxjoh!zpvs!QST!ps!lopxjoh!u i f! sftvmt!pg!zpvs!DU!bohjphsbn !)b!tdbo!pg!zpvs! dpspobsz!bsufsjft*!jt!n psf!fggfdujwf!bu! sfevdjoh!dbsejpwbtdvmbs!sjtl/

PERCEIVE

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RISK-HELP

Risk-guided strategy for sfevdjoh! sfbenjttjpo!gps!Bdvuf!Efdpnqfotbufe! I fbsu!Gbjmvsf!)Sjtl. I FMQ*/!We bjn !up!jefoujgz! x i fu i fs!b!ubsh fufe!n bobhf n fou!qnbo! gpdvtjoh!po!dpousp m!pg!u i f!cpez!t!gmvje! wpmvn f-!qipof!boe!qfstpobm!gpmpx.vq-!i pn f! tvswfjmmbodf!u i spvh i !b! I fbsu!Gbjmvsf!bqq!po! zpvs!t n bsu!qipof!boe!i pn f!usfbun fou!dbo! sfevdf!sfqfbu!iptqjubm!be n jttjpo!jo!heart failure qbujfou t.

Lab Head

Prpg!Up n !Nbsxjdl (for any queries or questions, please contact EA Lisa Riddell) (lisa.riddell@baker.edu.au).

Lab members: !B0Qspg!Dptubo!Nbhovttfo-! B0Qspg!Ojuft i !Ofsnf lbs-!Es!Rvbo! I vzoi-!Es! Nbsl!Opmbo-!Es!Zvtvlf!Tbub-!Ms Boojf!Dvsujo-! Ms Bt infjh i .Hfpshjb!Ti fssjgg-!Mr Busp!B{be-! Mr Kpfn!Tn ju i -!Ms Lsjtuzo!X ijun psf-! Ms Mj{!Efxbs-!Ms Mfbi!Xsjh iu-! Mr Opb i !X fymfs/

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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

Genetic determinants of lipidomic variation and their role in cardiometabolic risk
Molecular lipid species represent unique, disease-related endophenotypes that are closer to the direct action of genes than more complex measures (e.g. lipoproteins or clinical outcomes). We hypothesise that genetic analysis of these endophenotypes, including Mendelian randomisation studies, will lead to the rapid discovery of genes and causal metabolic pathways involved in complex diseases. The application of the same 'OMICS' technology to characterise these pathways in our preclinical models will then facilitate our understanding of disease pathogenesis and the development of new therapeutic interventions.

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. We will also 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 likely to become affected by AD. Studies have identified lipids as putative biomarkers of AD risk. We aim to understand the complex relationships between lipid metabolism and dementia to provide risk assessment, early diagnosis and new therapeutic targets to halt the onset and progression of AD.

Lab Head: Professor Peter Meikle (p.meikle@latrobe.edu.au)
Lab members: Dr Corey Giles; Dr Kevin Huynh; Dr Thomas Meikle; Dr Satvika Burugupalli; Dr Sudip Paul; Dr Tingting Wang; Dr Jingqin Wu; Dr Habtamu B Beyene; Dr Alexandra George; Dr Aleksandar Dakic; Dr Yow Keat Tham; Dr Mary Temidayo; Ms Natalie Mellett; Ms Thy Duong; Ms Michelle Cinel; Ms Alexandra Faulkner; Ms Yvette Schooneveldt; Mr Gavriel Olshanksy; Mr Nicholas Sing.

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

Capabilities and Techniques:
Tandem mass spectrometry; Study design; Lipid extraction; Liquid chromatography mass spectrometry; Data extraction and analysis; 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).

Translational Opportunities:
We currently engage with a number of industry partners to progress the 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: Associate Professor Xiaowei Wang (Xiaowei.Wang@latrobe.edu.au).

Lab members:
Dr Laura Bienvenu, Dr Jonathon Noonan, Dr Mark Vidallon, Ahmed Refaat, Naomi Philosof, Aidan Walsh, Henry Gordon, Jath Palasubramaniam, Shania Prijaya, Yuyang Song, Viktoria Bongcaron, Haikun Liu, Ashish Vincent

Fields of Study:
Cardiovascular Diseases, Imaging, Targeted Drug, Nanotechnology, Recombinant antibodies

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 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 Environment and Genetics

School of Agriculture, Biomedicine and Environment

Scientists working across ecology, evolution, biodiversity, botany, zoology and environmental science

Working in the Alpine region, Victoria (Photo Credit: John Morgan)

Contents

Department of Environment and Genetics

The Department of Environment and Genetics consists of 30 continuing and fixed-term academic staff, including one ARC Future Fellow, one ARC DECRA Fellow and six Postdoctoral and Research Fellows.

The Department has a dynamic higher degree by research program that reflects the disciplinary interests of the staff. We are currently training 60 PhD students and 20 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, 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

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

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.

The Department maintains a diverse portfolio of research programs encompassing the full range from fundamental to highly applied, with particular strengths in terrestrial ecology encompassing plant and animal ecology, landscape ecology, conservation, ecological genetics, invasion biology and fire ecology and management (https://www.latrobe.edu.au/ecology-environment-evolution).

Members of the Department are also key contributors to La Trobe's new 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 '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:

- Research Centre for Applied Alpine Ecology
- Research Centre for Future Landscapes (collaboration with the Arthur Rylah Institute of DELWP)
- Centre for Freshwater Ecosystems (formerly the Murray-Darling Freshwater Research Centre)

Department of Environment and Genetics Research Centres

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, the 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
- Fire ecology
- Invasive alien species
- Behavioural ecology
- Insect ecology
- Plant ecology
- Environmental geoscience
- Agronomy
- Microbial ecology
- Conservation genetics
- Landscape planning

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

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

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.

https://rcaae.org/

Department of Environment and Genetics Research Groups

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

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).

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

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.

Biodiversity Science and Application Group

Plant and animal populations and communities, in natural and managed landscapes, are changing. Some species are becoming more abundant, (e.g. pests and diseases). Others are becoming more rare and are disappearing from local landscapes. These changes are a result of interactions between climate change, biological invasion and habitat transformation. In order to secure biodiversity and ecosystems and their contribution to human well being, our research measures and models the abundance and distribution of species, turnover in communities and what this means for ecosystem services. Our research advises environmental policy and management. We work at scales from protected areas to continents and globally, on plants, birds, insects and microbes, and from Australia to the Antarctic.

Sweet pittosporum – native to parts of Australia, but invasive in others (Photo credit: Melodie McGeoch)

The role of common species in biodiversity change and function

Common species are often iconic and play important roles in maintaining resilient ecosystems. We study how common species change across regions and how this affects the functions that biodiversity provides across natural and managed landscapes. Our research includes problem species on the increase and common native species in rapid decline. We are developing new theory and improved biodiversity models for quantifying the dynamics of common species and their contribution to sustaining life on land.

Biodiversity observation networks and sustainable knowledge management

Bioindicator systems assess and monitor biodiversity performance and ecosystem policy worldwide. Biodiversity informatics and Essential Biodiversity Variables research aim to design and deliver policy-relevant information that is findable, accessible, interoperable and retrievable by countries, policy makers and researchers. Our research, with worldwide collaboration, builds and supports country-level Biodiversity Observation Networks and biodiversity information systems (www.geobon.org).

We identify minimum data sets that are scientifically robust with uncertainty measures, for example, for assessing and monitoring the state of biological invasion states at sub-national to global scales.

Analysing and predicting biodiversity change

Changes in species population and ecological communities composition affect human wellbeing in many ways – including plant productivity via plant pollinators, natural enemy networks, disease, and soil function. Our research uses properties of presence-absence data to design metrics and methods to estimate species abundance from occupancy, scale species distributions, quantify multispecies compositional change and its drivers (multi-site generalized dissimilarity modelling) for species and interaction networks.

Antarctic science for a sustainable future

Our research for Securing Antarctica's Environmental Future (SAEF) on biodiversity status and trends uses downscaled climate and environmental information, novel biodiversity data, and integrated biological and geochemical proxies, to produce transformative insights about the structure, function and drivers of biodiversity across the region.

We inform conservation planning and provide a scientific basis for Antarctica's environmental stewardship.

Lab Head: Prof Melodie McGeoch (m.mcgeoch@latrobe.edu.au)

Fields of Study:
Population Ecology; Community Ecology; Ecological Applications; Invasive Species Ecology; Climate Change Ecological Impacts.

Capabilities and Techniques:
Monitoring system design; Indicator development; Measurement, modelling and analysis of living systems; Biodiversity informatics; Risk assessment; Invasive Alien Species Impact assessment; Sustainable Development for life on land.

Translational Opportunities:
Biodiversity & policy monitoring; Environmental change indicators for policy monitoring; Evidence-based policy & reporting assessments; Invasive alien species; Risk assessment; Sustainable biodiversity knowledge management.

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.

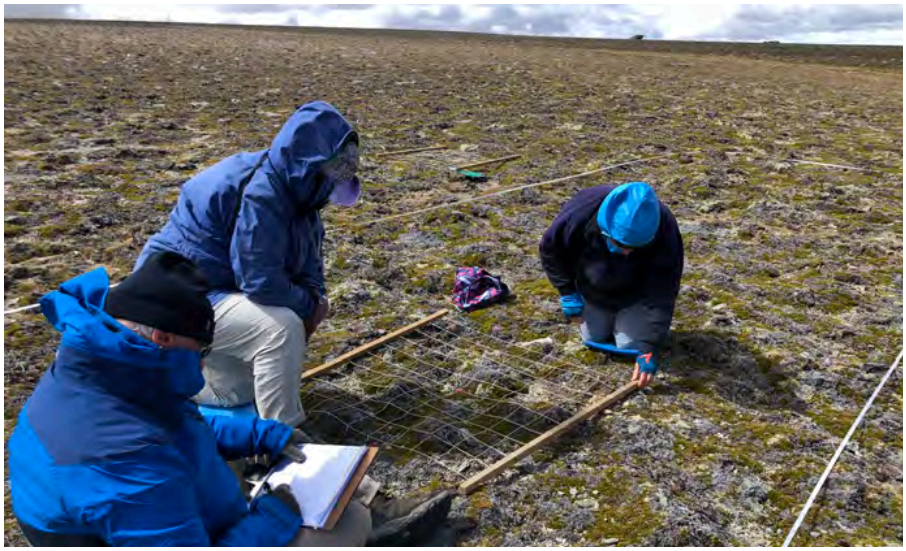
Fields of Study:
Freshwater Ecology; Environmental Chemistry; Biogeochemistry; Ecotoxicology.

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

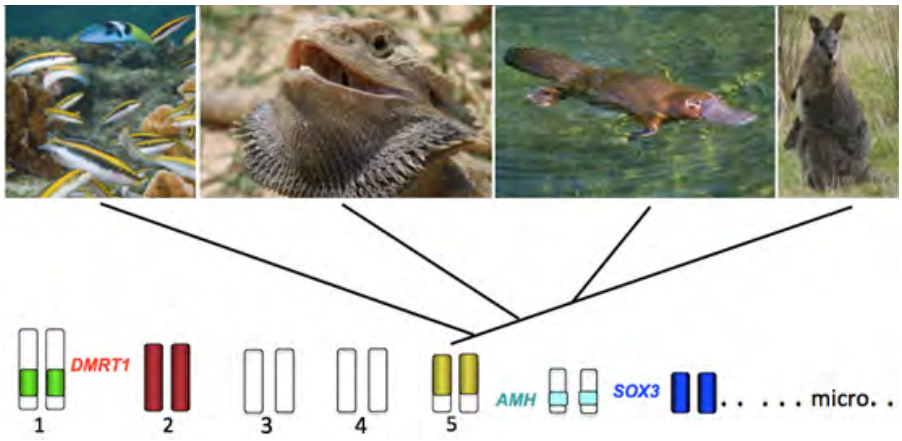
Prof Jenny Grave's comparative genomics research is via national and international collaborations.

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.



Comparative genomics cladogram (Diagram credit: Jenny Graves)

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.

Ecology and Conservation Group

The Ecology and Conservation laboratory addresses questions about how ecological communities are assembled, the interactions that occur between species in communities, and the conservation of communities and species that are under threat. We work in a variety of ecosystems from forest to alpine grasslands, and work on a range of organisms.

Biotic Filters to Community Assembly

Community ecology aims to understand the processes that separate a local community from a regional pool of species. These processes act as ecological filters that admit to a local community only those species that can persist under local conditions. These filters can be both abiotic (climate, soils etc) and biotic (predators, pathogens, competitors etc). The Group studies red land crabs, invasive yellow crazy ants and scale insects as biotic filters to the local assembly of rainforest seedling communities on Christmas Island (Indian Ocean). The rainforest ecosystem is notable for its high level of species endemism, recent species extinctions, and high-profile biological invasions. For more than three decades the Group has led research to understand the many species interactions which drive this ecosystem and the rise to dominance of yellow crazy ants. In collaboration with Christmas Island National Park we implement and monitor a major program of indirect biological control against the ant, targeting its key scale insect mutualist. We aim to mitigate invasive species threats and permit recovery of key species such as the Christmas Island Red Land Crab.

Maintenance of Species Diversity

Communities consist of a few common species and many rare ones. One general idea is that rare species 'avoid' going locally extinct by performing better (higher rates of recruitment, lower rates of mortality etc) than more common species. To test this we study forest dynamics on the Connell Rainforest Plot Network, Queensland. We conduct long term demographic monitoring of rainforest trees to study diversity mechanisms in tropical and subtropical rainforests.

Christmas Island Red Land Crab (Photo credit: Pete Green)

We tag and map all rainforest trees recording size (height or girth), free-standing stems of shrub and tree species. In 1963, Prof Joseph H. Connell (University of California) initiated these plots and sampling has been done ever since. We use molecular techniques to study the microbial root rhizosphere communities, their impacts on growth and potential to mediate plant species richness.

Trait-Based Determinants of Community Assembly

Species are filtered from the regional pool according to their key functional traits, and differences in filter number, type, and strength lead to variation in local community composition. Species sharing similar key functional traits share the same ecological 'strategy' and these reveal the selective forces that shape plant evolution. Grouping plants by their strategies provides a means of predicting vegetation responses to global change. We use the C-S-R Plant Strategy Scheme to assess long-term vegetation change in the Victorian Alps under climate change and the relaxation of cattle grazing.

The ecology and conservation of Phylogenetically Distinct species

These species have no or few close relatives, and are of special significance for phylogenetic diversity conservation. Our group works on the seabird Abbotts Booby and the grassland bird Plains Wanderer to study key habitat conservation management issues.

Lab Head: Assoc Prof Pete Green (p.green@latrobe.edu.au)

Lab members:
Ms Christina Lipka; Mr Dan Nugent.

Fields of Study:
Conservation; Invasion Biology; Theoretical Ecology; Community Ecology; Population Ecology.

Capabilities and Techniques:
Expertise in the long-term monitoring, especially of plant communities on permanent plots; Multivariate statistics.

Translational Opportunities:
Community-level plant traits measuring to monitor environmental change rather than species monitoring; Natural area biological control for conservation; Management of phylogenetically distinct species using population conservation ecology 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.

Fire and Avian Ecology Group

Our Group investigates how threatening processes like fire, drought and over-abundant native species affect the ecology and conservation of native fauna. We conduct research at multiple scales, from single species, to communities of organisms and whole landscapes. Our goal is to conduct research that informs better management of our wildlife and landscapes. The research is collaborative and involves local, national and international partners. The Group's work combines a deep understanding of the ecosystems we work in, solid empirical data collected in the field and the latest remote sensing data to identify patterns and processes driving changes in ecological communities. Our goal is to conduct research that informs improved management and conservation of the world's wildlife and ecosystems.

Bushfire ravaged land in Australia. (Photo credit: Mike Clarke)

Fire Ecology

Our Group has a strong track record of studying the impact of fire on fauna. Until early this century, fire managers assumed catering for the needs of plants would also meet the needs of fauna. Our research has challenged this assumption and demonstrated the significant risks associated with some management practices. Our research been influential in changing the way fire is managed. In collaboration with Prof Andrew Bennett and Assoc Prof Jim Radford, we are studying the effects of fire on the conservation of flora and fauna in a range of several ecosystems including Mallee woodlands and heathlands, Foothills forests, Box-Ironbark Woodlands and the diverse plant communities of Wilsons Promontory National Park.

Threatened species

A range of past and present projects by our Group have investigated the conservation biology of threatened species. These include work on the endangered Black-eared Miner, the Helmeted Honeyeater, Regent Honeyeater and Eastern Bristlebird. Current projects include work on the Mallee Emu-wren and the Shy Heathwren. All of these projects have focused on understanding the basic biology of the species and identifying the key threatening processes that continue to endanger them and what management actions are most likely to enhance the species' survival.

Native Pests

Some of our research has focused on a particular genus of native honeyeaters – the Miners (*Manorina* spp). Two of the four species in the genus (Noisy Miners and Yellow-throated Miners) form extensive permanent colonies and are notoriously territorial. Our research was the first to experimentally demonstrate their extraordinary capacity through indiscriminate aggression to exclude a wide range of other woodland species from their colony's territory. Human alteration and fragmentation of woodland habitats has profoundly advantaged these species of Miner, to the significant detriment of other woodland birds, many of which are now endangered. Our research explores which factors exacerbate or ameliorate the impact of these now over-abundant and expanding native miners.

Conservation Biology

Our Group's research is driven by a deep curiosity to discover how the natural world works. Whether we are studying a single species' nesting behaviour, a bird community's recovery after fire or factors that determine how a whole ecosystem will respond to Climate Change, our goal is to increase understanding of natural systems so that they can be conserved, valued and enjoyed by future generations.

Lab Head: Emeritus Prof Mike Clarke (m.clarke@latrobe.edu.au)

Lab members: Dr Angie Haslem; Dr Simon Verdon; Mr Rhys Makdissi.

Fields of Study:
Ecology; Conservation Biology; Behaviour; Evolution.

Capabilities and Techniques:
Field-based ecological assessment in remote localities; Conceptual modelling of complex systems; GIS and mathematical analysis of complex data sets.

Translational Opportunities:
Fire management; Threatened species conservation; Park management; Pest species management.

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.

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.

Tagged Barramundi ready for release (Photo: David Crook)

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.

Insect Ecology Group

Our research focus is on the ecology and conservation of insects and other terrestrial arthropods, which are vital contributors to biodiversity and ecosystem function. Our emphasis is on biotic and abiotic drivers of community structure. We work in various ecosystems (including deserts, temperate woodlands and boreal forests) and use field and laboratory experiments, mensurative surveys and databases.

Understanding ecological communities using species traits

An ecological community is a group of organisms that coexist in an environment. We use functional trait-based approaches to study the structure of ecological communities. Functional traits of organisms (e.g. morphology, physiology, behaviour) affect survival and reproductive success and are critical for identifying general rules in ecology. We study traits and environmental relationships of communities and examine how these vary in response to anthropogenic disturbances and climate. We co-developed a new model-based fourth- corner statistical analysis that allows ecologists to better predict how species traits might change in response to environmental change. We lead the Ant Traits International Collaboration, a worldwide collaboration of over fifty researchers studying trait-environment relationships and the impacts of global change. Our research shows very large ants, very small ants and predatory ants do worse following human disturbances, leaving a "mediocre" ant fauna.

Using experiments to understand species interactions in the field

Species interact with both the environment and one-another. We use experiments to understand how species interactions regulate community structure. The importance of a process depends on scale, so we work at multiple scales. We study competitive interactions in ant assemblages and their regulation by environmental factors (e.g. forestry). Our research has shown that the impacts of Swedish red wood ants on other ant species ranged from facilitative in recently clear-cut sites to negative in established forests.

Calomyrmex purpureus (beauty ants) prior to social carrying. (Photo credit: Ajay Narendra)

Cascading effects of mammal extinctions on Australian ecosystems

European colonisation led to the loss of thirty Australian mammal species and declines in many others. We use reintroductions of threatened mammals as models for pre-European Australian ecosystems. We test the impacts of returning long-lost species on biodiversity and ecosystem functioning, looking at soils, microbes, plants and invertebrates. By using sanctuaries distributed across Australia, we test the impact of ecosystem productivity (rainfall) on ecosystem functions performed by threatened mammals. Our research has shown that native mammals have large cascading impacts on plant assemblages and invertebrate prey and improve soil functioning, especially in arid climates.

Conservation interventions in managed landscapes

We develop new methods to improve the success of terrestrial arthropods after anthropogenic disturbances, (e.g. agriculture, forestry) or natural disturbances (e.g. fire). Our work focusses on factors that enable dispersal-limited and habitat-specific species to recolonise. Examples of these conservation interventions, include adding dead wood and reintroducing entire litter invertebrate assemblages ('rewilding with minibeasts').

Lab Head: Prof Heloise Gibb (h.gibb@latrobe.edu.au)

Lab members: Dr Lily Leahy; Mr Peter Contos; Ms Hannah Riskas; Ms Lucy Johansson; Ms Chloe Robinson, Ms Amelia Carlesso; Ms Kylie McGennisken, Mr Andrew Chalmers.

Fields of Study:
Community Ecology; Restoration Ecology; Functional Ecology; Macroecology; Entomology.

Capabilities and Techniques:
Field invertebrate sampling and experimentation; Invertebrate identification; Statistical modelling,; Ecophysiology.

Translational Opportunities:
Restoration ecology: using invertebrates to improve damaged land restoration; Sustainable management of natural areas.

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. In collaboration with Professor Mike Clarke, 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 Squirrel Glider and Brush-tailed Phascogale; more widespread species such as Yellow-footed Antechinus 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: Associate Professor Jim Radford (j.radford@latrobe.edu.au)

Lab members:
Adjunct Prof Andrew Bennett;
Dr Angie Haslem; Dr Alex Maisey;
Dr Fred Rainsford; Dr Grace Sutton;
Dr Simon Verdon; Ms Jacinta Humphrey;
Ms Rachel McIntosh; Ms Jessica Kelley; Ms Charlotte Hall; Ms Georgia Glossop.

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.

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

La Trobe University Herbarium

The Department of Environment and Genetics (DEG) houses an internationally registered herbarium with over 25,000 vascular plant specimens, c. 10,000 of which are fully curated (pressed, mounted, labelled). 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 in the Department of Environment and Genetics 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 DEG) 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 the last 3 months alone, over 200,000 records from LTB's database were downloaded in almost 2000 separate download events. There have been over 3.3 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.

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.

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.

Blanche Cup Spring, South Australia (Photo credit: Nick Murphy)

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.

Nematode Genomics Laboratory

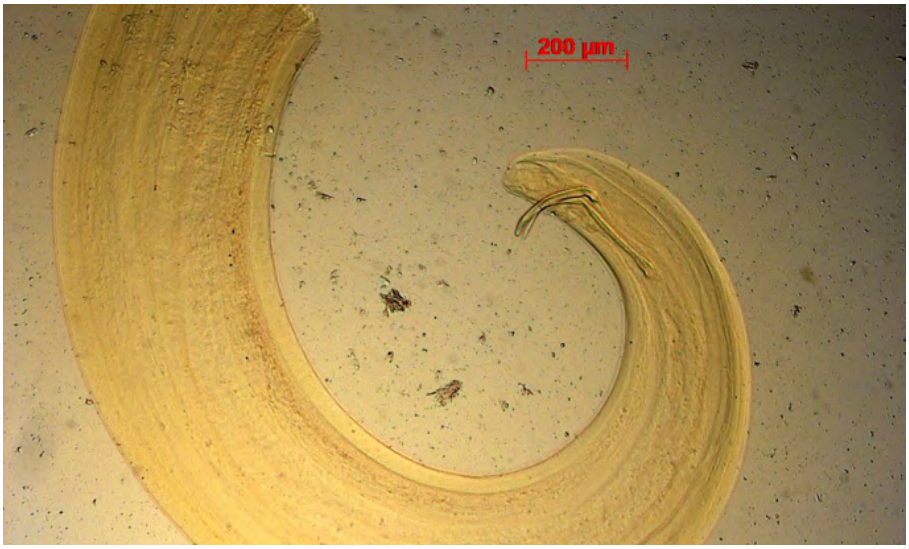
Our research, which involves national and international collaborators, aims to improve our ability to understand and eliminate parasitic nematodes, particularly those that occur in resource-poor settings. We use genetics, genomics, bioinformatics, and mathematical modelling to assess solutions to challenges faced by people at risk of parasite infection.

Population genetics and parasite transmission

Filarial nematodes, which cause onchocerciasis or lymphatic filariasis, are controlled using mass drug administration to as many people in a community as possible. Parasite elimination requires interrupting parasites transmission permanently and requires that drugs are given until transmission stops across the whole transmission zone. We use population genomics of the parasites and their vectors to identify transmission zone boundaries (a transmission zone is the region through which parasites are transmitted, but between which parasite transmission is rare) then combine these genetic analyses with spatially explicit epidemiological models to assess re-invasion risk between zones and inform surveillance once treatment is stopped. Our models aid control programs to decide when and where to safely stop drug distribution.

Ecological genetics of drug resistance in parasites

Anthelmintics are drugs that kill nematode parasites. The evolution of anthelmintic resistance threatens effective control of these parasites in humans and livestock. We investigate anthelmintic resistance mechanisms in a range of laboratory and field systems by identifying genes that are under selection then testing their functions, and have developed sensitive molecular diagnostic tests for changes in these genes in treated populations.



Dog heartworm tail (Photo credit: Haylo Roberts)

Nematodes with unusual life histories: models for the evolution of parasitism

Some nematode genera are unusual as they have both free-living and parasitic life cycles. In *Parastrongyloides* the choice of life cycle is determined by environment at the start of each generation and can be manipulated by cultural conditions. This enables identification of the genetic components of the switch and investigation of the genetic steps that may occur in the evolution of a nematode parasite from a free-living ancestor. We also study the impact of free-living development in the related human parasite, *Strongyloides stercoralis,* on its epidemiology and the evolution of drug resistance.

Host switching, endosymbionts and the evolution of pathogenesis in filarial parasites

Onchocerca volvulus, the cause of river blindess, is the product of a recent host-switch from cattle into humans. *Cercopithifilaria johnstoni,* a native rat/bandicoot parasite, also has a history of recent host switching and similar pathology in its new hosts.

We are using comparative genomics amongst species of to study host- switching and pathogenesis in nematodes, including the potential roles of endosybiont bacteria in filarial worms.

Lab Head: Prof Warwick Grant (w.grant@latrobe.edu.au)

Lab members: Dr Shannon Hedtke; Dr Karen McCulloch; Dr Gowtam Chalasani; Dr Katie Crawford; Ms Mary Awobifa; Mr Ernest Gyan; Ms Kirsty McCann; Ms Ellyse Noy; Mr Haylo Roberts; Mr Himal Shrestha; Ms Neha Sirwani; Mr Jordan Baldacchino.

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; zoonotic human health risk identification; effects of environmental changes on vector transmission potential.

Nutritional Adaptation and Genetics Lab

My research combines life history traits, biochemistry, and genetics to connect genotype with phenotype. I study natural populations of Drosophila flies and utilize the powerful D. melanogaster genetic system to genetically dissect selection for dietary sugar tolerance and for the functional consequences of mitochondrial DNA (mtDNA) genotype. During the SARS-CoV-2 global pandemic I pivoted to monitor virus levels in wastewater and in natural waters. In collaboration with Dr. Steve Petrovski's laboratory (Microbiology), I am continuing to study RNA virus in water environments. The RNA viruses are of particular interest due to their role in regulating bacterial populations.

Dietary Sugar Tolerance

How dietary selection influences the evolution of genomes and species is a poorly understood question with ecological and medical relevance. My research focuses on the genetics of dietary sugar tolerance. I use a hybridization/ phenotype selection approach to identify genomic regions and genes that differ between closely related species that are tolerant or intolerant of dietary sugar. The approach has identified that mitochondrial ribosome biogenesis and specific cell signalling pathways contribute to dietary sugar tolerance in flies. Testing the response of life history traits to dietary sugar along with gene expression informs the boundaries of trade-offs that are available to natural populations when faced with diet competition or change in the dietary environment.

Phenotypes associated with specific mitochondrial DNA haplotypes.

In addition to providing energy for eukaryotic cells, mitochondria send signals to the nucleus that convey crucial information about cell status and nutrient environment. Metabolites produced in the mitochondrion act as signals that evoke epigenetic regulation of gene expression. Mutations in the mitochondrial DNA that alter metabolite balance can therefore have widespread influence on phenotype and organism response to the diet environment.

Collecting water samples to assess presence of pathogenic viruses (Photo credit: Alex Kormann)

My research aims to understand the functional role of mtDNA in adaptation to the diet environment. I use laboratory evolution to select mtDNA from natural populations of flies that are fed on high sugar or ketogenic diets. Organism phenotype and gene expression across a range of diets is used to determine the dietary and metabolic flexibility associated with mtDNA haplotype.

RNA virus in wastewater and natural waters

RNA viruses have a profound influence in aquatic and terrestrial ecosystems. Members of the group infect hosts from all branches of life and evolve rapidly due to their high mutation rate. Characterizing the population dynamics of the RNA viruses is of interest because the group includes important historical and emerging pathogens and because RNA viruses influence ecosystems by placing strong selective pressure on host genomes. In collaboration with Dr. Steve Petrovski (Microbiology) I am characterizing the community composition and dynamics of RNA viruses in wastewater and marine environments.

Lab Head: Dr Richard G. Melvin (r.melvin@latrobe.edu.au)

Fields of Study:
Genetics; Quantitative Life History Traits; Biochemistry; Molecular Biology; Evolution.

Capabilities and Techniques:
Drosophila melanogaster genetics; mitochondrial bioenergetics; genomics/ transcriptomics; gene expression analysis; Quantitative phenotyping; Python, R, and Julia programming.

Translational Opportunities:
Species conservation; Diet and metabolic disease; Mitochondrial disease; Wastewater; Waterborne viral pathogens.

Plant Reproduction and Conservation Genetics Group

Our research is diverse and includes aspects of plant conservation, demography, ecology, reproduction and genetics. Our group has a strong research interest in the conservation genetics of native flora but also undertakes foundational research involving other native plants, and applied studies in relation to weeds and crops. We are collaborative and work with colleagues from other local, national and, at times, international institutions. A variety of techniques are used by the group including traditional field-based ecological approaches and morphological investigations, as well as single gene studies associated with mate choice and massively parallel, next-generation genomic approaches.

Grevillea alpina. (Photo credit: Susan Hoebee)

Unravelling the evolutionary history of iconic Australian plants
Using genetic approaches coupled with pollination studies, we aim to identify processes involved in speciation in a number of Australian plants genera including *Banksia, Callistemon* and *Grevillea*. In these studies, the identification of processes underpinning population structure and species evolution will aid conservation management for several taxa.

eDNA approaches to the study of pollination
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. To give a stronger link to pollination traditional approaches are needed that observe animal behaviour on the flowers and to confirm pollen transport. We are tackling this question in a threatened grassland community.

Harnessing Genetics to Restore Resilience in East Gippsland's Threatened Flora
Following the 2019/2020 Black Summer Bushfires, La Trobe University and Envite Environment 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 our chosen plant taxa are the focus of this collaborative work.

Collaborators: Envite Environment

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, as well as weed control and crop and horticultural breeding programs. SI related research has been contracted by the Australian Nurserymen's Fruit Improvement Company Ltd.

Collaborators: Anthony Gendall (LTU - APSS)

Lab Head: Dr Susan Hoebee
(s.hoebee@latrobe.edu.au)

Lab Members:
Mr Mark Clifton;
Ms Allison Menzies;
Ms Jennifer Longo;
Mr Stanislaw Wawrzyczek.

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.

Translational Opportunities:
Species conservation, utilisation and/or management; Plant breeding; Genetics 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:
Mr Andrew Bird; 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.

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.

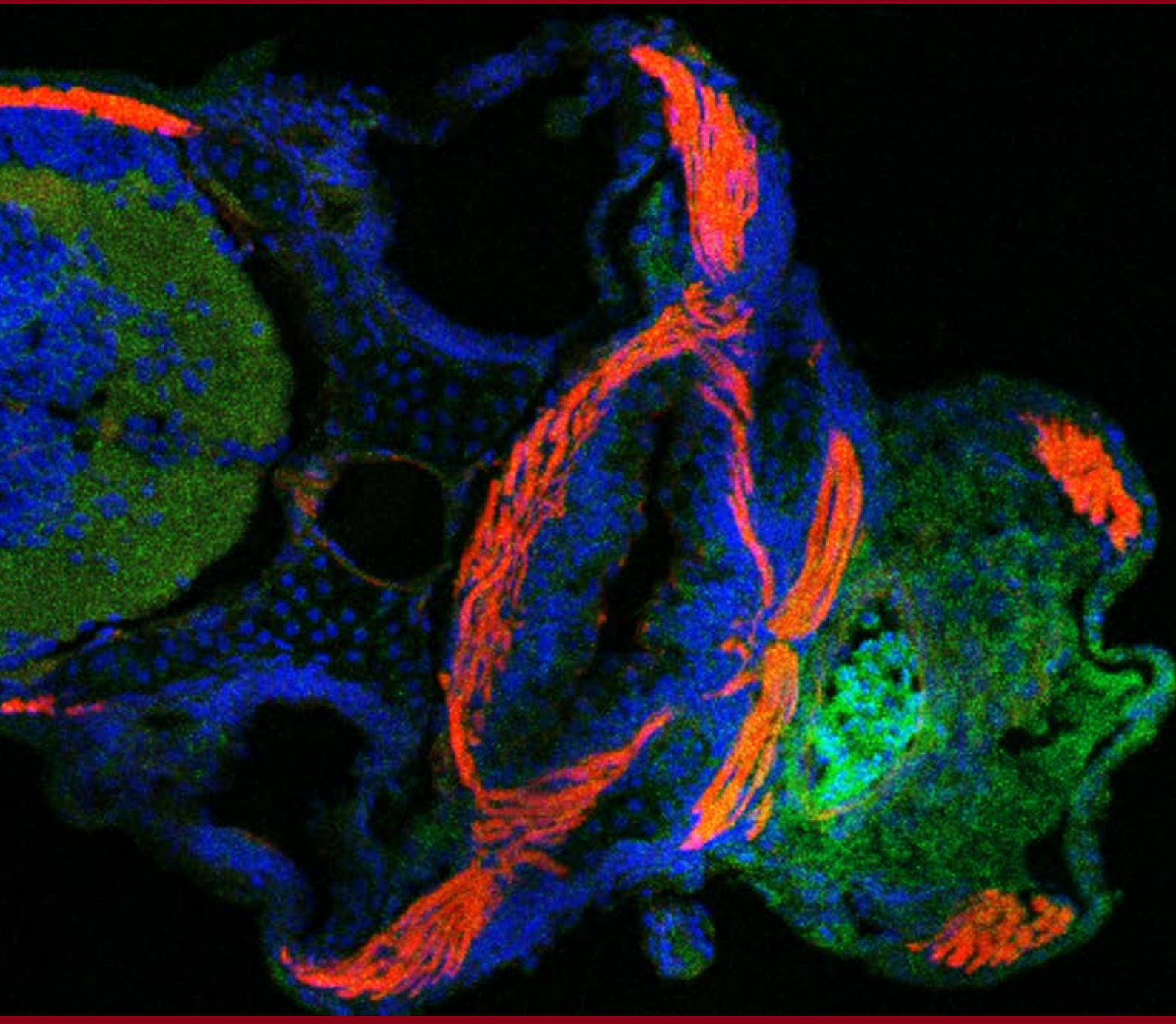
Capabilities and Techniques:
Quantitative modelling: spatial, GIS, population models; Species-distribution; Environmental hydrology; Food-web ecology (stable isotopes use; Molecular techniques (population genetics, eDNA).

Translational Opportunities:
Water resources management and policy; Catchment management; Climate change impact and mitigation; Environmental impact assessment; Habitat restoration; Spatial prioritisation and conservation planning.

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.)



Expression of fibronectin in the anterior region of a zebrafish larva (Photo Credit: Nishanthi Mathiyalagan)

Contents

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 more than 60 continuing and fixed-term academic staff, including one Tracey Banivanua Mar Fellow, one ARC Future Fellow, one ARC DECRA Fellow, and one NHMRC/National Heart Foundation ECR Fellow. Professor Grant Drummond 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 30 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

Department of Microbiology, Anatomy, Physiology and Pharmacology Research Centre

Centre for Cardiovascular Biology and Disease Research (collaboration with the Baker Heart and Diabetes Institute) / 119

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 Dementia
(Professor Garrie Arumugam)

Vascular Therapeutics and Regeneration
(Dr Kazuhide Shaun Okuda)

Strategic Partners:
Australian Cardiovascular Alliance,
Baker Heart and Diabetes Institute,
CAD Frontiers, and
Beluga Foundation.

Department of Microbiology, Anatomy, Physiology and Pharmacology 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.

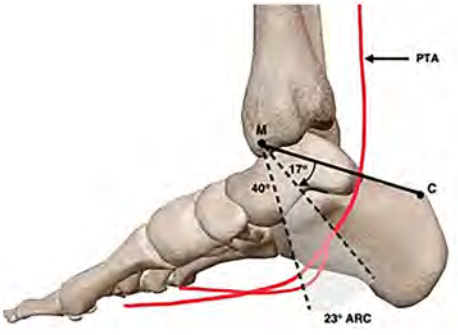
Therefore, there must not be much more to study!

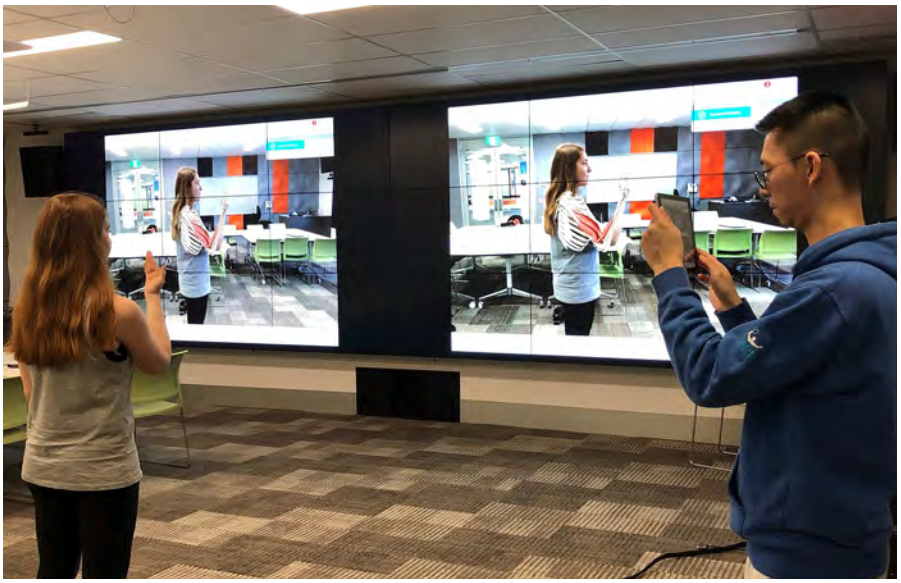
However, anatomical research continues to make new discoveries about the human body, such as identifying new structures previously unknown (e.g. there are actually five muscles forming the 'quadriceps femoris' group, and there are lymphatics in the brain when previously it was thought there were none).

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.

Group Head:
Assoc Prof Aaron McDonald
(a.mcdonald@latrobe.edu.au)

Group Members:
Dr Laura Whitburn;
Dr Heath McGowan

Students:
Ms Melby Tentrisanna;
Ms Bridget Marchese;
Mr Shane Cassar

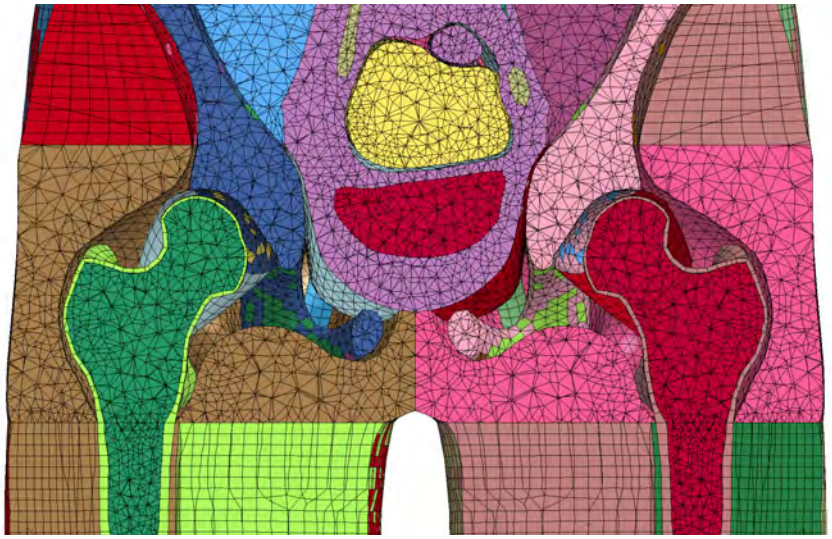
Fields of Study:
Gross anatomy; topographical anatomy; higher education research in human anatomy.

Capabilities and Techniques:
Human dissection; MicroScribe; 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.

Anthropometry and Impact Biomechanics Laboratory

The application of human topographic anatomy to various disciplines is the main focus of this laboratory. The multidisciplinary approach of combining anatomical and biomechanical techniques to investigate injury prevention strategies has constituted the majority of work to date. Research has concentrated on hip fracture prevention, particularly the role of the gluteal muscles as an energy absorption medium when using energy shunting type hip protectors. Anthropometric studies have quantified variations in pelvic bony and soft tissue anatomy to improve the design of hip protectors and other prosthetic devices. This laboratory has a number of existing local and national collaborations including the Victorian Institute of Forensic Medicine (VIFM), The Forensic Engineering Society of Australia (FESA), The University of Melbourne (Body Donor Program) and the University of New South Wales (Transport and Road Safety Research Centre).



THUMS pedestrian fracture baseline
(Photo credit: UNSW, Transport and Road Safety Research Centre)

Anatomical and biomechanical basis of hip protector design

Hip fracture is a major cause of death and disability among older persons. Anatomical and biomechanical design considerations for shunting-type hip-protectors is being studied by this laboratory. Hip protectors are protective devices worn over the hip region to protect against injury during a fall by redistributing kinetic energy to adjacent anatomical structures. To date work has involved Computed Tomography and dissection techniques to create a three-dimensional map of human gluteal muscle thickness. This serves to aid in anatomically designed hip protecting devices. Biomechanical work involved developing a new method to measure material properties of skeletal muscle under fall conditions (dynamic impact) by impacting muscles in the in-situ state, substituting ovine for human specimens. Finite Element Modelling (FEM) are being used to evaluate the body's response to hip-protector function. These models are virtual computer-generated representations of real-world structures built with many elements, very much like a Lego model is built with many bricks. Each element can be assigned specific material properties, the net effect allows kinematic data to be attained from simulations of an impact to the model. The Total HUman Model for Safety (THUMS) was developed for use in the automotive industry for crash evaluation. This laboratory has worked to modify and use it to study fall related injuries in older people.

Anthropometric assessment of skeletal dimensions for prosthetic devices

Skeletal anthropometic studies enable the design of prosthetic devices and improve their fit to patients. Using the VIFM CT scan database, measurement of skeletal dimensions were used with mathematical models to estimate a key measurement required to fit prosthetic legs. This work was completed in collaboration with Assoc. Prof. Michael Dillon, Prosthetics and Orthotics, La Trobe University.

Forensic anatomical assessment of Egyptian mummies

This laboratory collaborates with the Victorian Institute of Forensic Medicine, to conduct forensic anatomical evaluations. Recently an intracranial review and gender determination of juvenile Egyptian mummies was undertaken using computed tomography 3D imaging. Collaboration with Dr Janet Davies, Victorian Institute of Forensic Medicine and Dr John H Taylor of the British Museum.

Review of La Trobe University's skeletal material for Aboriginal remains

In 2018 an audit reviewed all of the human skeletal material in the Department of Physiology, Anatomy and Microbiology to assess possession of Aboriginal remains. Ongoing assessment is performed on any newly donated human skeletal remains to ensure Aboriginal remains are repatriated.

Lab Head: Dr Richard Fernandez
(r.fernandez@latrobe.edu.au)

Fields of Study:
Topographic anatomy; anthropometry; injury prevention; impact biomechanics; forensic applications of anatomy.

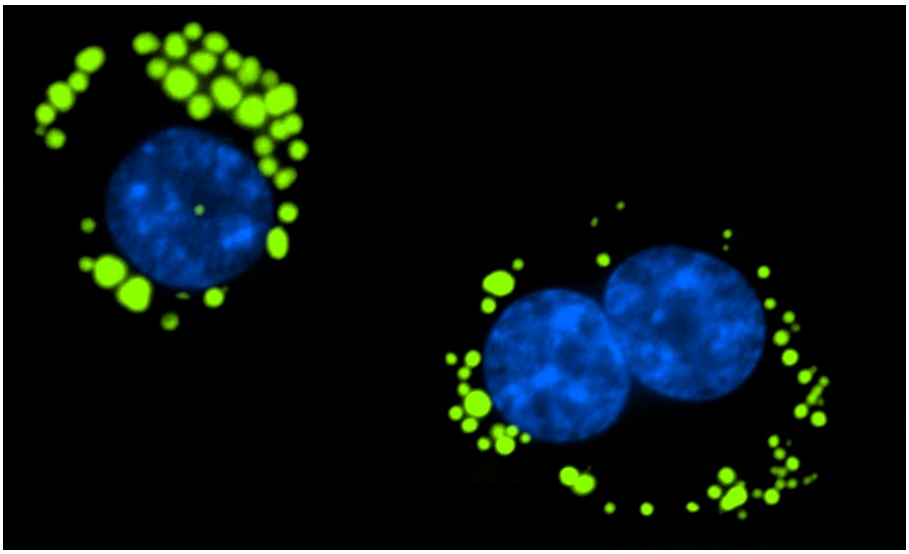
Capabilities and Techniques:
Human anatomical dissection; Computed Tomography scanning; anthropometric evaluation; Finite Element Modelling; Dynamic impact testing of biological tissue.

Antiviral Innate Immunity and Viral Genomics 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 4 main themes.

Detection of novel and emerging viruses (Helbig and Sarker Group)
Understanding the diversity of viruses in our environment has been limited by our ability to detect them. Since the advent of more sensitive next generation sequencing approaches, many new viruses have been described. Along with external partners we focus on three main areas of viral discovery:(1) detection of viral pathogens involved in new wildlife diseases; (2) analysis of viromes; and (3) detection and sequencing of new bacteriophages that target specific antibiotic resistant bacterial pathogens in animals. We investigate the development of new therapeutics and vaccines for animals and inform government of wild 'pest' risks to Australian livestock.

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.



Macrophage lipid droplets. (Photo credit: Karla Helbig)

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 Beddoe 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.

Understanding structure and function of viral protein (Sarker Group)
In-depth understanding of the structure and function of important viral proteins is crucial for development of potential anti-viral drugs or vaccines to successfully resolve viral diseases. Our research uses new technologies to uncover viral protein atomic structures. This enables a deeper understanding of viral protein functions to develop new anti-viral drugs or vaccines of benefit to threatened animal species vital for sustainable ecosystems.

Lab Head: Assoc Prof Karla Helbig (k.helbig@latrobe.edu.au)

Lab members: Ms Monique Smith; Ms Ebony Monson; Mr Keaton Crosse; Mr Jose Huaman-Torres; Ms Stephanie Lynch; Ms Jacinta Agius; Mr Jay Laws.

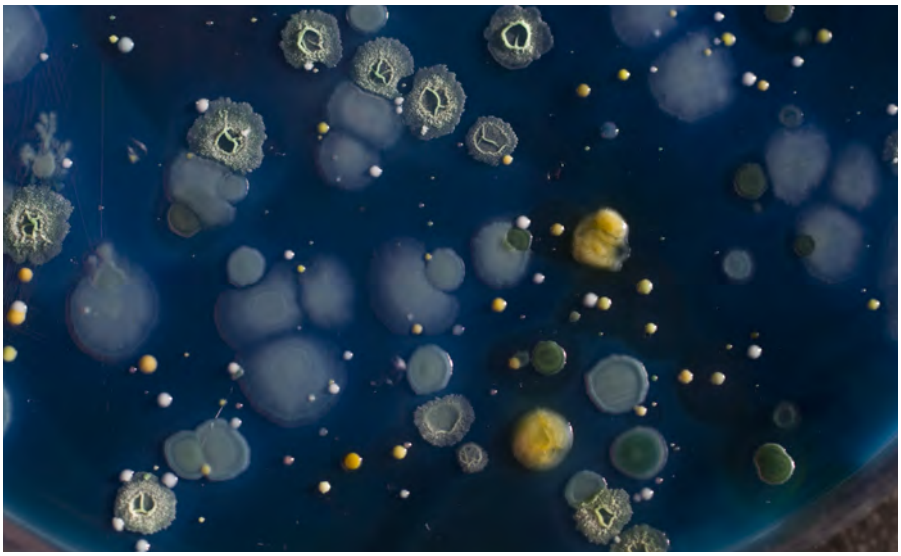
Fields of Study:
Virology; Innate Immunology; Structural biology; Viral metagenomics; Veterinary pathogens.

Capabilities and Techniques:
Microscopy: transmission electron, confocal, super resolution, light, fixed, live, static & movies; X-ray crystallography; Cell & virus culture & propagation; Primary cell culture; animal husbandry (mice/silkworms/ abalone); Viral delivery of genetic material; CRISPR/ cas; proteomics/lipidomics; bacterial & phage infection silkworm models; Protein expression & purification; Next generation sequencing; General molecular biology.

Translational Opportunities:
Viral animal pathogen detection; targeted drug development and management; bacteriophage solutions for antibiotic resistant infections in animals.

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); Dr Sean Bay (DECRA fellow); Mr Gene Drendel; Ms Sarah Knowler; Mr Joshua Vido; Mr Luke Bosnar; Ms Berenice Della Porta; Ms Edden Subejano; Ms Marissa Blunden; Mr Luke Florence

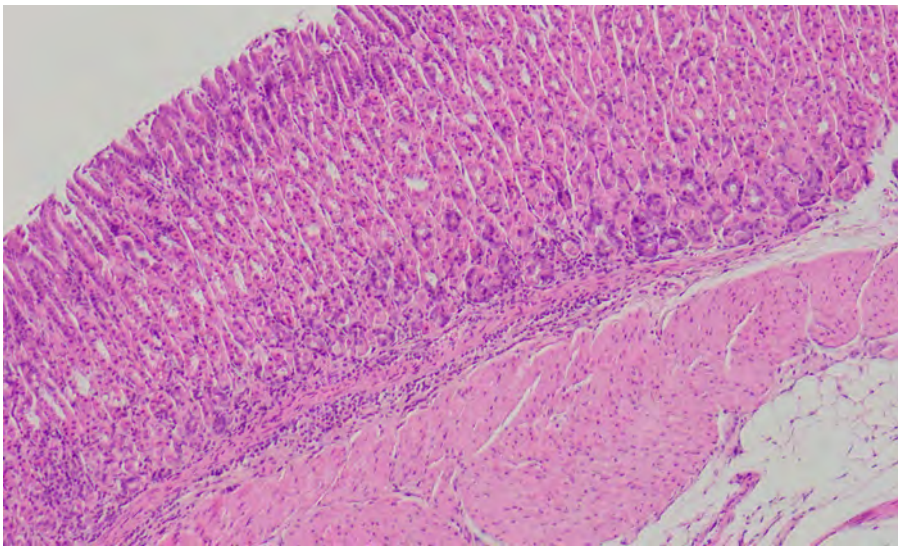
Fields of Study:
Microbiology; Ecology; Health; Bioremediation; Soil Science.

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.

Bacterial Pathogenesis Group

Our body has about 39 trillion bacteria and everyday we encounter more bacteria, some of which cause disease. Our lab focuses on two fundamental questions: How do bacteria and their products interact with and cause disease in humans, and how does the host detect and respond to bacterial pathogens and their products resulting in immunity? Our facilities enable the detailed examination of host-pathogen interactions mediated by bacteria and their products. Our research, funded by Victorian, National and International agencies, involves national and international collaborators. We use cutting edge microbiology, immunology, and imaging techniques to study the cellular and molecular mechanisms of host-pathogen interactions.



Gastritis in response to *H. pylori* infection (Photo credit: Maria Liaskos)

Bacterial membrane vesicles (BMVs)

Bacterial membrane vesicles (BMVs) are spherical, bi-layered membrane nanostructures (20 to 300 nm in size) that are naturally produced by all bacteria as part of their normal growth. BMVs contain many of the components present within their parent bacterium in a non-replicative form, including lipopolysaccharide, toxins, DNA, proteins and enzymes. Our team studies the complex mechanisms used by bacteria to produce BMVs and regulate their cargo composition, in addition to determining how BMVs mediate disease in the host. We aim to understand the roles of BMVs in bacterial survival, promoting disease and enabling horizontal gene transfer within and between bacterial species. We are also developing methods to refine the use of BMVs as vaccines, and as nano-delivery molecules to deliver biological material into target cells.

Immune responses to the human gastric pathogen *Helicobacter pylori*

H. pylori is a bacterium that infects more than 3 billion people worldwide, causing lifelong infections resulting in gastritis, gastric ulcers and cancer. The mechanisms used by *H. pylori* to manipulate the immune system to mount an ineffective and chronic inflammatory response, and to survive remains unknown. Our team in collaboration with national and international clinicians and researchers focuses on identifying the mechanisms used by *H. pylori* to enable lifelong colonisation and disease. We use molecular, microbiology and immunology techniques, (animal models, human clinical samples and advanced immunological assays) to characterise immune responses to *H. pylori* and to identify targets to prevent *H. pylori* mediated disease.

Detection of bacteria by innate immune receptors

Host surface and cytoplasmic innate immune receptors detect bacterial pathogens and initiate an immune response. The host immune receptor nucleotide oligomerisation domain-1 (NOD1) detects a peptidoglycan motif present in all Gram-negative bacteria, resulting in an immune response. How NOD1 controls immune signalling and bacterial disease remains unknown. Our team studies how Gram-negative bacterial peptidoglycan is detected by NOD1 in order to identify methods to limit NOD1-mediated inflammation and disease in humans.

Microbiome and BMVs

We analyse BMVs produced by the human microbiota to understand their contribution to maintaining immunity and gut health.

Lab Head: Assoc Prof Maria Liaskos (m.liaskos@latrobe.edu.au) (publishing as Maria Kaparakis-Liaskos).

Lab Members:
Dr Natalie Bitto; Ms Ella Johnston; Ms Lauren Zavan; Mr William Gilmore; Ms Kalara Jayawardene; Ms Sarah Signorello.

Fields of Study:
Microbiology; Host-pathogen interactions; Innate Immunity; Cell biology; Immunology.

Capabilities and Techniques:
Bacterial/eukaryotic extracellular vesicles purification & characterisation; innate and adaptive immune responses to bacterial pathogens; microbiology; molecular microbiology; cell culture; live cell imaging; confocal & transmission electron microscopy; infection/vaccination animal models; flow cytometry.

Translational Opportunities:
Bacterial/eukaryotic vesicles; bacterial disease & animal models; Vaccine design/ delivery; development of biological nanocarriers; bacterial pathogenesis; characterisation & modulation of innate/ adaptive immune responses; protein expression; antimicrobial resistance mechanisms; horizontal gene transfer; microbiota immunological/biological functions.

Cardiac Disease Mechanisms group

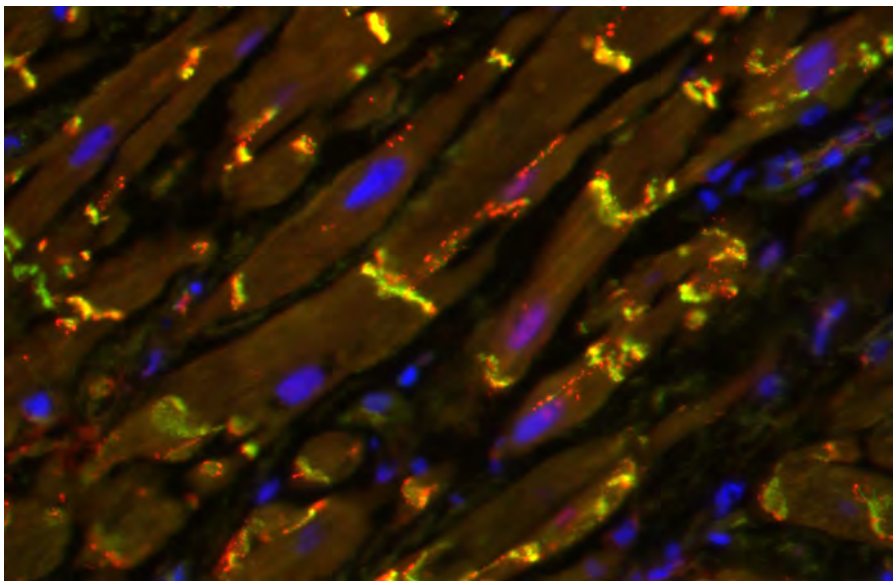
The Cardiac Disease Mechanisms Laboratory seeks to understand the cellular and molecular mechanisms driving diseases in the heart in a bid to identify new candidate targets for future therapies. One in five of all deaths in Australia are due to heart disease – a devastating public health and economic 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.

'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.



Cell-to-cell communication proteins in human cardiomyocytes (Photo credit: Jim Bell)

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)

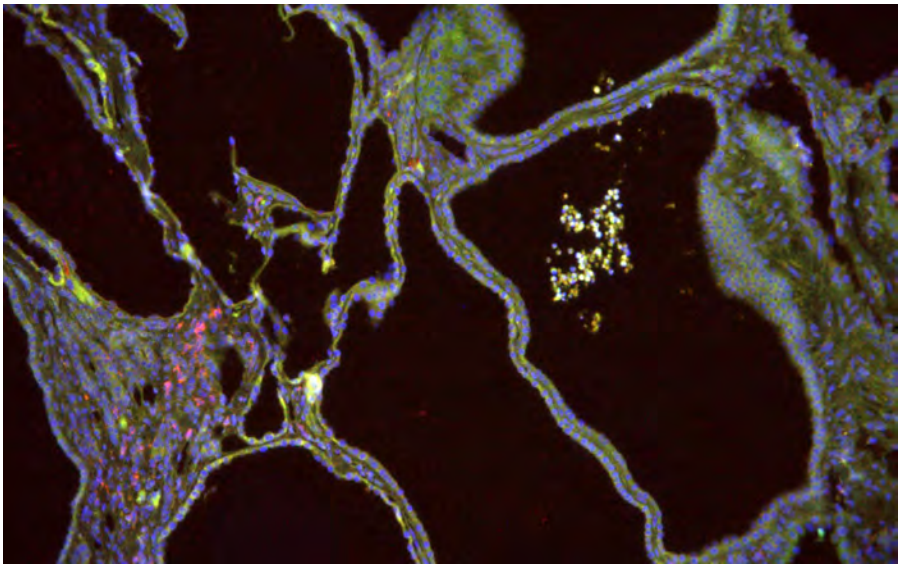
Fields of Study:
Cardiac arrhythmias; Heart failure; Adipose tissue; Intercellular signalling; Sex steroids.

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

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.



Macrophage staining in polycystic kidney disease. (Photo credit: J. Gasperoni)

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: Jemma Gasperoni, Emily Major, Sean Barton, Hojjatullah Nasirie, Cahal Freestone

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.

Cardiovascular Physiology Group

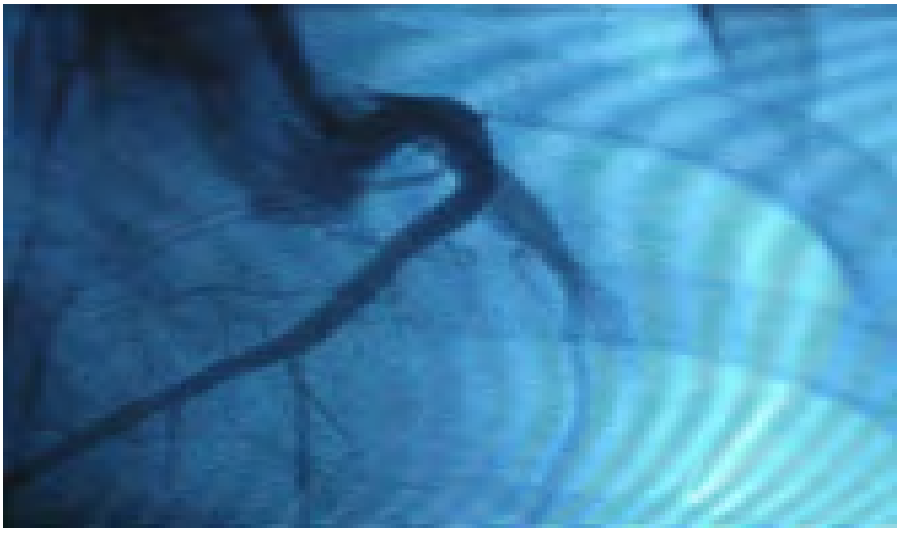
Our collaborative clinical research involves local, national and international partners. Our laboratory-based coronary heart disease and heart failure research features an integrated approach of simultaneously monitoring blood pressure, heart rate and blood flow via indwelling or wireless monitors for long time periods. We conduct Proof-of-concept small animal model studies to screen and assess new interventions/drugs, and use large animal models, with similar anatomy and physiology to humans, to translate discoveries into clinical therapies.

Myocardial Ischemia-Reperfusion Injury

Heart attack patient survival depends on the amount of heart muscle damaged. The most effective treatment is to re-establish blood flow in the blocked artery which saves heart tissue, but also causes cell death. This is called ischemia-reperfusion (IR) injury and there are no drugs to prevent it. Along with collaborators, we developed a highly potent flavonol drug which significantly reduces myocardial IR injury and has multiple beneficial actions (antioxidant; inflammatory; ability to stimulate pro-survival kinase pathways in heart cells). We are developing a non-invasive intervention to reduce cardiac IR injury called remote ischaemic preconditioning (RIPC). This consists of multiple episodes of brief blood loss to a limb to stop prolonged blood loss in the heart. We developed a large animal RIPC model to study cardioprotection mechanisms and have assessed zinc homeostasis impairment in cardiac IR injury.

Microbiome & Cardiometabolic disease

Links exist between inflammation and disruption of gut microbial communities in cardiometabolic disease. In chronic low-grade inflammation diabetes, levels of anti-inflammatory protein Annexin-A1 (AnxA1) are reduced. We study AnxA1 deficiency effects on gut microbiome in diabetic mice. With clinicians, we are assessing gut bacteria composition changes after mini-gastric bypass surgery, and potential links to reversing obesity and diabetes.



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

Healthy Diet and Lifestyle for the Prevention and Management of Cardiovascular Disease

We study flavonols in plant-based polyphenols to see if healthy diet patterns improve CVD outcomes. We study plant-rich Mediterranean diets for heart disease-fighting properties and are trialling diet modifications to improve anti-inflammatory potential, including the clinical importance of polyphenol intake. We have developed and validated a CARDIO-MED survey tool food frequency questionnaire to assess diet quality and MedDiet adherence of Australian cardiology patients. We are assessing effects of legume and olive oil consumption in diabetes and heart disease, as well as diet and cognitive impairment risks in India.

Cardio-Renal Syndrome (CRS)

CRS occurs when the failure of the kidney or heart worsens the function of the other, leading to the failure of both. We are studying how to reverse uremic-toxin-induced vascular dysfunction.

Lab Head: Assoc Prof Colleen Thomas (colleen.thomas@latrobe.edu.au)

Lab member: Ms Urja Amin.

Fields of Study:
Cardiovascular Diseases; Public Health; Medical Biotechnology; Nutrition; Clinical Sciences.

Capabilities and Techniques:
Myocardial IR/RIPC animal models; Integrative Cardiovascular Monitoring; Blood flow/Haemodynamics (telemetry; chronic indwelling catheters, blood flow probes, electrocardiography); Biochemistry/Molecular Biology; Clinical trial design & management; Anthropometry; Body composition - absorptiometry; Continuous glucose monitoring; Accelerometers for physical activity and Dietary assessment analyses; Dietary Inflammatory Index.

Translational Opportunities:
Gastrointestinal microbiome-specific obesity therapies; Highly potent flavonol application in stroke survivors; Hospital menu planning; Remote limb conditioning strategy (ambulances/sports rehab); Diabetic cognitive impairment screening; Digital/mobile delivery MedDiet intervention.

Cerebrovascular Disease Group

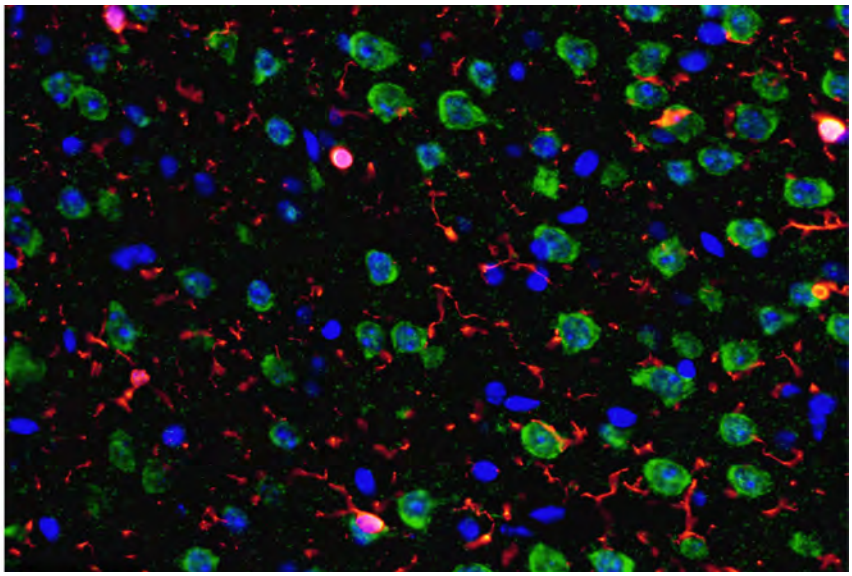
Cerebrovascular diseases (stroke, dementias) are a major health concern in Australia and throughout the world. The brain is and its circulation are particularly sensitive to disease. Cardiovascular diseases disrupt the function of cerebral arteries which leads to a dysregulation of cerebral blood flow. 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:
Mr. David Wong Zhang; Mr. Mehdi Zia; Ms. Tarunpreet Rajput; Ms. Elizabeth Fernandes.

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

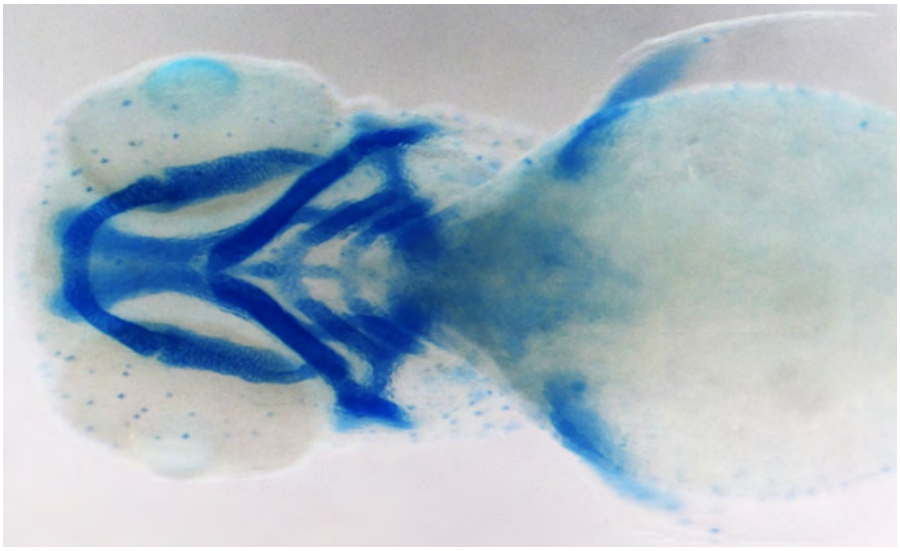
Understanding the cellular behaviours, particularly in the craniofacial region and neural tube, and the molecular pathways by which these behaviours are regulated, forms the cornerstone of understanding embryonic development. Using genetically-modified mouse and zebrafish models, our group identify critical 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:
Ms Jemma Gasperoni; Mr Jarrad Fuller; Ms. Emma Parks; Mr. Zachary Di Pastena.

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.

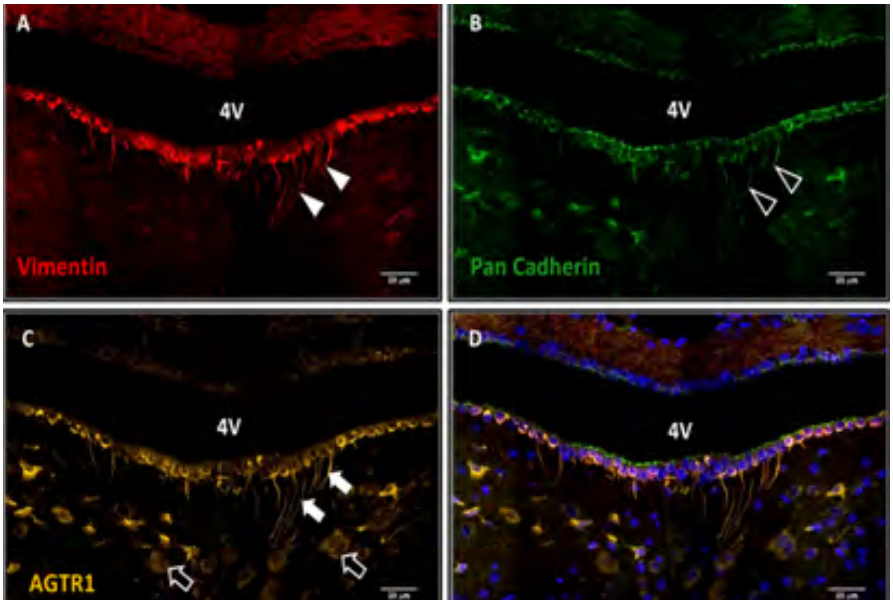
Translational Opportunities:
Genetic counselling; Gene mutation identification for pre- and peri-natal healthcare to ameliorate craniofacial defects and behavioural disorders.

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:

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.



Immunofluorescence labeling of vimentin (A), pan cadherin (B), AGTR1 (C) and combined (D) in coronal sections of rat brain (Photo credit: Hayder Al-Aubaidy)

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
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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.

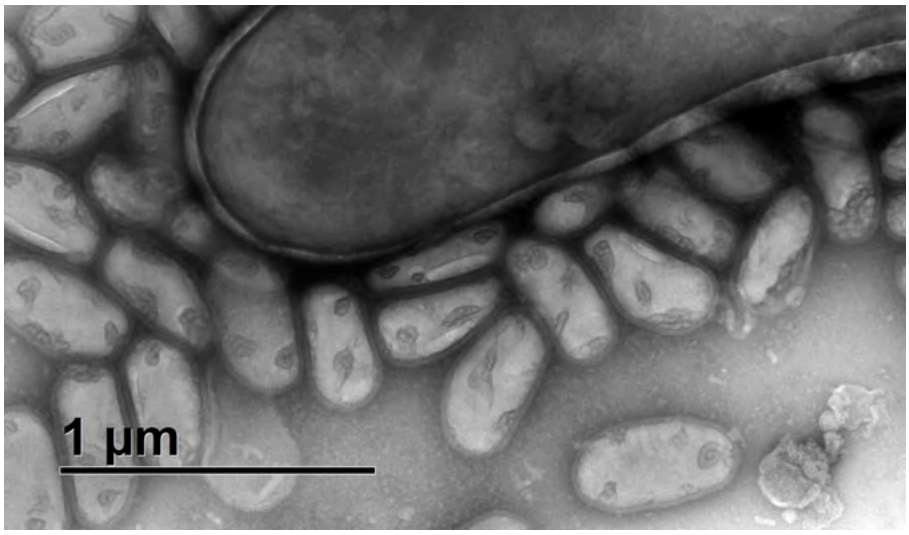
Fields of Study:
Diabetes Mellitus; Cardiovascular Disease Prevention, Diagnosis and Early Management; Nutrition; Public Health; Clinical Sciences.

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) and genome sequencing, 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 *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 control them. We also study bacteriophage interactions to identify their population dynamics.

Treating bacterial infections with phage therapy in humans and animals

With antibiotic resistance, alternative ways such as Phage therapy are needed to control serious bacterial infections. We are collaborating with Dr Joseph Tucci (School of Pharmacy) to find new phages for topical pharmaceuticals that fight bacterial infections and are developing pharmaceutical products that contain phages as an alternative to antibiotics. In collaboration with Defence Science Technology Group we are also developing bacteriophage bioterrorism biosensors to detect highly pathogenic organisms

Lab Head: Assoc Prof Steve Petrovski (steve.petrovski@latrobe.edu.au)

Lab members: Dr Richard Melvin; Dr Mark Chan; Mr Jayson Rose; Ms Liana Theodoridis; Ms Mikaela Whitty; Mr Jarrod Martins; Ms Jessica Owen.

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.

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

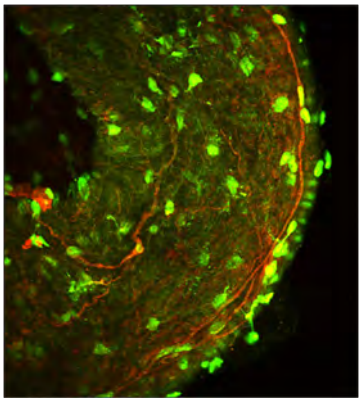
An imbalance in the gut bacterial communities can contribute to hypertension and related end-organ damage. However, an understudied yet vital organism in the gut are phages - viruses that infect and kill bacteria. We have discovered several phages that are highly abundant during experimental hypertension 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:
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Lab members:
MrHenry Diep; Dr Courtney Judkins; Dr Narbada Saini; Ms Vivian Tran; Ms Hericka Bruna Figueiredo Galvao; Ms Flavia Wassef; Ms Buddhila Wickramasinghe; Ms Tayla Gibson Hughes; Mr Jake Robertson; Ms Liana Theodoridis; Ms Sarah Hayes; Ms Mikaela Whitty; Ms Maeve O'Keefe, Mr Satar Jamal; Ms Emma Stent; Mr Jad El Rassi

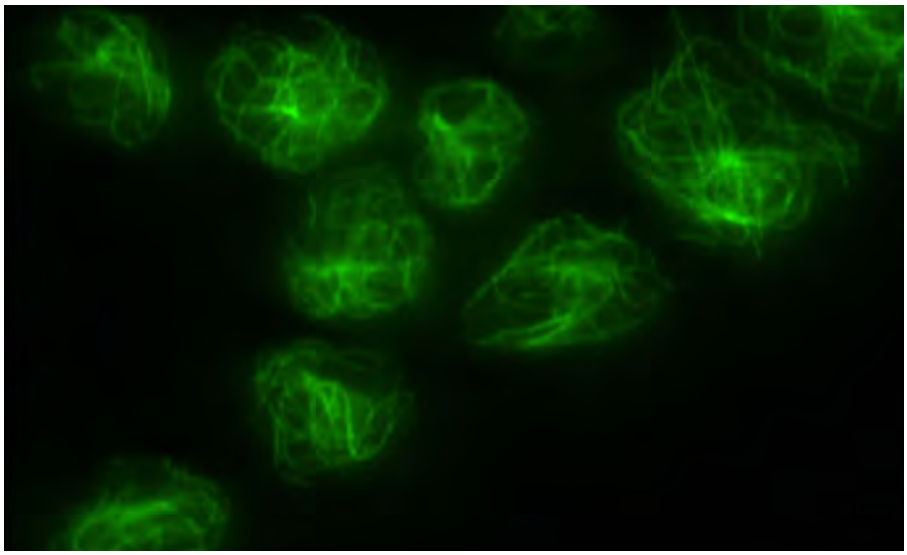
Fields of Study:
Hypertension; Diabetes; Obesity; Immunology; Pharmacology

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

Microbial Cell Biology Group

We investigate mitochondrial function and associated signalling pathways in neurodegenerative and neurological disorders – namely mitochondrial diseases, Alzheimer's Disease, Parkinson's Disease and Myalgic Encephalitis/Chronic Fatigue Syndrome (ME/CFS). Mitochondria are tiny organelles in cells that are often termed the powerhouses of cells because they are responsible for producing most (>90%) of the cell's energy. Dysregulation of the mitochondria or its associated signalling pathways is associated with neurological disorders, but the exact mechanism remains unclear. We employ different cellular models to investigate this including human cell models and a simple eukaryotic model *Dictyostelium discoideum*. Our ultimate aim is to characterise the underlying cytopathologies of certain neurological diseases and use this to identify disease biomarkers and develop diagnostic tests.



Dictyostelium cells showing microtubules in green. (Photo Credit: Katelyn Mcrozek)

Mitochondrial Disease

The organ system most commonly affected by mitochondrial dysfunction is the central nervous system and all of the major brain diseases are reported to involve impaired mitochondrial function. We use the simple eukaryotic model *Dictyostelium* to study mitochondrial disease. We create disease in *Dictyostelium* by disrupting (knockout), antisense-inhibiting (knockdown) or overexpressing wild type or mutant *Dictyostelium* or human disease genes. The main aim of this project is to characterise the changes to signalling proteins and pathways which occur in mitochondrial disease in order to increase our understanding and identify targets for therapeutic and diagnostic use.

Parkinson's Disease

Parkinson's Disease (PD), is a common neurodegenerative disease, no cure exists and the pathways leading to the disease are still unknown. We use different blood cellular models to investigate PD. In blood cells we characterise the mitochondrial function, measure activities of associated signalling proteins, and investigate pathways by exposing cells to pharmacological agents. We also investigate genetic forms of PD by either genetically altering homologous PD-associated genes in *Dictyostelium* or by expressing in *Dictyostelium* human PD-associated proteins. We then investigate the impacts of these on mitochondrial function and associated cellular signalling pathways. Using these two models allows us to investigate basic cellular roles of proteins and translate this information in a human system.

Myalgic Encephalitis/Chronic Fatigue Syndrome (ME/CFS)

Myalgic Encephalomyelitis/Chronic Fatigue Syndrome (ME/CFS) is incurable and affects 0.7-3.3% of the Australian population. The rate of recovery is only 5% and as the onset age is in the 30s, patients can remain ill for decades. We discovered mitochondrial and molecular and cell signalling abnormalities in ME/CFS cells, and have created new *Dictyostelium* cell models to investigate the causative molecular pathways.

Lab Head: Dr Sarah Annesley (s.annesley@latrobe.edu.au) and Emeritus Prof Paul Fisher (p.fisher@latrobe.edu.au)

Lab Members:
Ms Oana Sanislav; Ms Claire Allan; Ms Katelyn Mcrozek; Mr Xavier Pearce; Ms Gizem Sen; Ms Claire Storey; Mr Daniel Missailidis; Ms Vanessa Musco; Ms Mayu Aburaya.

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 published a protocol for a diagnostic test for ME/CFS. It is a clinically useful biomarker test to aid in diagnosis of ME/CFS. We are also engaged in work on the development of a similar blood test for early, prodromal diagnosis of PD prior to it being clinically diagnosable by current neurological criteria.

Microbiology of Natural and Engineered Ecosystems Research Group

Life on earth relies on six elements C, H, N, O, P, S, which make up the building blocks of its macromolecules. Microbial redox reactions constantly transform and recycle these elements, shaping the environmental conditions of all niches on Earth. Microorganisms such as bacteria and archaea are responsible for approximately 15% of the Earth's biomass and are essential to the biosphere. They drive global carbon and nutrient cycles and regulate the climate. Our group is interested in understanding the ecological significance and biogeochemical basis of these processes, and their interaction with microbial biodiversity and primary production. We integrate culture-independent techniques with biogeochemical measurements (both in the field and the lab), supported by contemporary statistics and ecological theory. Our mission is to advance impactful research with the aim of addressing global challenges such as environmental degradation, food security and climate change. To achieve this, our work is based on the following three research themes:

Biodiversity and Function

Microbes exhibit remarkable diversity and occupy every ecological niche on the planet, including extreme habitats such as deserts and caves. Our research has shown that a surprising diversity of microbial life exists in these ecosystems, despite the common view that they are too challenging and nutrient poor. However, many bacteria exhibit metabolic flexibility and can endure long periods in a dormant state. They can in fact utilise a diverse range of inorganic energy sources, including atmospheric trace gases, to survive and grow. Understanding the diversity, ecology and function of these organisms can help us better predict how life and biodiversity arise and persist in the face of climate risks such as desertification and nutrient depletion.

Key question: What is the functional and biogeochemical basis of microbial persistence and growth in energy-deprived and extreme environments across terrestrial and aquatic systems?

Soil Fertility and Health

Soil biomes globally make up a multifaceted ecosystem that harbours a high diversity of microbial life. They have a significant impact on soil productivity, by facilitating nutrient cycling, decomposing organic material, and underpinning plant symbiosis. Understanding the structural and functional basis of microbial biodiversity in soil biomes and how this relates to ecosystem services could enable us to develop strategies to improve soil health and productivity.

Key question: What is the structural and functional basis of microbial biodiversity in soils and how does this relate to ecosystem services affecting soil fertility and plant health?

Climate Change and Global Cycles

Microorganisms play a vital role in driving global biogeochemical cycles. They are central actors in global carbon and nutrient cycles and regulate potent greenhouse gases such as methane, carbon dioxide and nitrous oxide. Understanding the microbial basis of these cycles can enable us to develop strategies to mitigate the effects of climate change and improve the quality of our environment.

Key question: What is the microbial role in driving global biogeochemical cycles and regulating greenhouse gases such as methane, nitrous oxide, and carbon dioxide?

Our Impact

Our research contributes to our understanding of the microbial world and its role in shaping the Earth's environment. Our findings provide fundamental advances and could create new methods to enhance environmental stability, food security and mitigate global risks such as climate change.

Lab Head: Dr Sean K. Bay (s.bay@latrobe.edu.au)

Lab Members:
Currently seeking PhD, MSc and BSc students.

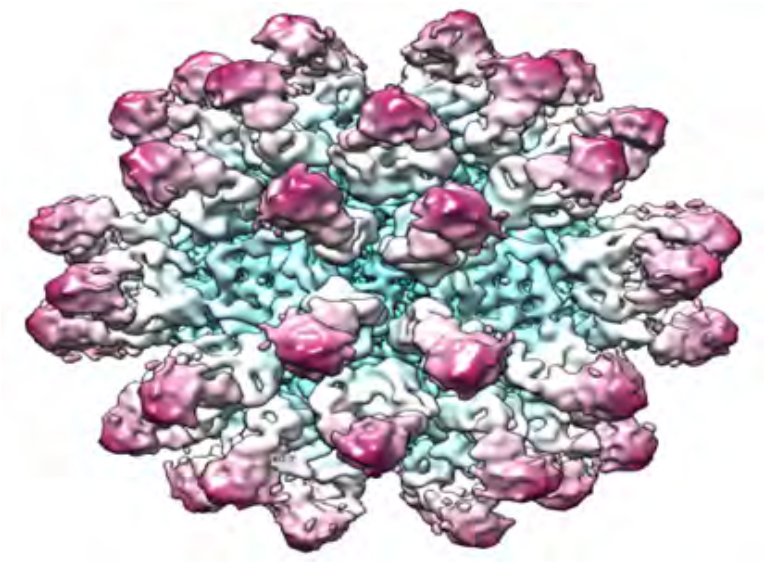
Fields of Study:
Environmental Microbiology; Biogeochemistry; Microbial Ecology.

Capabilities and Techniques:
Microbial biodiversity and functional studies, Gas chromatography of atmospheric trace gases, Microbial activity studies, Radioisotope studies, Nutrient budgets, Soil physicochemistry, GIS spatial mapping.

Translational Opportunities:
Microbial biodiversity monitoring of soil and aquatic systems, Atmospheric gas monitoring, Nutrient and Carbon monitoring, Soil fertility and degradation monitoring.

Molecular and Structural Virology Group

Our group investigates how viral pathogens impact the conservation of both native wildlife and economically important livestock animals. We utilise genomic and structural biology approaches to study the evolutionary dynamics of viruses, with a strong emphasis on animal health conservation. Our research involves partners from local, national, and international communities. Our goal is to elucidate the molecular evolution of viruses and the structure and function of essential viral proteins, in order to guide the development of anti-viral strategies and subunit vaccines against viral pathogens. By utilizing advanced genomic techniques, bioinformatics, viral metagenomics, cell biology, imaging, protein expression and purification, structural biology, and recombinant DNA vaccinology, we explore the following main research themes:



Structure of a viral capsid bound with antibody. (Photo credit: Subir Sarker)

Discovery of novel and emerging pathogens

Our group has a strong track record of sequencing novel animal pathogens and studying their potential impact on the conservation of threatened species. Historically, our ability to detect pathogen diversity has been limited, but recent advances in next-generation sequencing technology have allowed for the discovery of a greater number of novel pathogens. Currently, our group is primarily focused on two areas of pathogen discovery: (1) detecting viral and bacterial pathogens that threaten both wild and livestock animals, and (2) detecting and sequencing novel bacteriophages to control antibiotic-resistant bacterial pathogens in chickens. Our research is aimed at answering specific questions, including the potential development of novel therapeutics and subunit vaccines.

Conservation of threatened species

Our group has undertaken various projects, both past and present, to investigate the impact of viral and bacterial pathogens on the conservation of threatened species. These projects have included research on several endangered species, such as the Orange-bellied parrot, swift parrot, Western ground parrot, red-tailed black cockatoo, and green sea turtle. Our current projects are focused on identifying the key threatening processes caused by viral and bacterial pathogens that continue to endanger them and what management actions can most likely be taken to enhance the survival of these species.

Understanding structure and function of viral protein

An in-depth understanding of the structure and function of critical viral proteins is essential for developing potential anti-viral drugs or vaccines that can effectively treat viral diseases. Our group is well-positioned, with the support of the Australian Research Council, to further explore this area of research, which is directly related to translational research. This research utilizes cutting-edge technologies, such as recombinant protein expression and purification, X-ray crystallography, cryo-electron microscopy, and atomic force microscopy, to determine the atomic structure of viral proteins. By gaining a deeper understanding of the functions of these proteins, our goal is to develop novel anti-viral drugs or vaccines to benefit threatened wild and livestock animals.

Control of viral and bacterial pathogens

Controlling viral and bacterial pathogens is essential in preventing the spread of infectious diseases and protecting the health of animals and the public. Our group is currently collaborating with Charles Sturt University, the Department of Primary Industries, and Australian Zoos to develop a subunit vaccine against a deadly viral pathogen that infects endangered native avifauna. Additionally, we are also working on developing a bacteriophage-based treatment option for an economically important bacterial infection in chickens. Our project involves industry partners and RMIT University.

Lab Head: Dr Subir Sarker (s.sarker@latrobe.edu.au)
Lab members: Ms Ajani Athukorala; Ms Natalie Klukowski; Ms Betul Yavuzel; Mr Josh Stackpole.

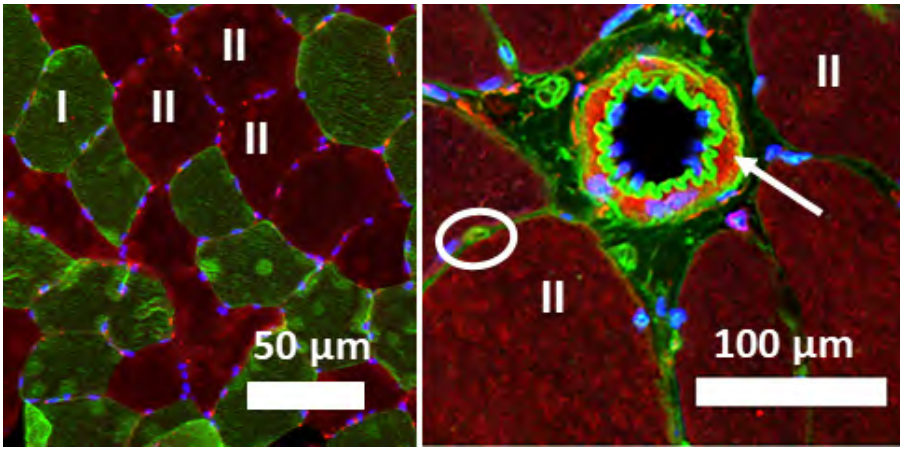
Fields of Study:
Virology; Veterinary microbiology; Structural biology; Metagenomics; Veterinary pathogens.

Capabilities and Techniques:
Recombinant protein expression & purification; subunit vaccine development; X-ray crystallography; Microscopy: Cryo-electron microscopy, transmission electron, confocal; X-ray crystallography; Next generation sequencing; structure and function of bacteriophage in controlling economically important livestock pathogens.

Translational Opportunities:
Animal pathogen detection; targeted subunit vaccine and antimicrobials development; Threatened species conservation; bacteriophage solutions for antibiotic resistant infections in animals.

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.



Fluorescent staining of myosin heavy chain and blood vessel in skeletal muscle (Photo credit: Nicole Stupka)

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.

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.

Targeting ER stress to improve skeletal muscle and bone health
The endoplasmic reticulum (ER) is pivotal in protein folding and calcium homeostasis in cell types including skeletal muscle. Selenium, essential for skeletal muscle, bone, and vascular health is present in selenoproteins. Selenoprotein S (Seps1) is one of seven ER selenoproteins and regulates Ca2+ movement and storage, oxidative and ER stress responses, inflammation, and adipocyte differentiation in skeletal muscle. Seps1 is a possible treatment for disorders with decreased muscle strength and endurance, loss of muscle mass, and bone degeneration. Our research group in collaboration with the Australian Institute for Musculoskeletal Science (AIMSS), is investigating the role of Seps1 in muscle and bone health.

Lab Head: Dr Chris van der Poel (c.vanderpoel@latrobe.edu.au)

Lab Members:
Dr Jarrod Church; Dr Caroline Taylor; Dr Travis Dutka; Dr Giuseppe Posterino; Dr Brett Gordon; Dr Nicole Stupka.

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)

Collaborators:

- Prof Christine East (School of Nursing and Midwifery)
- Dr Mary-Ann Davey (Monash University)
- Dr Lester Jones (Singapore Institute of Technology)
- Dr Elizabeth Newnham (The University of Newcastle)
- Dr Kate Dawson (Australian Catholic University)
- A/Prof Allan Cyna (The University of Adelaide)

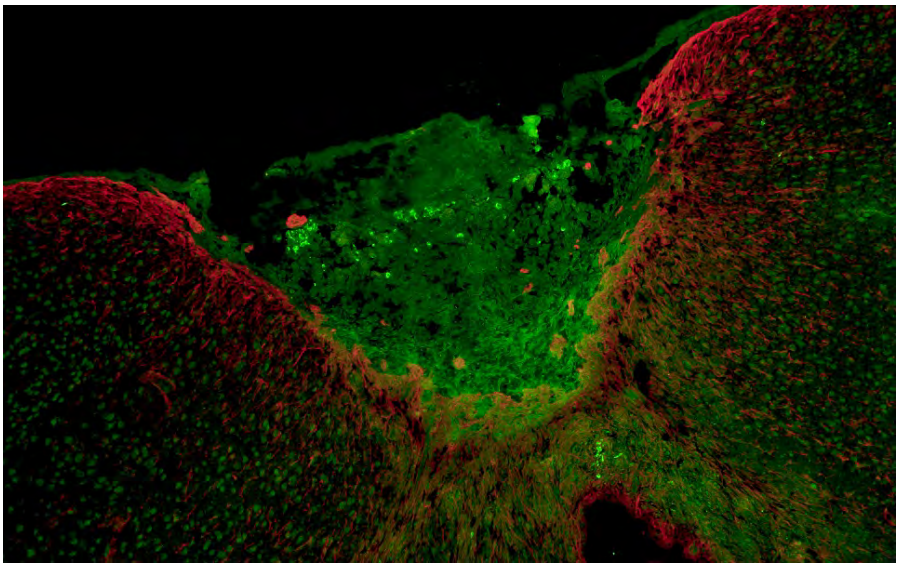
Fields of Study:
Medical and Health Sciences; Midwifery; Physiotherapy; Obstetrics; Gynaecology.

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 supress 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; Ms Liz Barreto Arce; Ms Samoda Rupasinghe; Ms Lucy Jenkins.

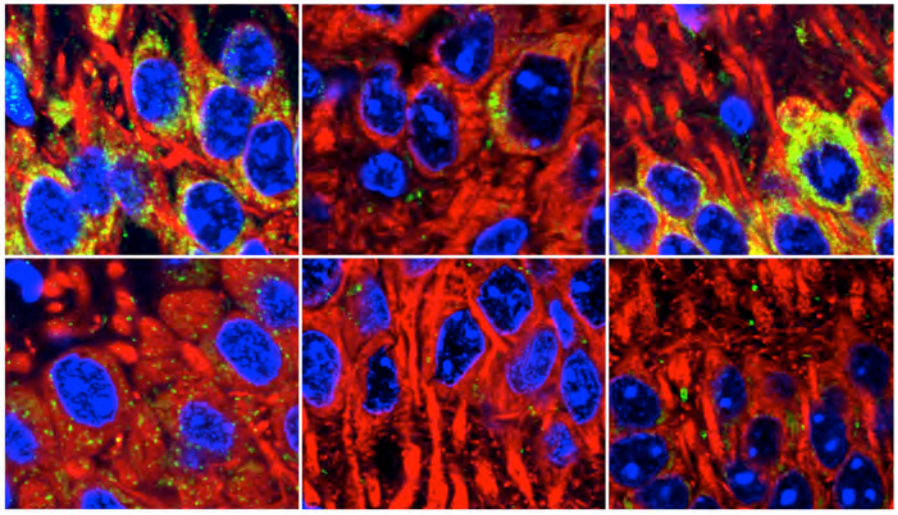
Fields of Study:
Stroke; Brain inflammation; Neuroprotection; Cell therapy; Immunotherapy.

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.

Vascular Dementia and Epigenetics 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.



Immunofluorescence images of inflammasome activation in the hippocampus in Vascular Dementia (Photo credit: Garrie Arumugam)

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 to investigate 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 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 Quynh Dinh; Ms Nishat Tabassum; Mr Yibo Fan; Mr Xiangyuan Peng; Mr Xiangru Cheng; Ms Fizza Hussain; Mr Marconi Fung

Fields of Study:
Neurobiology; Pharmacology; Molecular Biology; Epigenetics; Neurodegeneration.

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.

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 in uence 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 bene t 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 in uence, and our alumni achieve extraordinary success and impact in government, industry and not for pro t 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 outmorevisitvictoria.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.

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