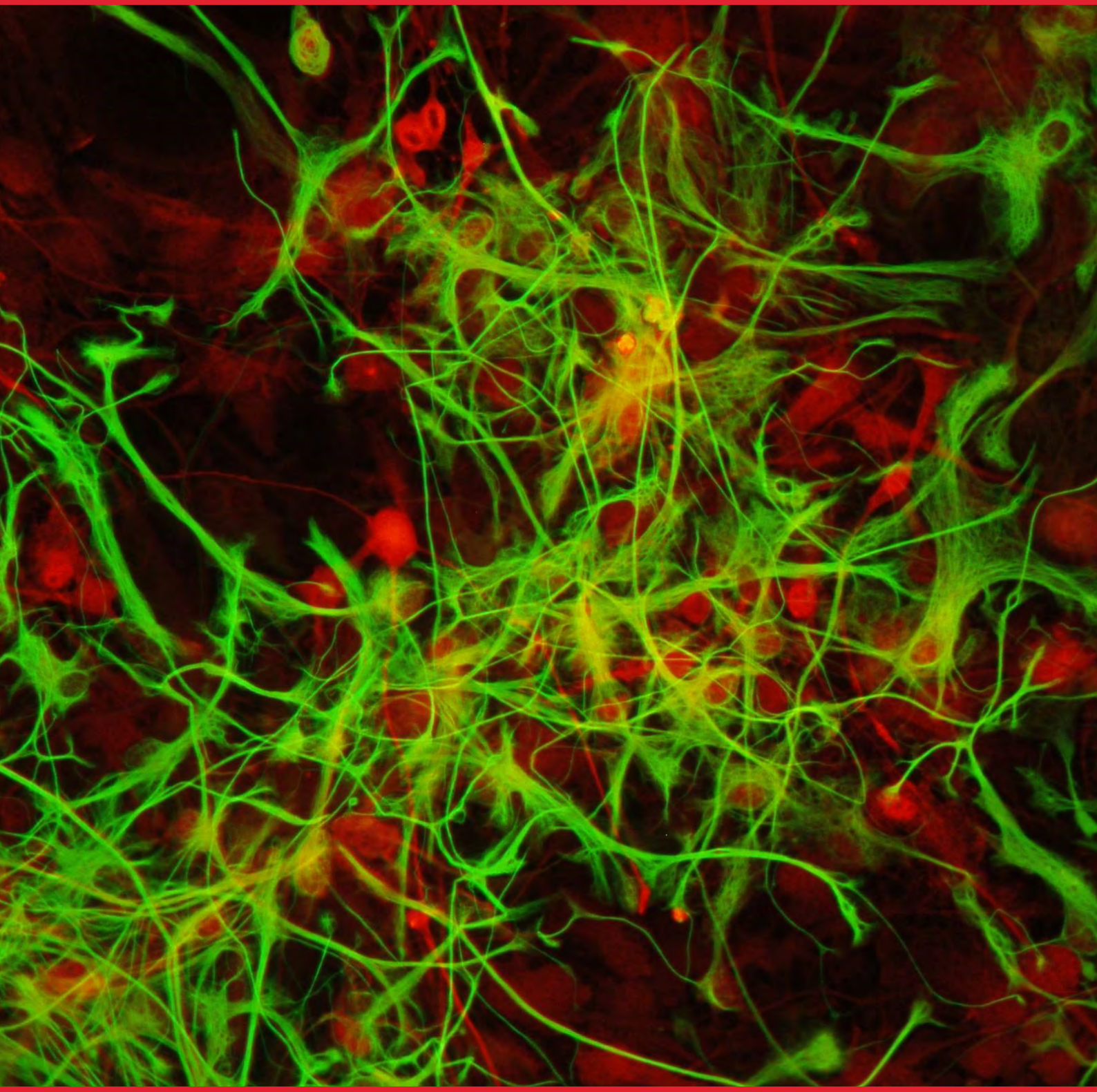
LA TROBE
UNIVERSITY • AUSTRALIA

School of Life Sciences

Scientists working across agriculture, botany, soil science, animal science, plant science, ecology, environmental geoscience, evolution, genetics, conservation biology, zoology, microbiology, physiology, neurobiology, pathophysiology, pharmacology and anatomy.



latrobe.edu.au/school-life-sciences

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Cover:
Modulation of astrocytes in cell culture - treated astrocytes
(Photo credit: Ross O'Shea)

Introduction

The School of Life Sciences is one of nine schools that comprise the Science, Health and Engineering College at La Trobe University. Provost Professor Rob Pike leads the College, Professor Shaun Collin is the Dean and Head of the School of Life Sciences and Co-director of AgriBio. There are three departments within the School of Life Sciences:

- Ecology, Environment and Evolution, (EEE)
- Animal, Plant and Soil Sciences, (APSS)
- Physiology, Anatomy and Microbiology (PAM)

The School of Life Sciences encompasses a broad range of disciplines:

- Agriculture
- Botany
- Soil Science
- Animal Science
- Plant Science
- Ecology
- Environmental Geoscience
- Evolution and Genetics
- Conservation Biology
- Zoology
- Microbiology
- Physiology
- Neurobiology
- Pathophysiology
- Pharmacology
- Anatomy

There are nine research centres within the School of Life Sciences:

- Research Centre for Future Landscapes
- Centre for Freshwater Ecosystems
- Research Centre for Applied Alpine Ecology
- Mallee Regional Innovation Centre (MRIC) (a joint venture with The University of Melbourne)
- La Trobe Institute for Agriculture and Food (LIAF)
- ARC ITRH (Industry Transformation Research Hub) for Medicinal Agriculture
- ARC CoE (Centre of Excellence) Plant Energy Biology
- Centre for Livestock Interactions with Pathogens (CLiP)
- Centre for Cardiovascular Biology and Disease (collaboration with the Baker Heart and Diabetes Institute)

Professor Robert Pike
Provost,
College of Science, Health and Engineering

Professor Shaun Collin
Dean, Head of School of Life Sciences,
Co-Director of AgriBio

College of Science, Health and Engineering

The College of Science, Health and Engineering contains 9 schools and 16 departments working across La Trobe's multi-campus operations, offering general and specialist undergraduate, postgraduate and research higher degree courses.

Our world-leading staff are dedicated to achieving significant educational and research outcomes in their fields. Our degrees are linked to emerging trends and are designed to prepare students for work in changing environments. We deliver a wide range of general and specialist courses that challenge students to expand their life and learning experiences.

We are engaged in both regional and metropolitan communities, with our courses offered across the Albury-Wodonga, Bendigo, Bundoora, Collins St (Melbourne), Mildura, Shepparton and Sydney campuses.

Our students have access to world-renowned research facilities including the A$100 million La Trobe Institute for Molecular Science (LIMS) and the A$288 million Centre for AgriBioscience.

Our world-class researchers work in collaboration with industry partners and multiple disciplines across the university to deliver significant research outcomes across five thematic areas:

- Building healthy communities
- Securing food, water and the environment
- Sport, exercise and rehabilitation
- Transforming human societies
- Understanding disease.

Our researchers work in an environment which encourages innovative solutions and opportunities for research breakthroughs across important scientific and social issues. They hold significant strength and expertise in:

- Environment
- Rehabilitation and Exercise
- Brain, Mind and Behaviour
- Food and Agriculture
- Infection, Immunity and Cancer Research.

School of Life Sciences

The School of Life Sciences is one of the largest in the University, with more than 170 continuing and fixed term staff across two campuses. Over the last three years the School has seen significant growth in both research (15% pa, $15m in 2019) and teaching revenue (10%, $57.7m in 2019). Staff in the School currently generate 10% of the University's teaching revenue, 17% of its research income, and supervise more than 170 higher degree research students.

The School is responsible for six 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.

The School of Life Sciences 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 School research environment is dynamic and growing, with several major research centre initiatives being launched in the past two years:

- Research Centre for Future Landscapes
- 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)
- La Trobe Institute for Agriculture and Food (LIAF)
- ARC ITRH (Industry Transformation Research Hub) for Medicinal Agriculture
- ARC CoE (Centre of Excellence) Plant Energy Biology
- Centre for Livestock Interactions with Pathogens (CLiP)
- Centre for Cardiovascular Biology and Disease (collaboration with the Baker Heart and Diabetes Institute)

LA TROBE UNIVERSITY • AUSTRALIA

Department of Animal, Plant and Soil Sciences

School of Life Sciences

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

latrobe.edu.au/school-life-sciences

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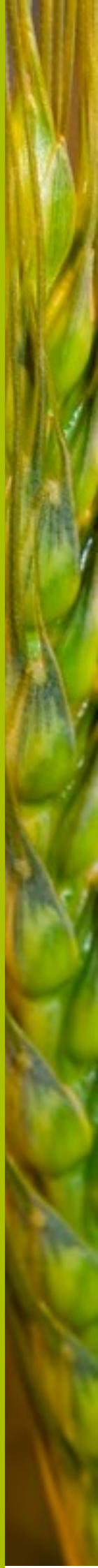


Cover Photo:
Crops (Photo Credit: James Hunt)

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 Agriculture and Food
- ARC Industrial Transformation Research Hub for Medicinal Agriculture
- Centre for Livestock Interactions with Pathogens (CliP)
- ARC Centre of Excellence for Plant Energy Biology

APSS Research Centres

ARC Centre of Excellence Plant Energy Biology

The Whelan Lab's extensive research in agricultural bioscience includes diverse aspects of plant energy metabolism such as the impact of energy and stresses on plant quality and yields and the effectiveness of phosphate fertilisers on specific plants and in current agricultural practices. This research comes together within the vision of raising the efficiency and efficacy of agricultural production; safeguarding and improving environmental integrity; and enhancing the communication and application of knowledge to influence policy on natural resources. We work on two aspects of plant energy biology: on mitochondria, the powerhouse of cells, and on phosphate, its energy currency.

Wheat (Photo credit: Jim Whelan)

Understanding mitochondrial biogenesis and function and their key signalling pathways over the plants' life cycle

Mitochondria provide the energy and building blocks for plant growth from the earliest stages of development through to senescence and cell death. Mitochondria also help plants to cope with adverse growth conditions and stresses which lead to large scale yield losses in agricultural production. We strive to better understand mitochondrial biogenesis and function as well as their complex underlying signalling pathways. This forms the basis to increase energy efficiency and stress resistance resulting in 'smarter' plants. We aim to identify the key regulators and signalling pathways involved in the communication of mitochondria with other organelles within the plant cell such as the nucleus and chloroplasts throughout the life cycle. This approach involves the identification and characterisation of mutant and transgenic plants on the phenotypic and molecular level. We are also profiling the stress responses of wild type and transgenic lines to identify mitochondrial components involved in making plants more tolerant to for example drought or submergence. This work includes mutant screening, genome-wide transcriptomics using RNA-seq and biochemical methods. The integration of results from these approaches will help us to understand the molecular mechanisms involved and identify targets for the development of improved plants with increased resilience to adverse and changing environmental conditions.

Identifying and characterising pathways to improve phosphate acquisition and use in plants

We research phosphate metabolism in order to produce 'smarter' plants that can take up more phosphate and use it more wisely. We study the biochemistry and molecular physiology of phosphate uptake and use within the plant to identify steps that can be targeted to optimise plant growth and productivity. Our research aims to identify gatekeeper cells that direct phosphate to growing organs to improve whole plant performance and yield. We use a variety of cutting-edge techniques such as obtaining cell-specific profiles of transcripts, proteins, metabolites and epigenetic marks. Manipulating regulatory circuits in these specialised cell types will give us insight on how to control nutrient fluxes. We study the genetic variation in natural *Arabidopsis* populations for adaptive traits to low soil phosphorus availability. Over 7,000 *Arabidopsis* accessions exist and many genomes have been fully sequenced allowing for genome-wide association studies. We screen over 700 accessions to identify those that are more tolerant or sensitive to phosphate changes. Using forward genetics combined with next-generation sequencing is a powerful tool to identify novel regulators of phosphorous signalling networks. We are screening for modulators of SPX4 stability under various nutrient regimes. SPX4 is a key sensor of plant nutrient status and a transcriptional repressor of the phosphate starvation response.

Lab Head: Professor Jim Whelan, FAA Research Director for the ARC Research Hub for Medicinal Agriculture and the La Trobe Institute for Agriculture and Food and Chief Investigator for the Centre of Excellence in Plant Energy Biology.

Lab Leaders: Dr Oliver Berkowitz, Dr Ricarda Jost, Dr Yan Wang

Twitter: @whelan_lab

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;
Dr 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

Centre for Livestock Interactions with Pathogens (CLiP)

One of the national priorities is the sustainable supply of safe, nutritious food.

Our aim is to improve the quality, performance and profile of our research in animal health.

The specific research that we carry out depends upon the research funds we attract and the researchers we recruit.

Our main focus is on understanding and controlling animal disease.

Specific research objectives are:

- To improve the ability to diagnose endemic diseases of livestock accurately and cheaply;
- To deepen our understanding of the interactions between hosts and pathogens;
- To develop more innovative methods of disease control and incorporate these into integrated disease control programs.

Major Research Projects include:

- Strategies to prevent two viruses devaluing Australian Crocodile Skins;
- Rapid, in-field molecular diagnostics of plant, animal and environmental pathogens and pests;
- Ecological control of Liver flukes: defining local situations and training in ecological control tools and concepts;
- Biochemical characterization of enzymes in the cannabinoid biosynthetic pathway;
- Structural resolution of PTEX, the translocon of virulence proteins in malaria parasites.

Crocodile (Photo credit: Travis Beddoe)

Student Research Projects include:

- Using LAMP to Improve Biosecurity Surveillance in Agriculture: the Footrot Model;
- *Fasciola glycans*;
- Vaccine Antigens and Adjuvants Against Fasciola and Avian Rotavirus;
- Molecular detection of agriculturally important livestock parasites and vectors;
- *Fasciola* Vaccine;
- Nematode proteases;
- Eosinophils of nematode infection;
- Bacterial phage therapy;
- Sheep movement to nematode infection.

Centre Director: Professor Travis Beddoe.

Lab Leaders:
Professor Mike Stear;
Associate Professor Karla Helbig;
Dr Tim Cameron;
Dr Subir Sarker;
Dr Caitlyn Jenvey.

Lab members:
Ms Nickala Best; Ms Jessica Wilke;
Ms Lily Tran; Ms Gemma Zerna;
Ms Sarah Sloan; Mrs Dalal Sader H Alenizi, Ms Stephanie Lynch;
Dr Fazel Almasi.

External Staff:
Professor Terry Spithill (Emeritus);
Assoc Prof David Piedrafita;
Dr Sarah Preston; Dr Grant Rawlin.

La Trobe Institute for Agriculture and Food

La Trobe Institute for Agriculture and Food (LIAF) has been established with the expertise and financial backing to apply world-class research that meets critical societal needs relating to the seed production, food and nutrition challenges posed by a growing population in a resource constrained world.

La Trobe University has made a strategic $25 million cash commitment over 5 years for LIAF to leverage further matched funding with the mission to support basic and translational research and training in the agri-food sector. La Trobe's visionary investment in the world-class AgriBio building, an agriculture research facility at the Bundoora campus that has the capability to carry out research from a molecular/ cellular level to whole organisms (plants and animals) in a variety of simulated environments. This has cemented its reputation in agriculture and food biosciences, creating a platform for further investment in intellectual capital that will support LIAF.

With an increasing global population, 69% more food calories will be needed to feed 9.6 billion people by 2050. Agricultural production in Australia is worth $62 billion p.a., however the cost of food related illness (including obesity) is $73 billion p.a. This highlights the need to integrate agriculture and health. LIAF's goal is to find solutions that enable sustainable agriculture that provide food of the quality and quantity to meet global food challenges in coming decades.

We have established partnerships with world renowned researchers, grain growers and their industry advisors, agricultural economists, health and nutrition specialists and leading national and international food producers to enable the research underpinning the production of grains that are "fit for a variety of purposes", namely higher yield and higher quality/more nutritious grains to work across all elements of the supply chain.

Greenhouse at the AgriBio Building

Capabilities:

- Transformation and Gene Editing for cereals and legumes
- Extensive Growth Facilities (Glasshouses (PC2/QC2)) and Controlled Environment Rooms (PC3/QC3)
- 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)
- Bioimaging Platforms (Immuno/EM)
- Mineral and chemical analyses of soil, plant and seeds
- Plant Phenomics (2D, 3D, cloud-based analytics)

Director:
Professor Tony Bacic, FAA.

Research Director:
Professor Jim Whelan, FAA.

Industry Engagement Director:
Professor Marilyn Anderson.

Senior Director:
Dr Veronica Borrett.

Program 1:
Soil Science and Agronomy.
Leaders: Professor Caixian Tang and Professor James Hunt.

Program 2:
Seed Biology.
Leaders: Professor Jim Whelan and Associate Professor Mat Lewsey.

Program 3:
Nutritional Bioengineering.
Leaders: Dr Monika Doblin and Dr Kim Johnson.

Program 4:
Medicinal Agriculture.
Leader: Professor Tony Bacic.

Email: liaf@latrobe.edu.au

APSS 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

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

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

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

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

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

Animal Parasitology & Immunogenetics Group

The Animal Parasitology & Immunogenetics Laboratory performs research to gain a better understanding of host-parasite interactions in animals and uses this understanding to improve methods of parasite control. Of particular interest to our group are gastrointestinal nematodes, more commonly known as roundworms. Roundworms are the most-costly infection of Australian livestock, costing Australian sheep and cattle producers over $400 million per year.

Immunity to parasitic infections

Host immunity to parasites tends to develop slowly and in the natural host often involves a mixed infection of multiple parasite species. The host response presents as a modified Type I hypersensitivity reaction, which involves the production of antibodies, such as IgG1, IgE and IgA, as well as eosinophils and mast cells. The major roundworm infecting small ruminants in the wetter, temperate regions of Australia is the Brown stomach worm (*Teladorsagia circumcincta*). There are two major manifestations of immunity to this parasite; the failure of incoming larvae to establish, which is most strongly associated with IgE activity against L3 and the number of discharged mast cells, and reduced size and fecundity, which is most strongly associated with mucosal IgA activity against L4 and the number of eosinophils.

Breeding sheep and cattle for resistance to disease

Standard practice to control roundworms is to drench infected animals with anthelmintics, a group of drugs that expel parasitic worms, but control is threatened by the evolution of drug resistance. One method that is being used by an increasing number of farmers is selective breeding for parasite resistance. Resistant animals can be identified by counting the number of parasite eggs in the faeces (FEC), however this method is slow, unpleasant and limits the use of drug treatments. Our group is investigating alternative methods that are cheaper and quicker, as well as more strongly associated with worm burdens and increased productivity.

Sheep (Photo credit: Mike Stear)

The role off eosinophils in host resistance to parasites

Eosinophils have a role in host immunity to parasites, however, the exact mechanisms by which this role occurs is not well understood, and eosinophil response appears to differ in different roundworm species. Eosinophils contain toxic granule proteins, two of which are uniquely expressed by eosinophils. Major basic protein 2 (MBP-2) appears to be the only homologue of MBP present in ruminants, and eosinophil peroxidase (EPX) may be dysfunctional in sheep and goats due to potential frameshift mutations, as well as the substitution of a conserved nitrosylated tyrosine with a cysteine (which is critical for post-translational modifications of eosinophil granule proteins). These findings indicate that eosinophil function is best studied in the natural host and that differences in eosinophil responses are sufficiently large to identify individuals at risk of clinical disease and decreased productivity. Our group intends to use this information to develop new methods of control.

The role of the MHC in resistance to roundworm infections

We have a long history of identifying genes that influence resistance to parasites and studying their function.

The most important gene for parasite resistance is DRB1 in the major histocompatibility complex. This gene influences which parasite molecules are recognised by the immune response; animals that recognise more molecules are more resistant.

Lab Head: Professor Michael Stear

Lab Members:
Dr Caitlin Jenvey; Ms Sarah Sloan; Mrs Dalal Alenizi; Mr Fazel Almasi.

Fields off Study:
Parasitology, Immunology, Genetics, Animal Production, Veterinary Science.

Capabilities and Techniques:
Field epidemiology, diagnostics, animal parasitology, genetic analysis, molecular immunology, immunogenetics, immunohistochemistry and immunocytochemistry, histology, confocal, bright field, phase contrast and differential interference microscopy, image analysis, bioinformatics, experimental design and statistical analysis.

Translational Opportunities:
Therapeutic parasite molecules to regulate the immune response in clinical diseases. Novel tests to identify disease-resistant and resilient animals, point of care tests for farmers, breeders and veterinarians.

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 and Professor James Hunt.

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.

Smoke (Photo credit: Stock Images)

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

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

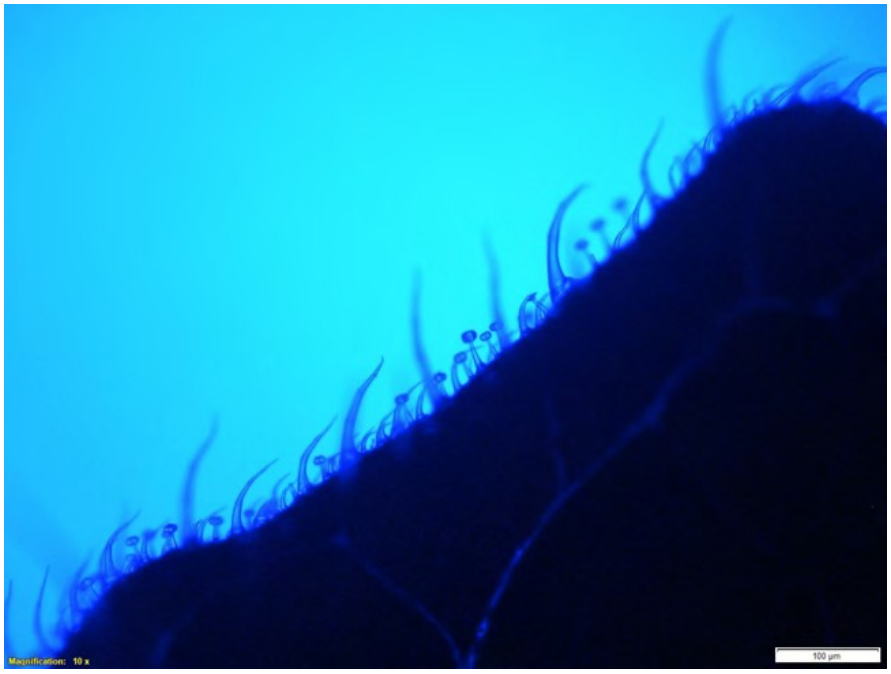
Seeds are the single most valuable output from plant production, providing 70% of global food resources. They are also a critical input to agriculture because the lifecycle of most crops begins each season from their seeds, which must germinate, grow and establish. We examine the temporal and spatial 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

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

We are part of "Legumes for Sustainable Agriculture", an ARC funded Industrial Transformation Hub. 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 of legumes. Both these outcomes will increase legume use and contribute to more sustain-able agricultural systems.

The symbiosome membrane: the interface between legume and rhizobia

We are studying the composition of this specialized membrane using proteomics to identify components. We use molecular and genomics techniques to understand the role of proteins in nutrient transport and signaling between the two organisms and how these processes contribute to control and efficien-cy of nitrogen fixation.

Metal transport in the l egume: 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 transport different metals in nodules using molecular techniques, microscopy and proteomics to determine their cellular location and transport assays in heterologous systems to study their function.

Improving the efficiency of nitrogen fixation in chickpeas

Nitrogen and phosphorus are the two most important macronutrients for plant growth. Nitrogen fertilizers are chemically synthe-sized using the Haber-Bosch process and production requires a large input of energy and also contributes to carbon emission and global warming. Fertilizers containing phosphorus are produced by mining rock phosphates, a resource that is non-renew-able. Both nitrogen and phosphorus fertilizers when applied in excess can 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 and in low P conditions. We will then analyse the genetic basis for this ability via genome wide association studies and other molecular analysis. Improving the efficiency of nitrogen fixation can make our agricultural systems more sustainable.

Left: chickpea plant with nodules.

Right: cowpea plant roots with nodules.

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 characterising lupin seed components using genomic and proteomic approaches. In particular the allergens of lupin are being characterised to determine if there is cross-reactivity with peanut allergens. The long-term aim is to determine the regulatory processes involved in formation of protein and fibre and use this knowledge to improve the seed for human consumption.

Lab Head:
Associate Professor Penelope Smith

Lab Members: Dr Frank Bedon

Fields of Study:
Molecular Biology, Plant Biology, Biochemistry, Cell Biology, Crop Production

Capabilities and Techniques:
Molecular Biology, Proteomics, Plant Transformation, Protein analysis, Microscopy.

Translational Opportunities:
Food allergy, plant breeding, plant biotechnology.

Molecular Plant Pathology Lab

Plant diseases caused by pathogenic microbes currently compete with humans for plant products, with up to 30% of world food production predicted to be lost in the field and after harvest. Our research focuses on understanding plant pathogens with an aim to find effective disease control options for crop production. We take a wholistic approach to plant disease research, investigating broad aspects including: understanding how plants detect and fight off would be pathogens; developing new tools to assist plant producers in their battle against pathogens; and how to best manage the use of the fungicides to avoid resistance evolution. For over 25 years Associate Professor Plummer has collaborated with Australian and international researchers in New Zealand, France, USA, Korea and Japan to understand the basis of disease and resistance in apple and pear fruit.

Fungal disease on apples (Photo credit: Kim Plummer)

ARC Medicinal Agriculture Hub P roject Collaborations

Healthyplants for human health: tackling plant disease in medicinal Cannabis production (*with CANN Group Ltd; NSW DPI)*
Diseases can reduce yield and contaminate medicinal Cannabis products with pathogens and agrichemicals. We aim to control fungal diseases without the use of agrichemicals and are developing surveillance techniques for early warning of pathogen presence, enabling timely interventions. We are also investigating whether metabolite engineering of Cannabis affects natural disease resistance.

Defining the role of plant melatonin as an anti-stress hormone
Plant melatonin, discovered in 1995, is linked to regulation of growth and development, and tolerance to biotic and abiotic tresses. We study the role and effects of melatonin for potential agricultural use. Our aim is to determine growth and genetic response variation among geographically diverse ecotypes of Arabidopsis thaliana. We are examining a melatonin biosynthetic gene serotonin-N-acetyltransferase1 mutant (atsnat1) to determine whether melatonin regulates plant gene expression in a similar way to plant hormone auxin. We also assess growth and motility responses of rhizobacteria and a pathogenic bacterium, as well as melatonin impact on crop soil microbial populations.

Detection of azole fungicide resistance in barley net-blotch pathogens in Victoria
(with Curtin University; AgVIC Plant and Food Research NZ; INRA France)

Improving natural plant defences by understanding plant-pathogen interactions using comparative genomics/transcriptomics of scab fungi *(with Massey University)*

Investigating a possible horizontal gene transfer in the apple scab fungus: determining the role of the PNP-like effectors in the apple scab fungus *(with Massey University, PFR NZ; Wageningen University)*

ARC Hub for Sustainable Crop Protection Project Collaboration
Development and validation of sustainable fungicide platform against Botrytis *(with University of Queensland; Queensland DPI)*
Novel solutions for plant disease protection are being developed and validated for an RNAi-based fungicide platform targeting pathogens of domestic and global significance to horticulture, including Botrytis. We aim to deliver a product with zero crop residue and low risk for resistance development.

Lab Head: Assoc Prof Kim Plummer

Lab Associates:
Dr Janet Wheeler; Dr Frank Bedon

Fields of Study:
Plant Pathology; Plant/Pathogen Genetics; Co-evolution; Plant-parasite Physiology; Bioinformatics.

Capabilities and Techniques: Genomic, transcriptomic and proteomic analyses, cell biology, microscopy, and molecular biology techniques are used to understand pathogenesis, plant disease resistance and the molecular basis of fungicide resistance; novel methods of pathogen control.

Translational Opportunities:
Various industry partnerships have developed where challenging plant disease problems have arisen, e.g. hemp and cannabis; strawberry; apple and pear; barley industries. Understanding of plant host and pathogen biology and genetics has led to research into the development of new tools for fighting disease, detecting pathogens, and turning the pathogen weapons against themselves with research into new technologies for disease control.

Plant Cell Walls and Bioactive Secondary Metabolite Group

The Plant Cell Walls and Bioactive Secondary Metabolite Group aims to understand at the molecular level how the biosynthesis, assembly and turnover of cell surface biopolymers is regulated. 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 establish a cross-disciplinary program that will provide a foundation for the improved production of plant-derived medicinal products, including cannabinoids, terpenes and other plant secondary metabolites.

Plant Cell Surfaces (Cell Walls)

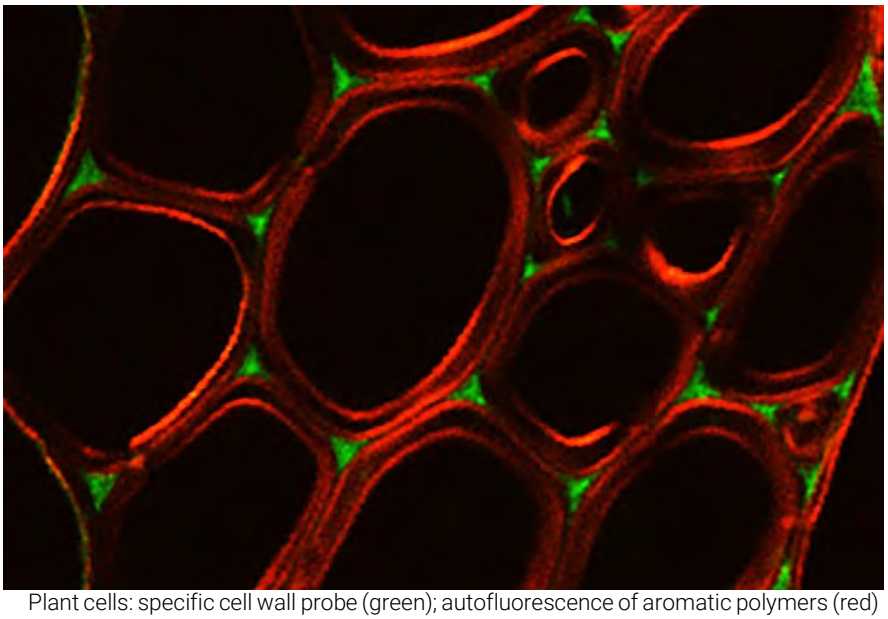
Most plant biomass consists of a carbohydrate-rich matrix present in cell walls. Cell walls, a major carbon sink, are our most renewable bio-resource and determine the quality and quantity of most plant-based products (food, fibre and fuel). Primary cell wall components are a key source of soluble dietary fibre (critical for human health). 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

Ever wondered how the venus fly trap senses the touch of a fly and shuts its trap to capture it? How a root can feel a rock and grow around it? How a tree stem can grow back upwards even if it gets bent? Plants have feelings too! They can sense changes in their physical environment and 'move' their body and change shape to best adapt to the conditions. Our work investigates cell surface sensors that feel touch and the response pathways that lead to changes in the cell wall and as a result, growth. This research aims to develop plants with greater plant biomass, optimise plant cell wall properties for food, fibre and fuel applications and enhance resistance to physical damage.



Plant cells: specific cell wall probe (green); autofluorescence of aromatic polymers (red)

Plant Bioactive Secondary Metabolites

For a complete description of the program see https://medagriculture.com/

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, Dr Kim Johnson and Dr Wei Zeng (Zhejiang A&F University, China)

Lab Members:

Nutritional Bioengineering & Fibre Quality: Dr John Humphries, Dr Pavani Nadiminti, Mr Alfie (Pengfei) Hao, Mr Yingxuan Ma (PhD), Ms Tia Guo (MSc), Ms Jacqueline Mantovani (MSc).

Medicinal Agriculture: Dr Myrna Deseo, Dr Matthew Welling, Dr Bill (Hiep) Lu, Dr April (Wen) Li (University of Melbourne), Dr Martin O'Brien, Mr Gianni Del Rosario Makridis (PhD).

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:

Imaging (light/fluorescence microscopy; scanning/transmission electron microscopy); Multi 'omics (glycomics/proteomics/metabolomics/transcriptomics/bioinformatics); Cell wall analytics; Mass Spectrometry; Cell, Molecular and Developmental Biology; extensive glasshouse/growth facilities.

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; 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

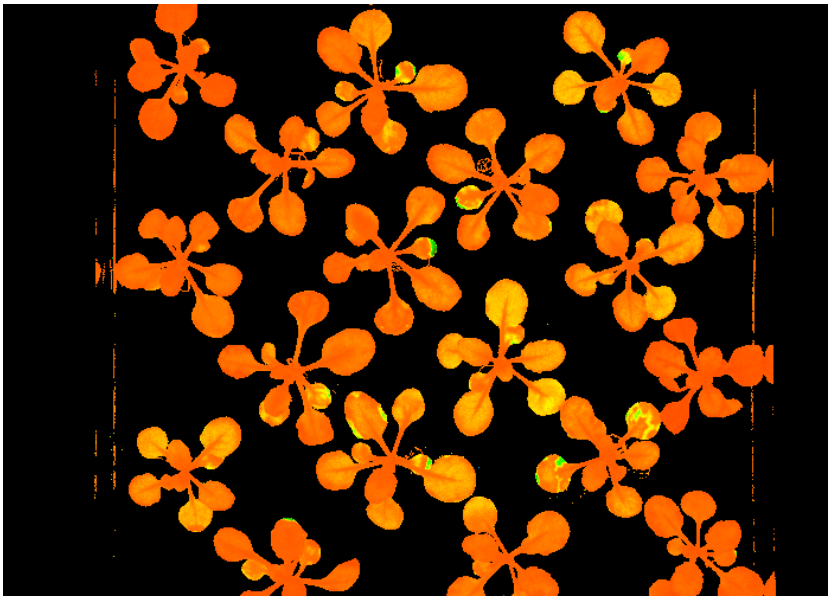
A major area of interest in the lab is the regulation of ion homeostasis by a family of intracellular Na+/H+ antiporters in the model plant *Arabidopsis*. Overexpression of many of these family members leads to increased salt tolerance, but the mechanisms for this resistance is poorly understood.

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.

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 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.

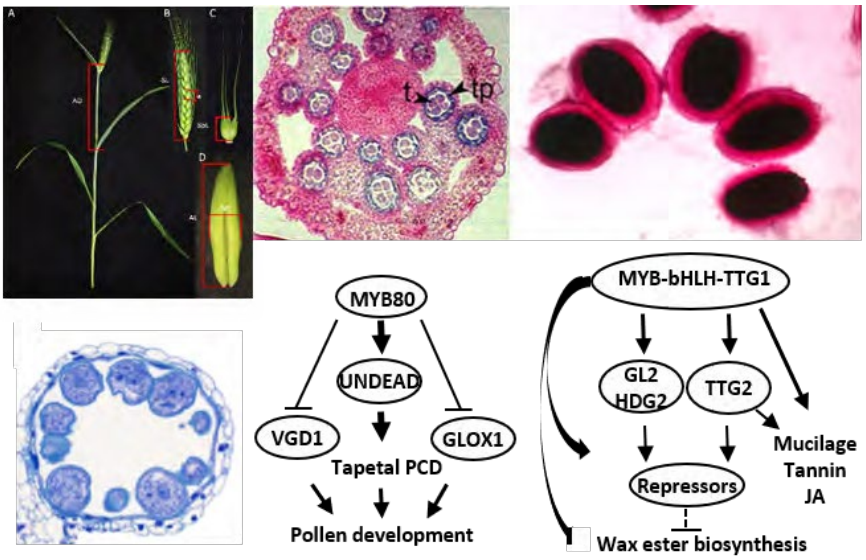
Heat stress and anther development

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, 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.

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.

Lab members: Dr Gary Clark; Dr Juan Wang; Dr Jian Jin; Dr Han Weng; Assoc Prof Peter Sale.

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.

LA TROBE
UNIVERSITY • AUSTRALIA

Department of Ecology, Environment and Evolution

School of Life Sciences

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

latrobe.edu.au/school-life-sciences

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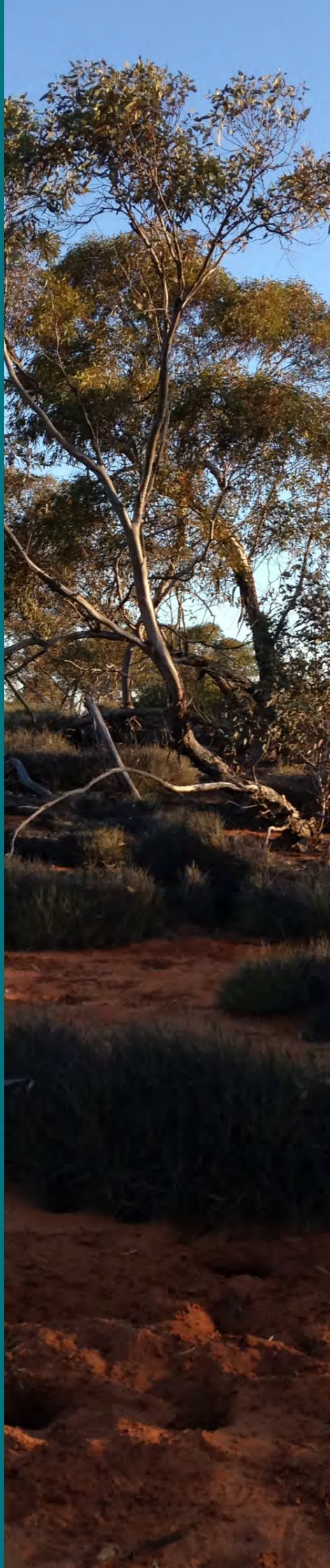


Cover Photo:
Working in the Alpine region, Victoria (Photo Credit: John Morgan)

Department of Ecology, Environment and Evolution

The Department of Ecology, Environment and Evolution 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)

EEE 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 our forbears' decisions are felt today, the way in which we manage the 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 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 into 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 want to recruit, support and train the next generation of scientists committed to solving pressing environmental problems.

We have research expertise in:

- Landscape ecology
- Fire ecology
- Animal-plant interactions
- Behavioural ecology
- Insect ecology
- Plant ecology
- Environmental geoscience
- Agronomy
- Microbial ecology
- Conservation genetics
- Landscape planning
- Social science

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

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/

EEE 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.

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 Aquatic Ecology Research Group

Our group conducts applied and fundamental research on the ecology of freshwater, estuarine and near-shore marine ecosystems, and applies this knowledge to aquatic environmental problems. Located in the Centre for Freshwater Ecosystems, we research species biology and community interactions, traits and life history, food webs, ecosystem processes, impacts of human induced threats (particularly flow regime change, land use changes, invasive species), and technological advances in monitoring of aquatic ecosystems.
We maintain active collaborations with a diverse range of stakeholders, industry and research partners to ensure that our research contributes to the development of policy and management to support conservation and sustainable aquatic resources.

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

Water Management and Environmental Flows

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

Aquatic Biodiversity and Ecosystem Monitoring

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

Improving aquatic restoration and management outcomes

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

Theme Members: Prof Nick Bond; Assoc Prof David Crook; Dr Michael Shackleton; Dr Luke McPhan; Dr Nicole Thurgate; Dr Andre Siebers.

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

Capabilities and Techniques:
Field-based aquatic sampling; Field & lab experiments; 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 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.

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 and Dr Aleicia Holland.

Lab Members: Dr Michael Shackleton; Dr Andre Siebers; Dr Luke McPhan; 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:

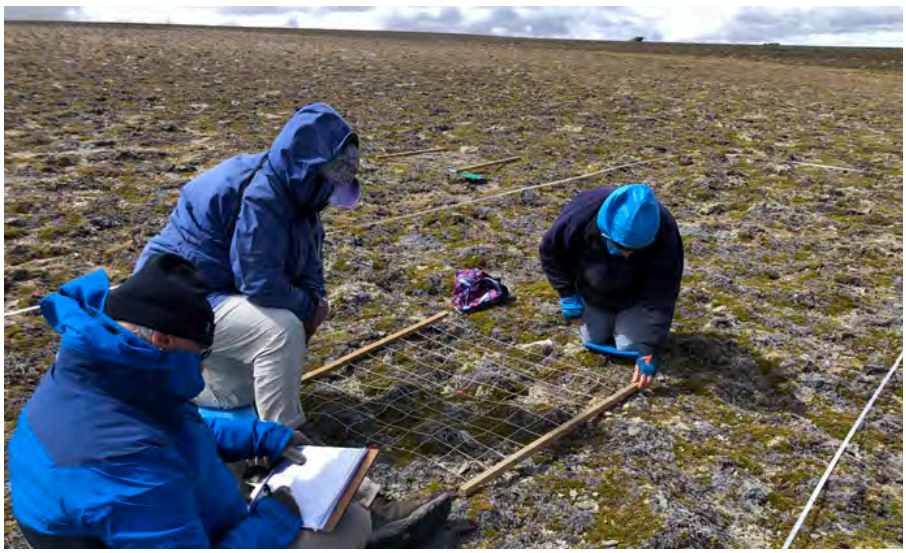
Aquatic ecosystems field sampling; Water & soil analysis; Aquatic system productivity (GPP & ER); Laboratory risk assessment of contaminants; Liquid chromatograph mass spectrometry; Fluorescence and absorbance spectroscopy (FEEM); Synchrotron IRM & XAS; Metagenomics; Chemical speciation & thermodynamic 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 f or 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

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 Merinda Day-Smith; Ms Claire Hutton; Mr Alex Blackburn-Smith; Ms Amy Buckner; Ms Hayley Sime.

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 >70 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

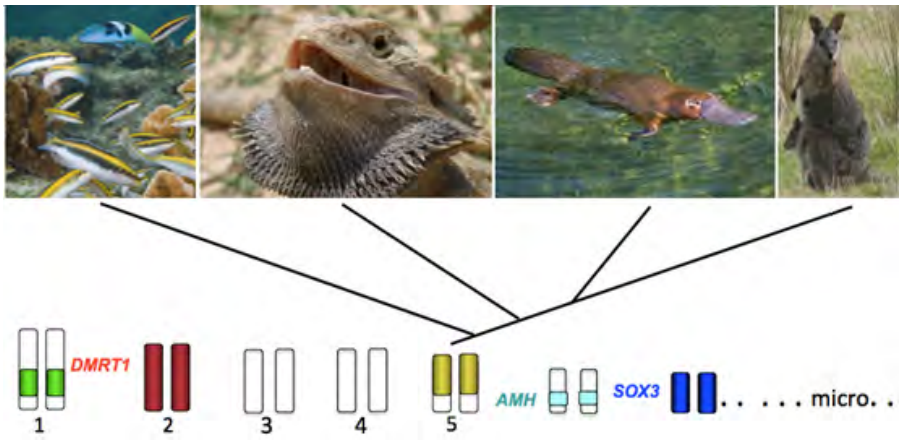
Prof Jenny Grave's comparative genomics research is via national and international collaborations.

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.

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.

Ecological Genomics Group

Our Laboratory has state-of-the-art facilities to study genes through to genomes of vertebrates and invertebrates. Our highly collaborative research involves local, national and international partners. We use first, second and third generation sequencing techniques to decipher the genome and determine how it has changed over time due to selection and demographic effects. We link RNA expression with the epigenome to recognise and link genomics with fundamental features of basic ecology and behaviour. Our ability to detect and recognise these cues is critical to each species' health and survival – including our own. We use model species to understand and unravel basic processes that influence an organisms' ability to survive and reproduce in a fluctuating environment.

Evolutionary history of Australian native animals

Australian scientists have an obligation to learn more about our native species. Focused research projects can help us understand how they fit into the ecological landscape. Evolutionary history studies can resolve and quantify the genomic variations of animals enabling a precise genomic definition of species and buttress future conservation efforts. We are eager to collaborate on genomic studies of all native animals. Over the past decade we have worked on the Australian dingo. After winning the International "World's Most Interesting Genome Competition" in 2017, we determined the genome of "Sandy" the Desert dingo. Deciphering her genome is our first step to understanding the evolutionary history of the four dingo ecotypes' and determining when and how they came to Australia.

Landscape genomics of apex predators

The first step towards adaptation to future climate change is diminishing vulnerability to present climate variability. One component of conferring resilience against globally threatening processes is to develop our understanding of apex predator responses to change because they are drivers of ecosystem dynamics and biodiversity conservation. We are developing our genomic understanding of all apex predators. In Australia, dingoes are the terrestrial vertebrate apex predator, and influence the behaviour, spatial distribution and abundance of prey populations. Dingoes are a part of Australian culture's fabric, and are considered a "lightning- rod" of the land, generating heartfelt and often polarised opinions from Aboriginal people, tourism operators, pastoralists, ecologists, and conservationists. The unclear distinction of dingoes from feral dogs is the main controversy leading to differing opinions of conservation efforts' value. We conduct behavioural, metabolomics, microbiome, and nutrigenomic studies on Sanctuary dingoes.

Domestic animal genomics: One genome at a time

There are over 100 horse, cattle, pig and chicken breeds. In Australia, there are 195 dog breeds, 22 sheep breeds, 21 cat breeds and two alpaca types. A reference genome should be developed for each and every domestic breed and type to help maximise productivity and enable targeted identification of breed specific genetic diseases. It will also help to group genomic regions that are similar between breeds and allow future proofing the genome. We have sequenced the entire genomes of a German Shepherd Dog and a Basenji dog. Next, we will determine an optimal protocol for assembling three dog breeds' genomes: Chow Chow, Australian Cattle Dog (ACD), and Bernese Mountain dog (BMD). We selected these three morphologically distinct breeds as they span the currently proposed dog breed phylogeny. These canine genomes will enable hypothyroidism studies in Chow Chow, deafness in the Australian Cattle Dog and histiocytic sarcoma in the Basenji Mountain Dog.

Nutrigenomics: it's all in the genes

When we look online for foods that help to make us healthy or fit, they are the same for females and males, all ages, races, and body types. Yet, the suggestion that our genomes are the same is simply untrue. Science has determined that our genomes are not identical, and the expression of many genes changes as a person ages. Soon, elite athletes' genomes will be unraveled to construct diets that maximise energy production and reduce disease riskThe same will occur for primary production animals to determine how diet can be optimised for each genome, energetic requirement, and age. We have studied the influence of diet on energy production in Drosophila flies and have shown that a single mutation in the mitochondrial genome can influence developmental time. We are researching whether this metabolomic difference will then determine the frequencies of flies in the population when specific foods are available.

Sandy (Photo credit: Barry Eggleton)

Lab Head: ProfJ. William O. Ballard.
Lab members: Dr Sonu Yadav.

Fields of Study:
Genomics; Evolution; Nutrigenomics; Metabolomics; Behaviour; Ecology.

Capabilities and Techniques:
Whole genome sequencing and assembly; Molecular Biology; Metabolomics; Epigenomics; Detecting selection; Statistical testing for genetic subdivision; Behavioural assays.

Translational Opportunities:
Testing whether dingo scent-marking can develop a chemical fence that excludes pure dingoes from farmland; Developing a test for severity and reducing prevalence of canine hip dysplasia in German Shepherd Dogs.

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.

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.

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, and the Regent Honeyeater. 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: Prof Mike Clarke.

Lab members: Dr Angie Haslem; Dr Kate Callister; Mr Simon Verdon; Mr Rhys Makdissi; Mr Shannon Braun.

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.

Theme Head: Assoc Prof David Crook.

Theme members:
Assoc Prof Alison King; Prof Nick Bond; Dr Luke McPhan; Dr Michael Shackleton; Dr Andre Siebers; Dr Nicole Thurgate.

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.

Lab members: Ms Lucy Johansson; Dr Orsi Decker; Mr James Buxton; Ms Melissa Van de Wetering; Mr Peter Contos; Mr Zac Kayll.

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.

Insect-Plant Interactions Lab

We study how plant-feeding insects use their hosts and the damage they cause them. Most of our research concerns native Australian insects that feed on eucalypts and other myrtaceous plants but we also study economically important exotic insects affecting fibre and crop plants.

Defoliation and stress responses of eucalypts

Australia has few native aphids. Instead, we have a diverse and often abundant psyllid (Hemiptera: Psylloidea) fauna. Like aphids, psyllids are tiny, piercing-sucking insects that can attain very high abundances. While the majority of psyllids appear to cause no damage to their host eucalypts, feeding by species belonging to a few genera is associated with the formation of lesions that induce premature leaf abscission and severe defoliation and even death of trees. Our research seeks to explain factors causing irruptions of psyllid populations, stress responses induced in leaves by their feeding and polyphenolic defences of eucalypts. We focus on eucalypt polyphenolic compounds because they are the plant specialised metabolites most likely to affect sucking insects and are implicated in photoprotection responses of plants.

Honeydew as a mediator of trophic cascades

Honeydew is a sugary liquid excreted by many members of the order Hemiptera but especially by the Sternorrhyncha which includes psyllids, aphids and scale insects. We are investigating how psyllid lerp mediates the trophic cascades associated with the phenomenon of Bell Miner Associated Dieback (BMAD). Many genera of Australian psyllid alter the chemical composition of honeydew so that it solidifies on contact with air and can be formed into small shelters called lerps. Lerps composed of substantial quantities of unaltered sugars are attractive to birds, including Bell Miners. The establishment of Bell Miners alters regulatory processes keeping psyllids in check and triggers community-wide change in eucalypt forests. We are also studying how honeydew produced by the Giant Pine Scale alters communities of native and exotic Hymenoptera (latter including feral Honeybees and European wasps).

Fifth instar nymph of a *Cardiaspina* species (lerp removed). (Photo credit: Nicholas Porch)

Biology and ecology of Australian insect herbivores

Australian plants and insects have been widely distributed around the globe – intentionally and unintentionally – and become environmental weeds or threats to tree plantations, respectively. A long-term focus of our research has been explaining how and why native insects use the species of eucalypt and other native plants they do, and what it means for their abundance through time. This research represents an essential knowledgebase for international researchers tackling incursions of Australian insect defoliators or those seeking to identify insect herbivores that could be biocontrol agents for environmental weeds of Australian origin.

Lab Head:
Assoc Prof Martin Steinbauer FRES.

Postdoctoral Associates:
Dr Aimee McKinnon; Dr Thomas Sayers.

PhD Students:
Mr Santosh Khanal; Mr Reza Najafabadi; Mr Duncan Jaroslow; Mr Surendra Bam.

Honours/Masters Students:
Ms Julia Smith; Ms Berenice Della Porta; Mr James Martin.

Fields of Study:
Animal Behaviour; Forestry Pests; Invertebrate Biology; Natural Products Chemistry; Terrestrial Ecology.

Capabilities and Techniques:
Gas chromatography-mass spectrometry (GC-MS); VOCs sampling; Olfactory bioassays; Insect pheromone & plant semiochemicals research; Eyesonhives cameras; Insect sampling and experimentation; Insect identification.

Translational Opportunities:
Biological control of weeds; Eucalypt foliar chemistry; Eucalypt health & defoliation; Forestry pest surveillance; Honeybee health; Insect pheromone research.

Landscape Ecology Group

Our group investigates how landscape structure, function and change influence the ecology and conservation of native fauna. 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 to identify effective actions that landholders can undertake. Several long-term projects (>10 years) give key insights into changes through time (e.g. impacts of the Millennium Drought).

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,dry box-ironbark forests, 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.

Lab Head: Professor Andrew Bennett.

Lab members:
Dr Angie Haslem; Dr Jim Radford (RCFL); Mr Alex Maisey; Ms Jess Lawton; Mr Fred Rainsford; Ms Jacinta Humphrey; Ms Rachel McIntosh; Ms Emmi van Harten.

Fields of Study:
Landscape Ecology; Conservation Biology; Wildlife Conservation.

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.

La Trobe University Herbarium

The Department of Ecology Environment and Evolution 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 Ecology, Evolution and Environment 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 DEEE) 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, Eucalyptus 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 1000 separate download events. There have been over 1.6 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 DEEE. 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 (DJPR). 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.

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.

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.

Lab Members:
Ms Nicole Wilson; Ms Adrienne Cheong; Dr Adrian Flynn (Honorary); Dr Adele Harvey.

Fields of Study:
Muscle Physiology; Comparative Physiology; Behaviour; Ecology and Conservation.

Capabilities and Techniques:
Force recording of intact, bundles & mechanically skinned single muscle fibres; Microscopy; Behavioural testing; Field sampling & observations; Access to Fathom Pacific Pty Ltd marine vessels for research dives, surveys, mapping, bioacoustics etc.

Translational Opportunities:
Environmental management strategies; Establishment of artificial reef systems; Restorative muscle function and prosthetics.

Molecular Ecology Group

We a use range of genetic and genomic tools to study terrestrial and aquatic species. Our research ranges from addressing important population-level process such as genetic diversity, dispersal, kinship and population structure to deeper level evolutionary processes responsible for shaping present day biodiversity. We also use genomic methods to investigate elusive and hard to identify species from environmental DNA and to study species diets. Our research addresses a range of critical management questions including the conservation of threatened species, invasive species management and biodiversity monitoring. Our research is highly collaborative, with many industry and academic partners across Australia.

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

Freshwater Fish

Australian freshwater systems are under pressure from a multitude of stressors, including changes to flow regimes. To promote the genetic health of vulnerable Victorian fish species, we use highly resolving single nucleotide polymorphism markers (SNPs) and genome sequencing, to investigate the relationship between critical demographic factors (breeding dynamics and dispersal) with environmental watering and fish stocking programs. Our research across diverse species over multiple years is informing water management strategies to develop the best methods for promoting genetic diversity within the Murray Darling Basin.

Invasive Deer

Our research is undertaken in collaboration with ongoing government partnerships aimed at improving deer management, mainly through detection of deer species and assessment of deer connectivity and density across Australia. We use genetic tools to identify deer hybridisation, population size, identify distinct management units, track dispersal and assess deer control methods. We study deer diets to identify effects on native flora and the potential to spread invasive weeds.

Conservation Genetics

Many Australian species are threatened with extinction, and rapid declines can negatively impact the genetic diversity and fitness within the remaining populations. We directly inform endangered and threatened species managers on conservation strategies. We focus on genetic diversity patterns to define species management units and assist with genetic management plans. We have shown there are fitness costs associated with inbreeding in threatened species which can be addressed by incorporating genetics into species management plans (e.g. the helmeted honeyeater - *Lichenostomus melanops cassidix*).

Trace DNA

We study trace DNA for conservation and management of species and ecosystems. We use eDNA techniques to detect single species of conservation importance or species of management interest. We also use DNA metabarcoding to characterize entire communities from both unique aquatic environments for biomonitoring, and from dung samples to characterize diet and food webs to better understand species interactions.

Short Range Endemics

Vulnerable short range endemic species act as bioindicators for the overall health of their ecosystems. We study groundwater dependent and forest litter ecosystems to identify the biodiversity present and understand the ecological and evolutionary impacts of long-term environmental changes and short-term events on dispersal limited species.

Lab Head: Dr Nick Murphy.
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.

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 an iconic Australian plant genus
Using genetic studies coupled with pollination studies, we aim to identify processes involved in speciation in a group of Australian plants belonging to the genus *Grevillea*. The project is multi-pronged with a phylogenetic component, a narrower population genomics approach and an aspect that combines floral cues and pollination biology. Owing to habitat fragmentation and declining pollinators, identification of the processes underpinning population structure and species evolution will aid conservation management for several taxa.
Collaborators: Gareth Holmes (La Trobe University (LTU); Royal Botanical Gardens Victoria)

Diversity within the bush food Sweet Quandong
Preliminary studies have shown that in northern Victorian and southern NSW population, Sweet Quandong harbours low genetic diversity, with many stands consisting of single multilocus genotypes. Multiple stems of single genotypes were widely spaced suggesting vegetative growth via root suckers is extensive. Furthermore, there was no geographic structure to the diversity identified.Interestingly some individuals were putatively polyploid (i.e. having more than two sets of chromosomes) – a finding that is consistent with some studies but equivocal with others. Using an array of approaches, we plan to determine if variation in ploidy level of this widely distributed bush food species is more common than is currently recognised. The results will have implications for the bush foods industry, seed production areas and other revegetation programs.
Collaborators: Linda Broadhurst (CSIRO), Jim Begley (Goulburn-Broken CMA)

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. In this proof-of-concept project, we will identify markers of sexual compatibility by an extension of differential gene expression analysis based on an RNA sequencing approach. This will have broad applications across many plant species with both conservation and agronomic value. *Collaborators:* Anthony Gendall (LTU); Roger Cousens (University of Melbourne)

Other SI related research has been contracted by the Australian Nurserymen's Fruit Improvement Company Ltd.

Lab Head: Dr Susan Hoebee.
Lab Members:
Ms Tamandra (Mandi) O'Dombrain;
Ms Simone Currie; Mr Graham Jury;
Mr Stanislaw Wawrzyczek;
Mr Surendra Bam.

Fields of Study:
Ecology; Evolution; Genetics;
Plant Reproduction; Conservation Biology.

Capabilities and Techniques:
Field skills; Refractometry and Reflectance (with application to floral traits); Standard and High-throughput genomic techniques; Scanning electron microscopy.

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.

Understandingtheecologicalandgenetic consequencesofpollinationbyvertebrates

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.

Lab Members:
Mr Stan Wawrzyczek; Mr Tobias Hayashi.

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

Capabilities and Techniques:
Field experiments; Behavioural observations; Plant-pollinator networks; Spectral reflectance analysis; Camera trapping,; DNA barcoding.

Translational Opportunities:
Species conservation; Ecological restoration; Threatened species recovery; Invasive species management.

Reproductive Ecology and Conservation Biology Group

Our group's research is broadly focused on reproductive ecology and conservation biology in captive and field-based wildlife studies. Current reproductive research examines maternal/paternal effects on offspring phenotypes, sex allocation, mate choice and the physiological and endocrinological basis for variation in life history. Our conservation research address questions on endangered species, anthropogenic disturbance (especially artificial light at night and climate change), captive breeding, behavioural traits and reintroduction success. We use a multidiscipline approach to question-oriented research using a diverse range of taxa, including but not limited to reptiles, birds, bats and marsupials.

Bridled nailtail wallaby *(Onychogalea fraenata).* (Photo credit: Kylie Robert)

Understanding the mechanisms and adaptive advantage of sex allocation

Sex allocation theory predicts parents bias their investment into the offspring sex that maximises their fitness. Current theories on adaptive adjustments in offspring sex ratios and have provided some compelling examples. However, offspring sex ratios in many taxa (especially mammals) have proven difficult to understand and would be better facilitated by a mechanistic understanding. Our research focuses on unravelling mechanistic underpinnings of adaptive sex allocation from paternal contribution in ejaculate to maternal condition at time of conception and the role of sex steroid and glucocorticoid hormones. Our research uses the unique ability to access marsupial pouch young as neonate equivalents in-utero to test the adaptive advantage of raising one sex over the other through cross-fostering offspring prior to significant maternal contribution.

Ecological impacts of artificial lighting on wildlife

Artificial lighting fundamentally changed the earth's night-time environment, with a wide range of biological effects on animals. Organisms have evolved to respond to natural light cues to control or modulate behaviour, activity, reproductive timing and physiological function. We study artificial light impact on reproduction timing in seasonally breeding wildlife. Using our knowledge of the visual and non-visual sensitivities of our target species we 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.

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

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.
Theme Members: Assoc Prof David Crook; Assoc Prof Alison King; Dr Luke McPhan; Dr Nicole Thurgate; Dr Michael Shackleton; Dr Andre Siebers; Dr Julia Mynott.

Fields of Study:
Ecology; Hydrology; Landscape Ecology; Ecosystem Science.

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

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

Sleep Ecophysiology Group

Sleep is something we all do. We 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.
Lab Members: Mr Robin Johnsson; Miss Shauni Omond; Miss Erika Zaid.

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.

Water Geochemistry and Landscape Evolution Group

The Water Geochemistry and Landscape Evolution Group studies processes that affect groundwater composition, including acidic drainage at mines, and the landscape evolution of eastern Australia.

Acid lagoon, Murray River near Mildura. (Photo credit: John Webb)

Groundwater composition

Groundwater composition is determined by the interaction between rainwater and the soil and rock through which the groundwater moves. In Southeast Australia, we used major element and isotopic analyses to show that plants alter infiltrating rainwater composition before it reaches the groundwater, by transpiration and the extraction of particular species, e.g. potassium. To understand flood impact, we used high resolution bore water level data in Murray River native red-gum forests to determine the influence of trees and river leakage on the amount and composition of groundwater.

Dryland salinity occurs when groundwater comes close enough to the ground surface to be affected by evaporation, which concentrates salt in groundwater. Salinity impacts large areas in western Victoria, reducing agricultural productivity. Our studies identified climate as the primary factor determining the extent of dryland salinity; during droughts, dryland salinity recedes as groundwater levels drop.

Future northern Victoria rainfall is predicted to decrease and become episodic due to climate change (more rainfall in high intensity storms). The impact of 2010-2011 northern Victorian floods was studied and showed that groundwater recharge during short-lived flooding was high enough to almost negate the preceding years of below-average rainfall. So climate change impact on groundwater resources in this region may not be as negative as first thought.

Acid mine drainage

Acid mine drainage (AMD) is generated when exposed mined sulphide minerals are oxidised, releasing acidity and dissolved heavy metals. AMD must be neutralised before disposal, generating sludge. We studied AMD neutralisation using limestone, particularly anoxic and open limestone drains. We are studying ways to increase the chemical stability (resistance to leaching) of neutralisation sludges to enable safe disposal, and ways of reducing AMD generation from waste rock dumps using cement. AMD often contains large concentrations of copper and zinc. We are developing AMD neutralisation procedures to extract these metals to help offset costs.

Landscape evolution

We study the old and young landscapes of Southeastern Australia: alpine high plains (~200 M years old), beach dunes deposited by an inland sea ~10 M years ago, highlands (uplifted ~5 M years ago) and volcanoes (~2 M years old). Current projects include characterising ancient river systems that flowed north from the highlands and deposited gravels during catastrophic floods. We also study karst landscapes that form on limestone and contain caves with sediments and stalagmites; these record climate impact and surface landscape change, providing landscape development insights.

Geoarchaeology

Our group provides expertise for worldwide archaeological projects to help understand landscape evolution and human settlement interactions, e.g. ~5 K years ago, an earthquake near the Dead Sea in Jordan made a previously fertile area uninhabitable by removing access to water. Our expertise has aided projects on hornfels artefacts and ochre in Tasmania and explained the location of aboriginal silcrete quarries in Queensland.

Lab Head: Assoc Prof John Webb.
Lab member: Dr Susan White.

Fields of Study:

Water Geochemistry; Acid Mine Drainage; Landscape Evolution; Geoarchaeology.

Capabilities and Techniques:

- Water analysis (major elements);
- Mineralogical & chemical rock analysis;
- Grain size analysis.

Translational Opportunities:

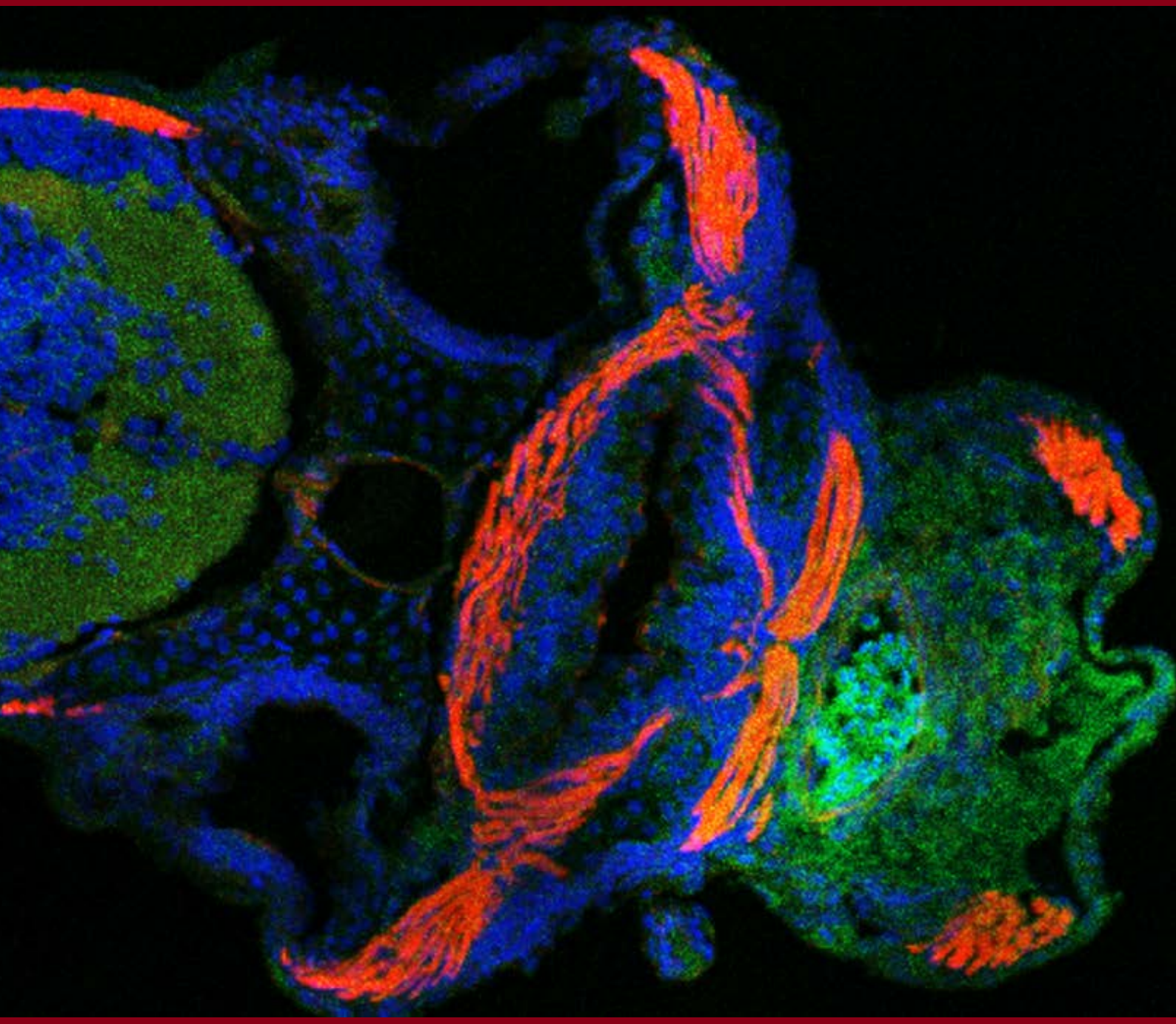
- Better remediation of acid mine drainage.

LA TROBE
UNIVERSITY • AUSTRALIA

Department of Physiology, Anatomy and Microbiology

School of Life Sciences

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



latrobe.edu.au/school-life-sciences

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

Department of Physiology, Anatomy and Microbiology

The Department of Physiology, Anatomy and Microbiology 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

PAM Research Centre

Centre for Cardiovascular Biology and Disease Research (collaboration with the Baker Heart and Diabetes Institute) / 60

Centre for Cardiovascular Biology and Disease Research

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

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

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

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

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

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

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

We strive for:

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

Co-Directors:
Profs Chris Sobey and Grant Drummond.

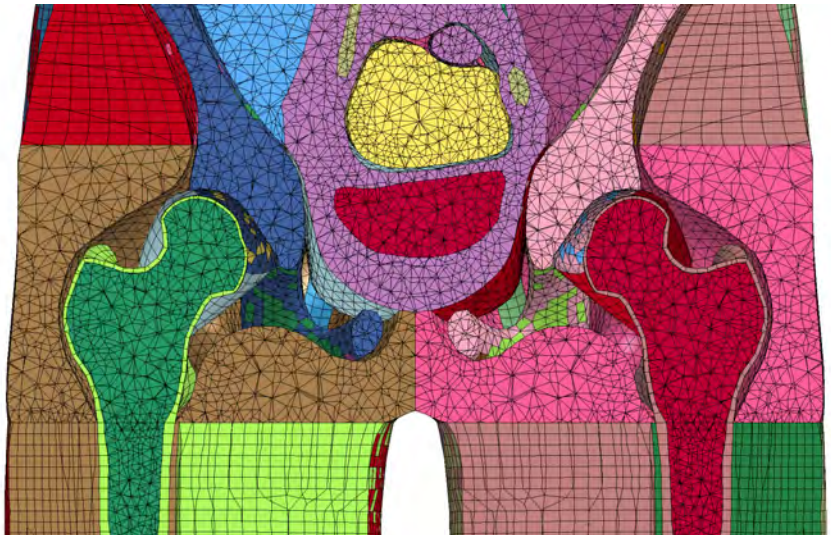
Group Leaders:
Prof Garrie Arumugam (Vascular Dementia);
Dr Alex Pinto (Cardiac Cellular Systems);
Dr Antony Vinh (Immunity and Hypertension);
Dr Helena Kim (Stroke and Brain Inflammation);
Dr Maria Jelinic (Obesity and Diabetes);
Dr Michael De Silva (Cerebrovascular Disease).

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

PAM Research Groups

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.

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

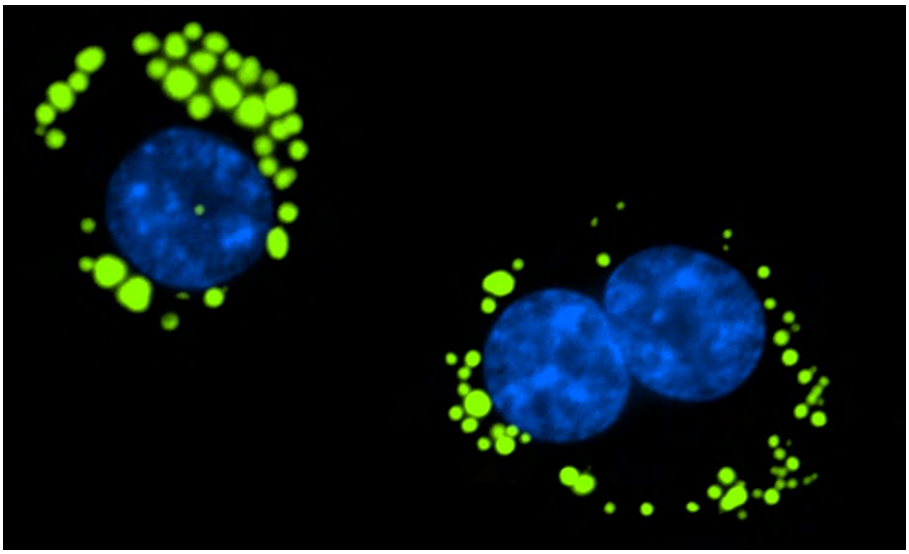
Viruses infect all living organisms. Our laboratory studies both viruses of animals and humans to unravel the role of novel host and viral proteins in the control of viral infection, with a goal towards development of novel strategies to combat viral infection in both humans and animals. Our group uses 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.
Lab members: Dr Subir Sarker (DECRA Fellow); Ms Monique Smith; Ms Ebony Monson; Mr Keaton Crosse; Mr Jose Huaman-Torres; Ms Stephanie Lynch; Ms Jacinta Agius; Mr Jay Laws; Ms Ajani Athukorala.

Fields of Study:

Virology; Innate Immunology; Structural biology; Viral metagenomics; Veterinary pathogens.

Capabilities and Techniques:

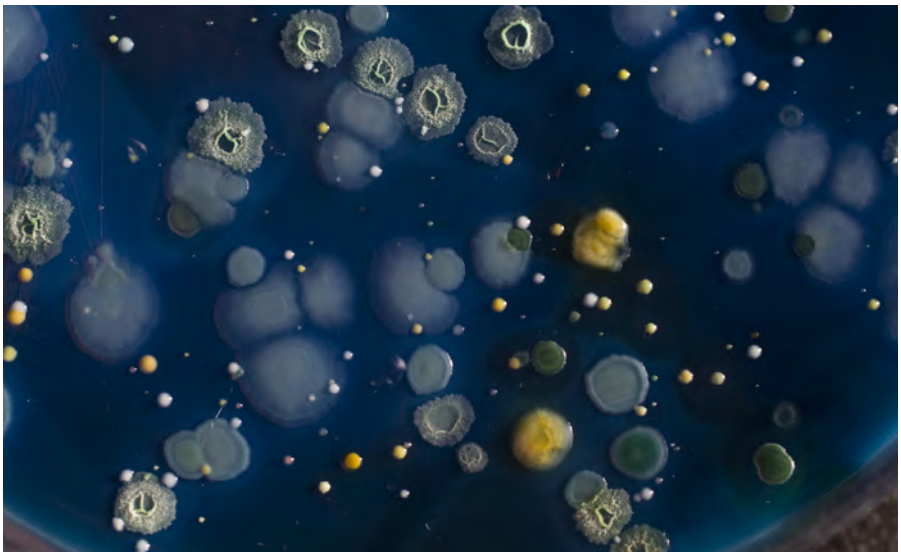
Microscopy: transmission electron, confocal, super resolution, light, fixed, live, static & movies; X-ray crystallography; Cell & virus culture & propagation; Primary cell culture; animal husbandry (mice/silkworms/ abalone); Viral delivery of genetic material; CRISPR/ cas; proteomics/lipidomics; bacterial & 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 plant, 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 trait-based approaches for understanding of microbial communities.



Culturing diverse microorganisms (Photo credit: Gene Drendel)

Microbial trait ecology (what is your microbiome doing?)

Functional traits are physiological or morphological attributes that increase the fitness of a microbe in a given environment. Traits go beyond looking at 'who' is present in a community, to understanding 'how is the community behaving'. We are pioneering trait-based approaches for understanding microbial community behaviors in health, disease and the environment, leading to identifiable opportunities for 'engineering' these communities for beneficial outcomes.

The human microbiota and branched fatty acids promoting 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, cerebral malaria and gynaecological disorders.

Promoting plant productivity and diversity from the ground up

Agricultural and natural ecosystems rely on soil microorganisms for soil and plant productivity and wider ecosystem function. We study soil microbiology, plants, climate and soil management interactions to generate practical information that can be incorporated into improved farming practices and holistic conservation and management strategies.

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.

Lab Heads:

Dr Jennifer Wood & Prof Ashley Franks.

Lab Members:

Dr Anya Schindler; Mr Gene Drendel; Ms Sarah Knowler; Mr Joshua Vido; Mr Matt Brewer; Ms Jacqulyn Evans.

Fields of Study:

Microbiology; Ecology; Health; Bioremediation; Soil Science.

Capabilities and Techniques:

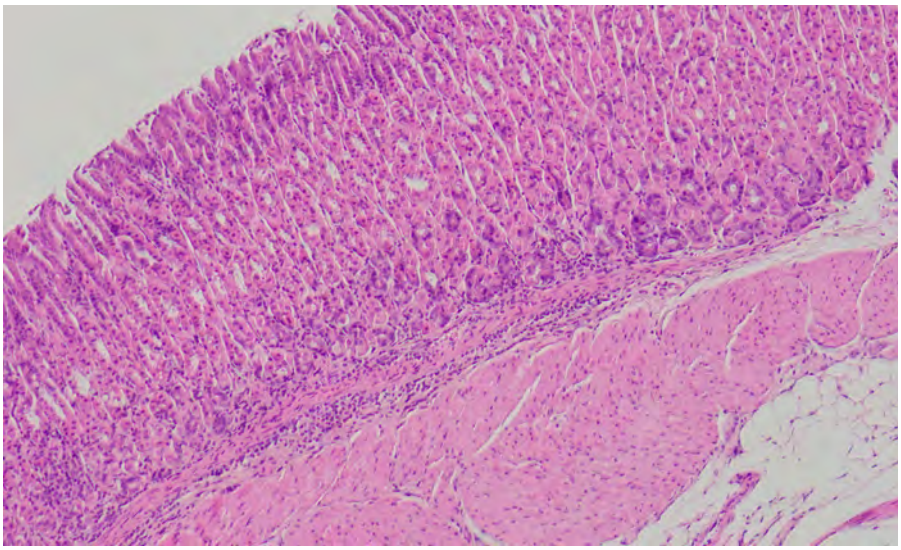
ARISA community profiling; Next-generation sequencing, quantitative PCR; Anaerobic microbiology (gassing station & anaerobic chamber); Electro-microbiology; multivariate statistics; bioinformatics.

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 (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.

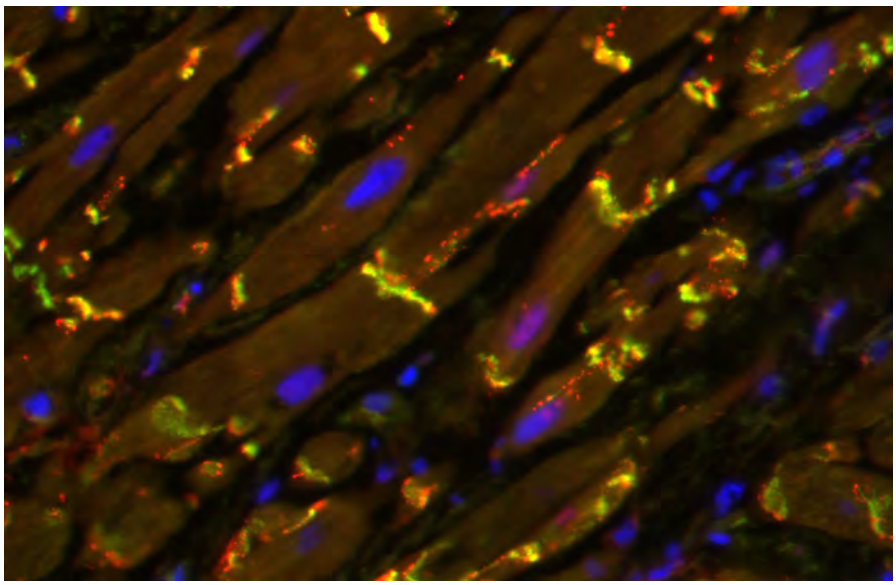
Fields of Study:
Microbiology; Host-pathogen interactions; Innate Immunity; Cell biology; Immunology.

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.



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

'Heart fat' emerging as a critical mediator of heart disease

Increased body fat (especially visceral tummy fat) is known to be an important contributor to the development of heart disease, releasing factors into the blood that travel to the heart and disrupt function. Up until recently though, the role of the fat immediately surrounding the heart has been largely overlooked. This 'heart fat' increases markedly in obesity, with aging, and in post-menopausal women – all important risk factors for heart disease. Heart fat is increasingly thought to be critical to the development of irregular heart rhythms and relaxation abnormalities that represent a primary component of cardiac demise.

Inter-cellular communication between heart fat and muscle cells drive irregular heart rhythms

We have very recently shown that heart fat exerts a unique, detrimental influence on the surrounding heart muscle. Our findings show that the very close proximity between the fat and muscle cells within the heart greatly increases the potential influence of this local fat on heart function. We have taken the first steps in identifying the factors released from the heart fat, and look to establish how these modulate the function of neighbouring heart muscle cells in a manner that increases their vulnerability to potentially fatal irregular heart rhythms.

Relaxation abnormalities in fatty hearts?

We are also taking the field in a new direction, by investigating a very recently described clinical link between heart fat and the capacity of the heart to relax. An inability of the heart to relax properly disrupts its capacity to fill with blood, and is an emerging global health issue with no effective therapies available. Building on our growing understanding of the factors released from heart fat that influence heart rhythmicity, we seek to also identify how these may drive relaxation abnormalities that eventuate in heart failure and death.

Our research capacity is supported by ongoing pre-clinical/clinical collaborations developed both locally (University of Melbourne, Baker Heart Institute) and internationally (University of Birmingham, UK).

Lab Head: Dr Jim Bell.

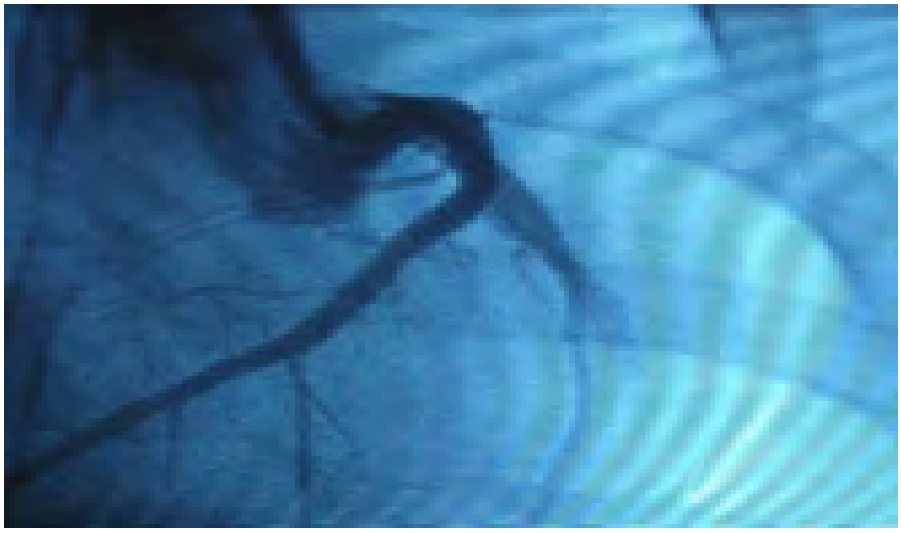
Fields of Study:
Cardiac arrhythmias; Heart failure; Adipose tissue; Intercellular signalling; Sex steroids.

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.

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.



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

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.

Gene Therapy for Heart failure

As populations age, and obesity and diabetes rates increase heart failure (HF) is becoming worse. About 25% of heart attack survivors develop HF which has no cure. We study the activation of 'good' genes as opposed to inhibiting 'bad' genes that cause heart disease and are trialling new gene therapies in mice to assess their therapeutic potential for acute and chronic HF.

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 are assessing effects of legume and olive oil consumption in diabetes and heart disease, as well as diet and cognitive impairment risks in India.

Microbiome & Cardiometabolic disease

Links exist between heart inflammation and disruption to gut microbial colonies. 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.

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.
Lab members: Ms Shan Huang; Mr Sebastian Bass-Stringer; Mr Daniel Couch; Ms Denica Chahine; Ms Adonia Kalandos.

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:

Cardiac myocyte-specific heart failure 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.

Comparative Nutrition Group

The comparative nutrition laboratory has access to state-of-the-art facilities to investigate the role of diet in health and disease in a range of animals including animal models, livestock and human subjects. The research is collaborative and multi-disciplinary involving molecular, genetic and physiological approaches. Researchers use both in vitro and in vivo approaches to investigate the role of diet and dietary supplements in health and disease.

Caenorhabditis elegans group

Using a novel, liposome-based food delivery system, the model organism *C. elegans* is cultured in chemically defined, bacteria free medium to investigate the role diet and dietary components including phytochemicals in health and disease.

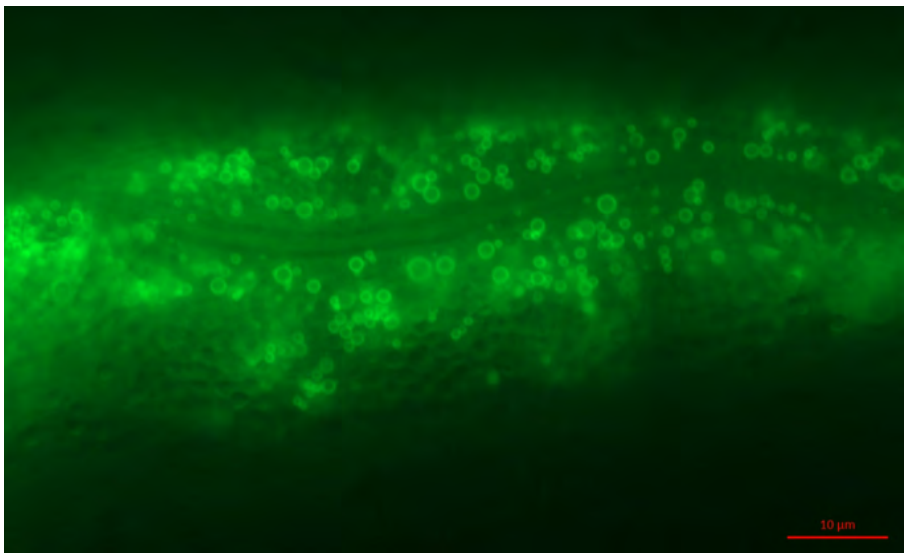
Current research projects:

- Effects of cocoa on the onset and progression of dementia induced by amyloid-βtoxicity in *C. elegans*
- Interactions between the diet, phytochemicals and the effects of anti-psychotic medications on body fat and health span
- Identification and functional characterization of sugarcane polyphenols
- Effects of macronutrient profile on lifespan and health span of *C. elegans*

Public Health Nutrition Group

Current research projects:

- Clinician-patient relations as barriers or enablers to uptake of interventions
- Understanding of self-management practices of Arabic-speaking people living with diabetes in Australia
- Dietary effects of culinary herbs and spices on body weight in patients on anti-depressants
- Effect of sugarcane polyphenols on glycaemic response in healthy subjects



Liquid droplets *C. elegans* (Photo credit: Mark Jois)

Ruminant Nutrition Group

Current research projects:

- Polyphenol-enriched formulations for sustainable dairy and beef industries: effects on enteric methane emission and on health and productivity of cattle
- Effect of PolygainTM on methanogenesis and microbiota in the rumen fluid dairy cows: a dose response study
- The relationship of perinatal maternal behaviour on ewe-lamb bond and lamb survival using sensor technology in extensive farming systems
- Application of sensor technology to assess pain and pain relief in lambs
- Effects of polyphenols on enteric methane emission in cattle
- Microbiome of the reproductive tract as a marker of fertility in dairy cows

Lab Head: Dr Markandeya (Mark) Jois.

Lab members: Dr Jency Thomas; Dr Sabrina Gupta; Dr Serpil Kucuktepe; Mr Rajneet Sohi; Ms Mihiri Munasinghe; Mr Abdullah Almotayri; Mr Awais Ahmed; Ms Deniz Heydarian; Mr Rahul Puvvada; Mr Anwar Althubyani; Ms Thi Huyen Trang Pham; Ms Chandana Deekshith; Ms Mia Bettio; Ms Alexandra Carroll; Mr Benjamin Chaffey; Ms Rochelle Joseph; Ms Atika Morrell; Ms Grace Shing-Francis.

Fields of Study:
Nutrition; Public Health; Clinical Sciences; Neurosciences; Animal Production.

Capabilities and Techniques:
Axenic *C elegans* culture; primary hepatocytes preparation; organ perfusion; surgical preparation of indwelling catheters; radiotracers; feeding/clinical trials; Dual Energy X-ray Absorptiometry; livestock feeding/rumination monitoring; remote sensing/monitoring livestock.

Translational Opportunities:
Bioactive compounds high throughput screening; clinical trials; public health policy; livestock productivity/welfare smart sensors; livestock methane output sensors/ mitigation.

Developmental Genetics Group

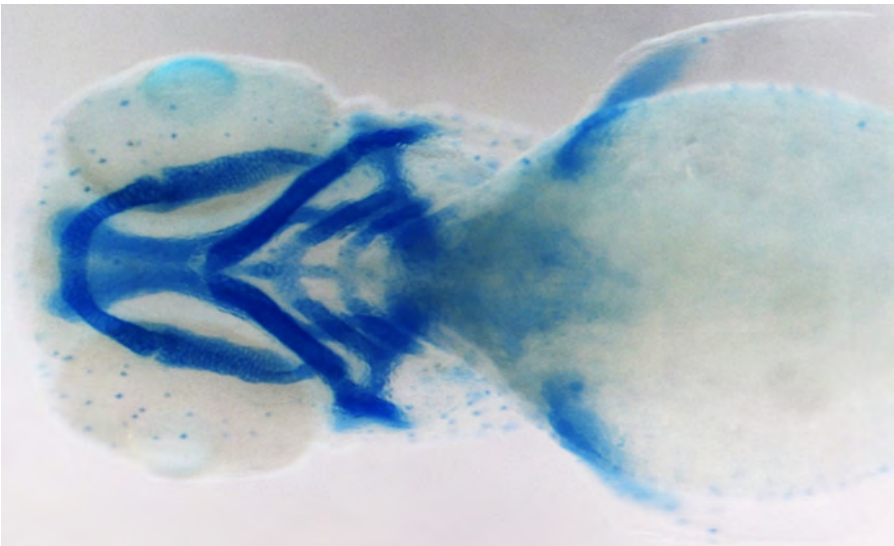
Cellular behaviours, particularly in the craniofacial region and neural tube, and the molecular pathways by which these behaviours are regulated, forms the cornerstone of understanding embryonic development. Using genetically-modified mouse and zebrafish models, our group identify critical genetic networks 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 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 affect 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. Mutations in these genes cause human craniofacial defects and disrupt epithelial development in the skin, lung and epididymis. 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 models to model structural human craniofacial skeleton birth defects. By identifying genes that are known to cause birth defects in humans and identifying and inhibiting the respective zebrafish orthologues of these genes, we study how and why mutations in these genes lead to defects, and how these may ultimately be overcome.

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: Dr Seb Dworkin.
Lab members: Mr Michael De Vries; Ms Nishanthi Mathiyalagan; Ms Stephanie Tran; Ms Joanne Wong; Ms Jemma Gasperoni; Mr Jarrad Fuller; Mr Jeremy Neylon.

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.

Developmental Programming Lab

Our laboratory focuses on how events during pregnancy can alter the long-term health of offspring.

This involves investigating the effects of fetal growth restriction on the programming of adult diseases, as well as the effects of maternal lifestyle interventions (such as exercise or pharmacological treatment) on long term offspring health.

Due to the increased levels of obesity observed in our population, we are also focused on examining the effects of maternal obesity and high fat diet on various offspring outcomes.

Current research projects include:

Effects of Metformin use during pregnancy; consequences for maternal short term and offspring long term health
Metformin is a commonly prescribed medication for individuals suffering from type 2 diabetes, however it is not frequently prescribed to treat gestational diabetes as the side effects to the grown fetus is unknown. We are investigating how metformin affects placental nutrient transport and thus fetal growth. These studies are critical in the assessment of this drug in pregnancy.

Effects of treadmill exercise before and during pregnancy on maternal bone health in an obese rodent model
Exercise is known to have beneficial effects on almost all body systems. In regard to the skeleton, exercise improves bone density, content and overall strength. Given pregnancy is a time of calcium lost from the maternal skeleton for fetal skeletal mineralization, we are investigating whether exercise can help influence calcium transport to the fetus.

Transgenerational transmission of deficits through placental adaptations
We are all familiar with various disease that are passed down from generation to generation. However, what we don't know is how the placenta is involved in the transmission of certain disease states to the growing fetus. Current studies have investigated how placental oxygen, nutrient, and hormone transport influences disease passage transgenerationally.

Newborn baby (Photo credit: Tania Romano Stasis)

Effects of maternal obesity on offspring immune function
The incidence of obesity is consistently rising in our population. This directly links to a higher proportion of women become pregnant while they are obese. Although studies have investigated the effects of maternal obesity on both pregnancy and offspring outcomes, we are specifically interested in looking at how maternal obesity influences the immune cells within the placenta and the fetus.

Long term effects of maternal high fat feeding on offspring
With more women being obese during pregnancy, we are interested in understanding the long term impact maternal obesity has on offspring health. Studies have reported clear links between the in utero environment, the offspring's birth weight and the development of various adult diseases. We are interested in learning more about how maternal obesity influence placental development, offspring growth, and the development of various disease states in later life.

Lab Head: Dr Tania Romano Stasis.

PhD Student: Ms Yeukai Mangwiro.

Fields of Study:
Programming; Long term health; Pregnancy; Development; Growth.

Capabilities and Techniques:
Rat model of fetal growth restriction; Rodent treadmill exercise; Glucose tolerance testing; Insulin challenge testing; Tissue collection; Plasma assays; pQCT bone analysis; Growth analysis; Tail cuff blood pressure; Tail vein blood sampling.

Translational Opportunities:
Our research projects to date have involved animal models given the timelines involved in our studies. However there is scope for translation with the design of longer term follow up studies with the appropriate collaborators.

Diabetes and Metabolic Syndrome Group

The Diabetes & Metabolic Syndrome Laboratory 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 its cardiovascular complications.

The antioxidant, anti-inflammation and hypoglycaemic effects of selected nutraceutical supplements

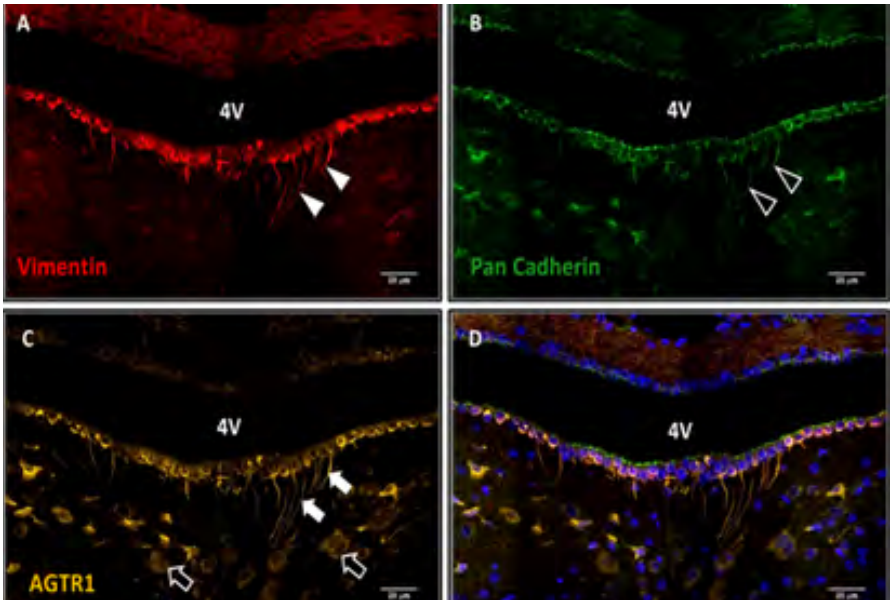
This research field aims to investigate the effects of a series of nutraceutical supplements (including citrus bioflavonoids and phytosterols) on the levels of oxidative stress, inflammation and glycaemic index in prediabetes and type 2 diabetes mellitus.

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, New Zealand).

Indicators of poor glycaemic control

The research group is working on 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 - United Arab Emirates, 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

The research team has established collaborations 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.

This project involves researcher collaboration from University of Kufa, Al-Nahrain University, Al-Qadisiyah University and University of Basrah - Iraq, as well as the Era's Lucknow Medical College & Hospital, and Birla Institute of Technology & Science - India.

Through the above established collaborations, the research team managed to supervise several national and international research high degree students and generate high impact publications in peer reviewed journals and scientific conferences.

Lab Head: Dr Hayder Al-Aubaidy.

Fields of Study:
Diabetes Mellitus; Cardiovascular Disease; Prevention; Diagnosis; Early Management.

Capabilities and Techniques:
Ultra-Performance Liquid Chromatography-Mass Spectrophotometry; Enzyme Linked Immunosorbent Assay; Fluorometry; Molecular Biology; Epigenetics; Immunohistochemistry.

Translational Opportunities:
The current research work will provide a template for translational research aiming to test for the efficacy of selected nutraceutical supplements in reducing blood glucose levels and improving oxidative stress and inflammation in animal model as well as in human model.

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: Dr Steve Petrovski.

Lab members: Dr Steven Batinovic; Dr Mark Chan; Mr Vaheesan Rajabal; Mr Daniel Rice; Ms Aurelie Tsee; Ms Cassandra Stanton; Mr Jayson Rose; Mr Riley Scandolera; Mr Beau Patrick; Mr Damian Hughes.

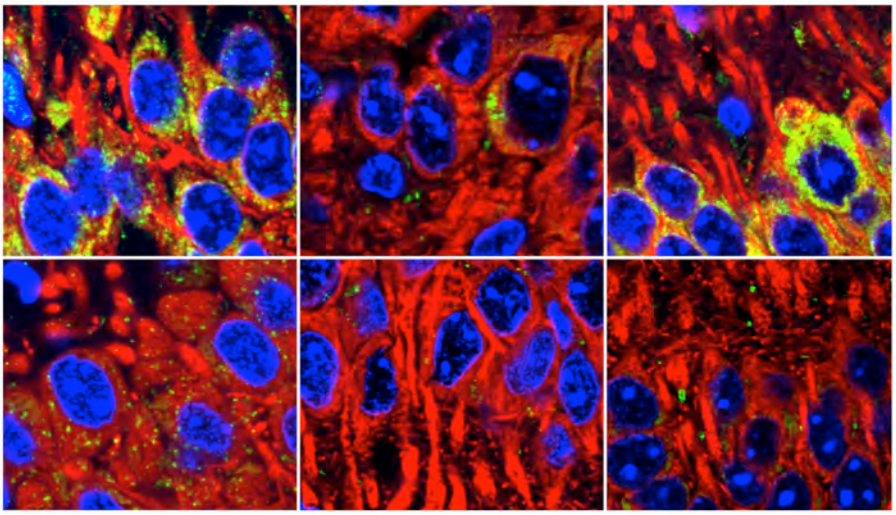
Fields of Study:
Microbiology; Genetics; Microbial Ecology; Evolution; Biosensors.

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.

Experimental Stroke and Inflammation Research Group

Our group aims to identify the molecular and cellular mechanisms that are involved in the injury process of ischaemic stroke and vascular dementia (VaD) and find new therapies for these diseases. We have discovered many new targets and used a number 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 in Stroke

We have found that hypoxia (which occurs when part of the body is deprived of oxygen at the tissue level) and cerebral ischaemia (which occurs when insufficient amounts of blood flow to the brain) activate five signaling pathways that converge on a region called the 'hypoxisome' (a conserved DNA-associated nuclear multi-protein complex). The hypoxisome controls the genes that determine the fate of neurons. Our research is focused on how hypoxisome affects cell death following ischaemic stroke. We are studying when ischaemic injury is severe, and the hypoxisome up-regulates proteins that trigger and execute a neuronal death program. We also study the hypoxisome during remodeling following ischaemic stroke, when the hypoxisome up-regulates adaptive stress response genes encoding proteins that promote neuronal survival.

Uncovering the Mechanisms of Sterile Neuroinflammation in Stroke and Vascular Dementia (VaD)

Neuroinflammation causes neuronal tissue injury, impairments and disabilities. The mechanisms that initiate neuroinflammation following stroke are poorly understood. We found that cerebral ischemia/hypoxia activates innate immune receptors that initiate signaling cascades that activate protein kinases to start an inflammatory response. Activation of intracellular signaling pathways increases production of inflammasomes (multi-protein complexes) which contribute to cell death in tissue injury. We found inflammasomes affect neuronal tissue injury and behaviour in stroke (MCAO) and VaD (BCAS) models. We study how immune/PRRs recognize self-ligand in neurons undergoing metabolic stress, and activate inflammasomes and caspase-3 to initiate neuronal injury/death. We are studying how blocking the immune/PRRs signaling pathways weakens the amplification and initiation of inflammatory cell responses, to improve functional outcomes.

Intermittent Metabolic Switching and Neurodegeneration

Studies found that healthy people with metabolic diseases have an increased risk for stroke and VaD. Intermittent fasting is a dietary protocol, where energy restriction is achieved by alternating periods of feeding and fasting. Intermittent fasting in rodents lessens or prevents cellular dysfunction and degeneration in cardiovascular disease models, including ischaemic stroke, via a preconditioning effect of energy restriction. How intermittent fasting alters expression of these proteins remains to be established. We found intermittent fasting protects from ischaemic stroke and cerebral hypoperfusion-induced brain injury. Studies have found epigenetic germline inheritance of diet induces obesity and insulin resistance. We found epigenetic changes occur in animals after intermittent fasting, and these changes may be responsible for the beneficial effects observed in several disease conditions. We aim to identify if intermittent fasting-induced epigenetic changes promote the expression of protective genes that improve outcome against ischaemic stroke and VaD.

Lab Head: Prof Thiruma V. Arumugam (Garrie).

Lab members:
Ms Luting Poh; Ms Sharmelee Selvarajii; Ms Vismitha Rajeev.

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 work on hypoxisome and inflammasome reveals novel cell death mechanisms and offers new therapeutic targets for ischaemic stroke and vascular dementia that could be translated in the clinical setting. Research outcomes from our group played an instrumental role to initiate three clinical trials for the treatment of stroke.

Labour Pain 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. In countries such as Australia, intervention rates are escalating.

Over three-quarters of women use drugs for pain relief during labour, and one-third of women give birth by caesarean section. Although epidurals are very effective for pain relief, they paradoxically do not enhance women's labour experience and reduce their chances of having a normal birth.

Concerningly, the use of pharmacological pain interventions during labour increases the chance of poor health outcomes for women (e.g. emergency caesarean sections) and their babies (e.g. admission to special care), and is costly to the health sector.

Dr Laura Whitburn leads an innovative research program to reconceptualise labour pain. This program aims to develop a more sophisticated understanding of the nature and determinants of labour pain utilising contemporary pain science theories, and is based on the principle that labour pain is not a pathological pain condition.

Persephone's Birth (Photo credit: Jason Lander)

This research includes an investigation of the influences on women's attitudes and confidence as they approach labour (particularly on decisions to use pharmacological pain interventions) and the impact of the labour experience (particularly the ability to manage pain) on transition to parenthood.

This knowledge can then inform the development of novel strategies to improve women's experiences of labour and birth, enhance non-pharmacological pain management and reduce medically unwarranted interventions.

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

Lab Head: Dr Laura Whitburn.

Collaborators:

- Prof Christine East (School of Nursing and Midwifery)
- Dr Mary-Ann Davey (Monash University)
- Mr Lester Jones (Singapore Institute of Technology)

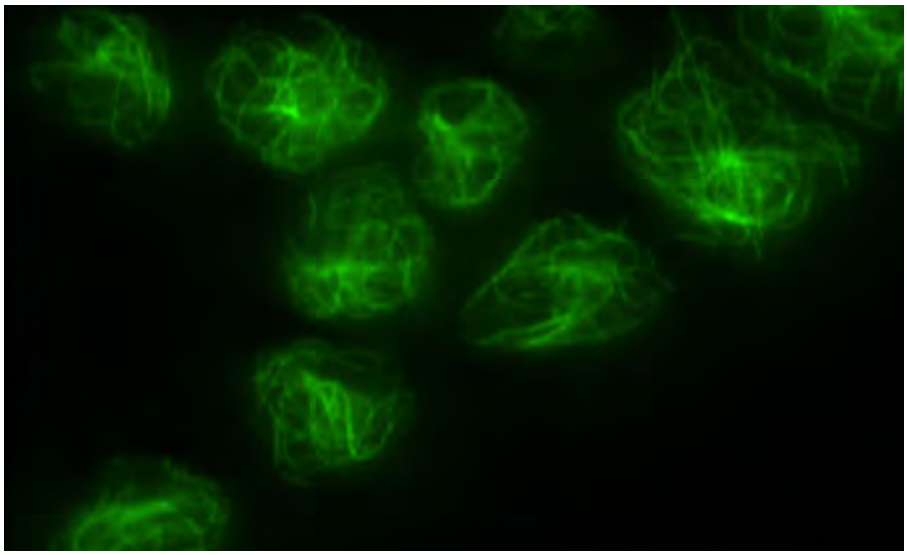
Fields of Study:
Medical and Health Sciences; Midwifery; Physiotherapy; Obstetrics; Gynaecology.

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.

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 and Emeritus Prof Paul Fisher.

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.

Molecular Neuropharmacology Group

Understanding the ability of non-neuronal cells of the central nervous system to maintain neuronal health is critical to developing effective treatments for neurodegenerative diseases.

Our research focusses on the mechanisms underlying neuronal death in neurodegenerative diseases (such as Motor Neurone Disease, Parkinson's Disease and Alzheimer's Disease) and the role of non-neuronal cells in protecting against this neuronal death.

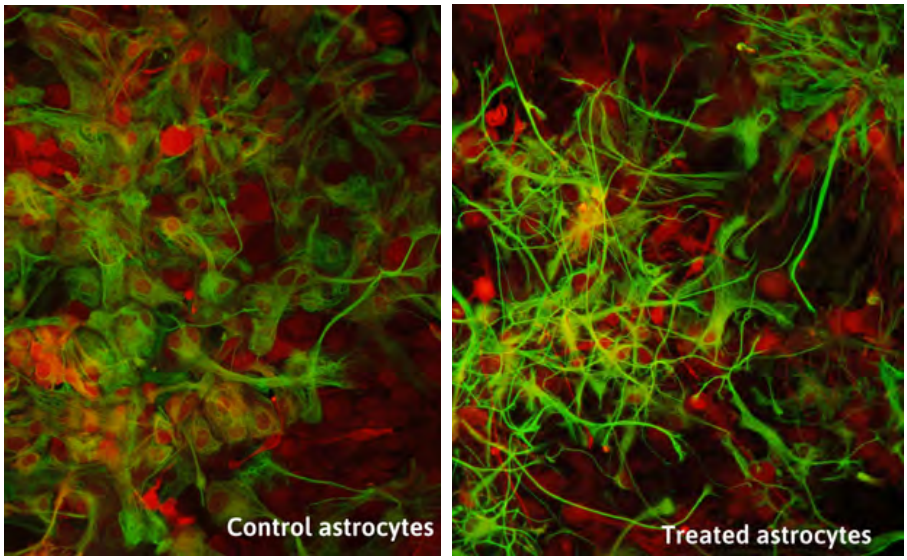
Astrocytes are the most abundant type of cell in the brain and play major roles in brain physiology and pathology.

The Molecular Neuropharmacology Laboratory focuses on identifying markers of "health" and disease in brain astrocytes and investigating pharmacological treatments that recruit astrocytes to protect neurones.

There have been numerous attempts to engineer neurones and stem cells for transplantation to promote re-establishment of function in neurodegenerative diseases, but targeting astrocytes for this purpose is a novel approach.

Astrocytes exert numerous positive influences on neuronal function by releasing trophic factors, controlling energetics and normalizing transmission; hence they represent a unique biological resource to keep "threatened" neurones alive.

Development of novel cell culture models to mimic brain injury and repair
Cell culture models are widely used to screen drug treatments affecting cellular processes, but lack key elements relating to brain function. We develop and implement cell culture models that more accurately reflect the nature of intact brain tissue and cell-cell interactions between diverse cell types. Models include organotypic (slice) cultures of brain regions, and 3D cell culture of brain astrocytes and neurones, using nanoscaffolds, to better model brain environment.



Modulation of astrocytes in cell culture (Photo credit: Ross O'Shea)

Identification of molecular pathways that promote neuronal survival
Astrocytes are extremely plastic cells that normally perform vital roles that maintain neuronal survival.

The activity of astrocytes is commonly impaired in neurodegenerative diseases; although these cells generally survive, their ability to promote neuronal viability is impaired. There is also evidence showing that astrocytes can actually initiate neuronal death in these diseases).

Numerous studies have demonstrated that astrocytes can be modulated in order to stimulate activities that support neuronal survival, and our previous work has identified important regulators of astrocytic structure and function.

Current work aims to investigate whether novel drugs with differing selectivity for inhibiting key pathways have differential effects on astrocytes that might promote neuronal survival.

Lab Head: Dr Ross O'Shea.

Fields of Study:
Pharmacology; Neurosciences.

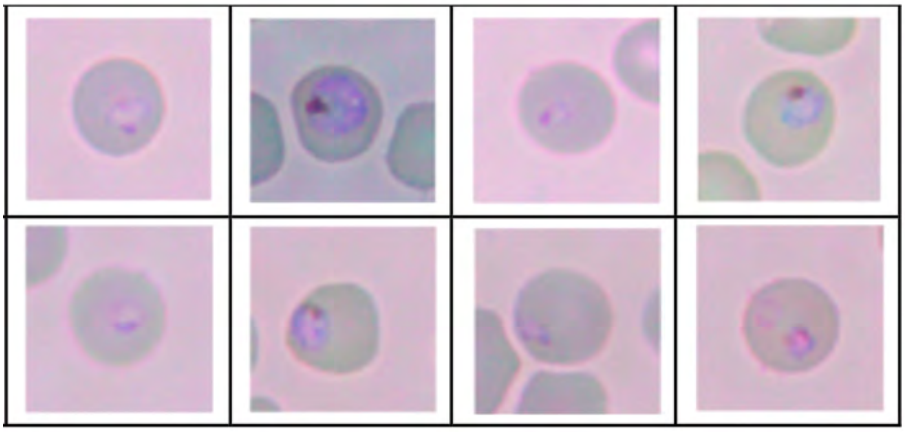
Capabilities and Techniques:
Cell culture – primary brain cells (astrocytes, microglia, neurones, mixed cultures, organotypic slice cultures); 3D cultures using nanoscaffolds; cell lines; Real-time imaging and immunocytochemistry in cultured cells (fluorescent markers of viability, metabolism, cytoskeletal function, protein localisation and abundance); Advanced image analysis of cell cultures and tissue sections – cell morphology; expression of proteins and cytoskeletal markers; viability; metabolism; Biochemical and pharmacological analysis of cell function in cultures; Western blotting including cellular fractionation (cytosol versus cell surface expression).

Translational Opportunities:
None as this is basic research.

Molecular Parasitology Lab

Parasitic infections heavily affect human and animal health. Indeed, half of the world population is at risk of contracting malaria, and one in four people on the planet suffer from soil-borne helminthic infections. Further, a variety of parasites also infect livestock, causing tremendous impact on animal health and significant economic losses.

Parasites can be transmitted by an insect vector, or simply present in water, soil or food, so infection rates can be very high. However, there are very few anti-parasitic vaccines available, and virtually none for human parasitic diseases. Treatment options can be limited and inefficient, and drug resistance is an increasing problem. Therefore, new treatment for parasitic diseases are urgently needed.



Testing of novel 3D-heterospirocycle compounds on malaria parasites (Photo credit: Teresa Carvalho)

How can we identify novel treatments for malaria?

Our laboratory studies *Plasmodium falciparum*, the most virulent of human malaria parasites that causes half a million deaths every year. In the absence of a malaria vaccine and with increasing drug resistance, it is urgent to identify novel anti-malarial treatments. Our team has a multi-disciplinary approach to this problem. We collaborate with chemists that produce novel chemical structures and test them for their anti-parasitic activity. We also test if treatments that are already available to treat other human disease (such as cancer) can be repurpose as anti-malarials.

From a fundamental perspective, we aim to understand the biological and genetic mechanisms that allow the parasite to survive inside its human host and cause disease. Ultimately, we use this knowledge to identify new molecules or re-purpose existing compounds, to prevent parasite growth and design novel treatments for malaria.

How to identify potential emerging pathogens?

Our research team also has a keen interest in animal parasites, and in particular in parasites of wildlife. Wild animals are well known to act as reservoir hosts of identified and emerging pathogens that can be transmitted to domestic animals, livestock and humans.

We aim to characterise the diversity of parasites that infect Australian wildlife, in particular in hosts such as wild deer and wild dogs. Wild deer and wild dogs have become increasingly prevalent in Australia in recent years and contact with livestock and human populations has increased.

We aim to evaluate if these animals constitute a pathogen reservoir populations and pose a risk of pathogen transmission.

Lab Head: Dr Teresa Carvalho.

Lab Members: Ms Coralie Boulet; Mr Jose Huaman; Ms Mary Fletcher; Mr Manon Reist; Ms Liana Theodoridis; Mr Lars Capule; Mr Derek Wong; Ms Lily Evans-Kenchington; Mr Corey Pollock.

Fields of Study:
Microbiology; Host-parasite interactions; Parasitology; Emerging pathogens; Biochemistry and Cell biology.

Capabilities and Techniques:
Parasite and human cells in vitro culture (PC2 laboratory); Fluorescent microscopy; Flow cytometry; Molecular biology; Drug inhibition assays; Protein expression; Protein immunoprecipitation; Mass spectrometry.

Translational Opportunities:

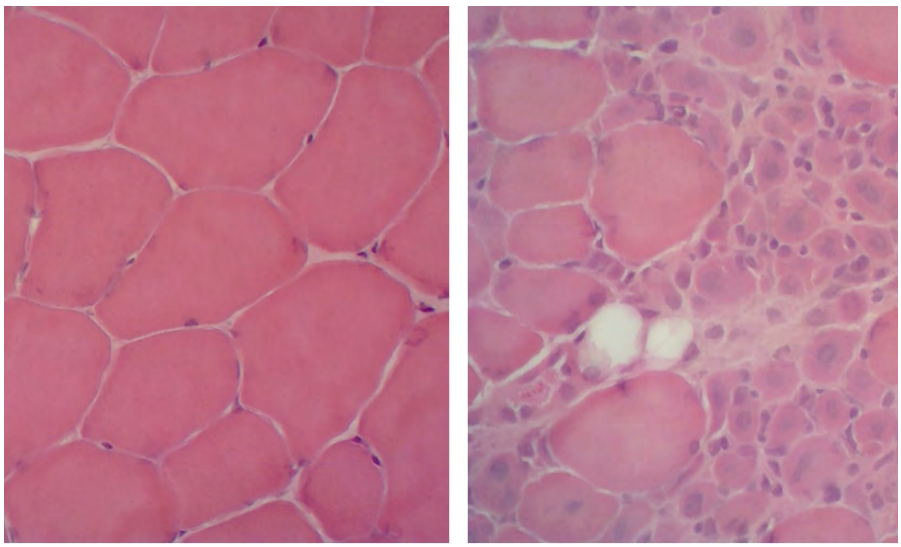
Drug repurposing; anti-parasitic drug discovery; host-directed therapies; animal parasite detection; emerging pathogens; zoonotic diseases.

Tweet: @lab_carvalho

Website: www.latrobe.edu.au/physiology-anatomy-and-microbiology/research/carvalho

Muscle Biochemistry Group

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



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

Calpains and MMPs

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

Glycogen related proteins

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

Mitochondrial dynamics

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

Lab Head: Prof Robyn M. Murphy.

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.

Muscle Cell Research Group

The Muscle Cell Research Group has a long history of research into fundamental questions surrounding the physiology and pathophysiology of skeletal, cardiac and smooth muscle. The group employs several unique and sophisticated techniques/methods that allow the study of both the physiology and molecular biology of muscle.

Development of Novel Techniques

As world leaders in single muscle fibre methods, we have continuously pushed the envelope by developing novel techniques/methodology used to examine the physiology of skeletal muscle.

For example:

- Electrical Stimulation of mechanically skinned fibres;
- Kinetic measurement of glucose transport in single muscle fibres
- Skinned vascular smooth muscle techniques.

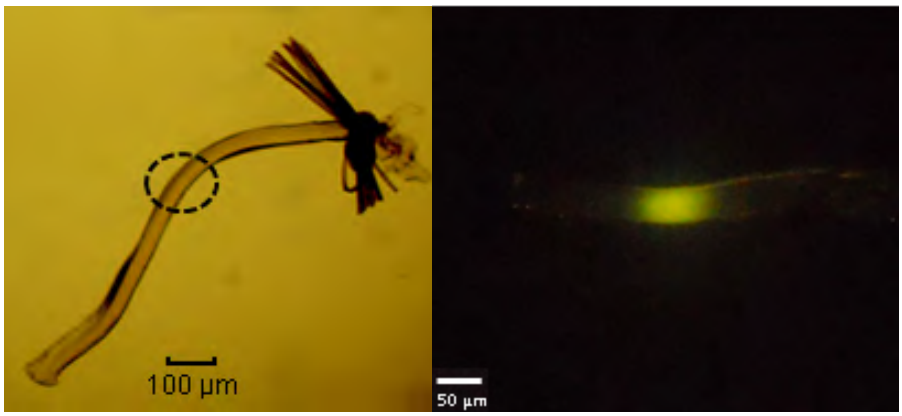
Glucose transport and glucose regulation of skeletal muscle contraction

Glucose is the most fundamental source of energy in all cells. Skeletal muscle is the largest consumer of glucose in animals. Despite a great deal of knowledge around the way glucose is transported and used in skeletal muscle there remain a number of unanswered, yet important fundamental questions.

For example:

1) how fast does glucose actually diffuse across cell membranes
2) what are the fibre type differences in transport rates
3) what are the rate limiting processes in glucose transport.

Recent studies have identified that glucose may also have important roles in contraction outside of metabolism and energy supply.



Single fibre fluorescence imaging of intracellular free glucose (Photo credit: Guiseppe Posterino)

Notably, elevated intracellular free glucose may affect the coupling between excitation of the muscle via the arriving action potential to Ca2+ release from intracellular Ca2+ stores. Chronic elevated free glucose may alter important ion channels in a way that may limit calcium release and contraction.

Cross-bridge kinetics

The development of force in all muscles arises from the molecular interaction between to major proteins, actin and myosin. The relationship between the development of the cross-bridge, the kinetic parameters involved in the cycling of cross bridges and force have been studied for some 60 years. However, recent work in the laboratory has identified that the cross-bridge does not develop true maximum force even at saturating [Ca2+]. The molecular mechanisms underpinning this will identify why muscle can at time develop more force than otherwise predicted.

Developmental changes in muscle leading to disease

Insult to the developing foetus, whether by insufficient nutrient or oxygen supply, leads to an increased risk of metabolic disease in adulthood.

Such insults leading to poor foetal growth, defined broadly as Intrauterine growth restriction (IUGR), affect multiple organs during development. The skeletal muscles are the largest sink of glucose utilisation and are affected by IUGR resulting in increased risk of insulin resistance in adulthood. We are interested in understanding the changes in the transport of glucose in skeletal muscle in models of IUGR.

Lab Head: Dr Giuseppe Posterino.

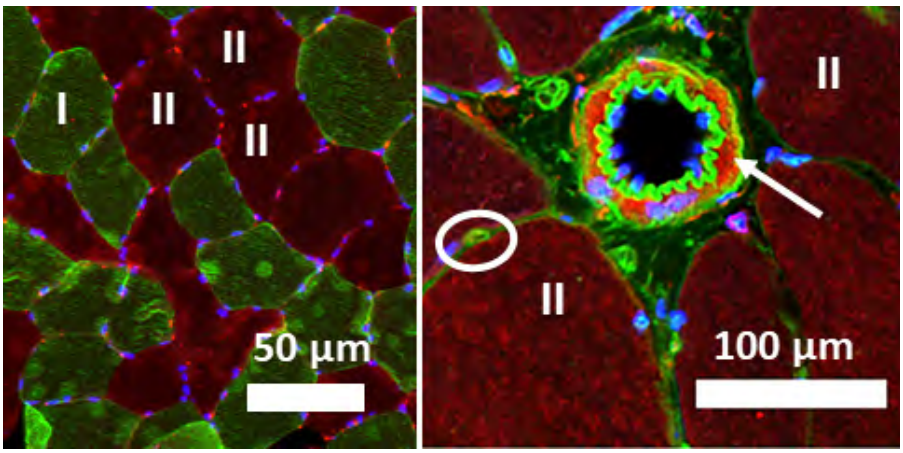
Fields of Study:
Physiology; Biochemistry; Development.

Capabilities and Techniques:
Intact whole muscle; single fibre and skinned single fibre technologies; gel electrophoresis; fluorescence imaging.

Translational Opportunities:
Exercise physiology; sports medicine; treatments for muscle diseases; muscle specific metabolic disorders.

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.

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.

Nematode Genomics Laboratory

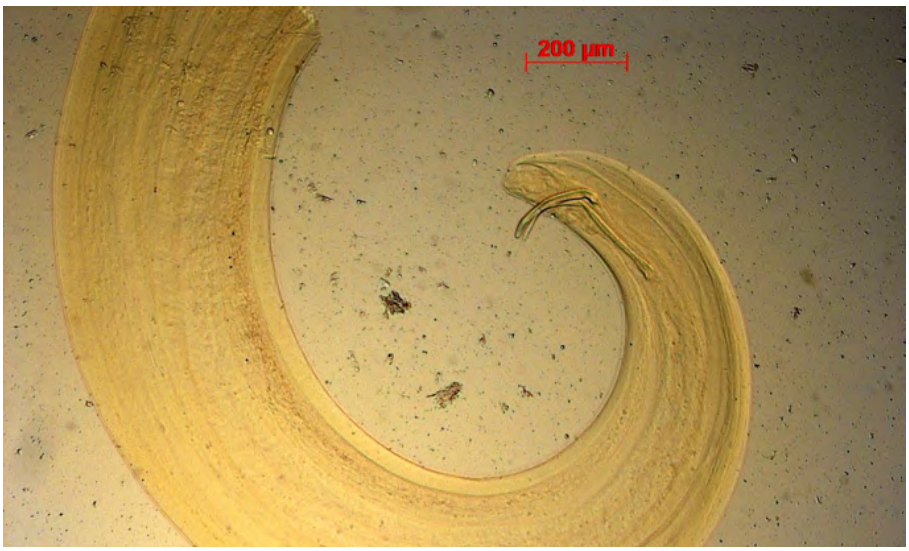
Our research, which involves national and international collaborators, aims to improve our ability to understand and eliminate parasitic nematodes, particularly those that occur in resource-poor settings. We use genetics, genomics, bioinformatics, and mathematical modelling to assess solutions to challenges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

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.

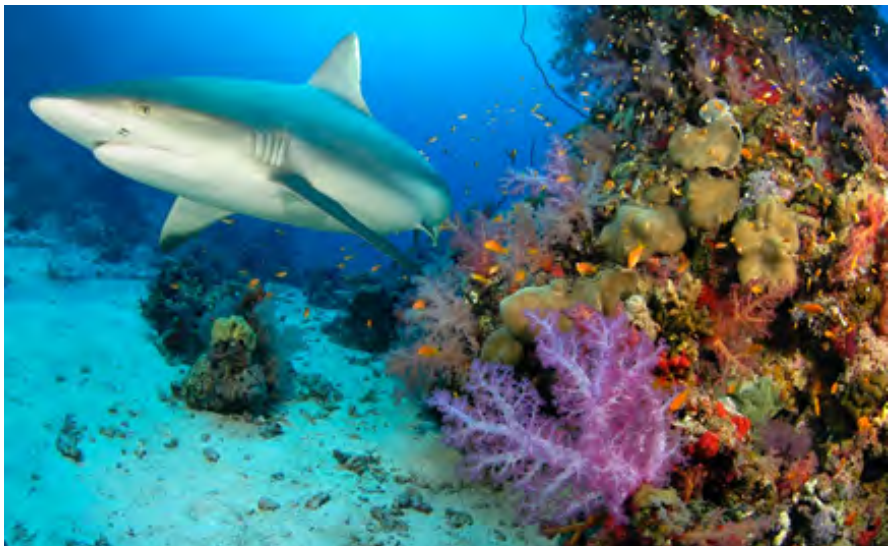
Fields of Study:
Evolution; genomics; epidemiology; parasites; bioinformatics.

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.

Neuroecology Group

Neuroecology bridges the gap between our knowledge of the neural bases of behaviour in the context of an animal's habitat and ecology. Our collaborative research involves local, national and international partners using neurobiological techniques (molecular genetics, bioimaging, electrophysiology, anatomy and behaviour) to examine how elements of the physical environment (light, sound, odours, and electro-magnetic fields) are detected and processed by the peripheral and central nervous systems and how this influences behaviour. Perception of environmental cues is critical to the survival of each species. We use model indicator species to assess ecosystem responses to climate variability and habitat loss or degradation.



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

Shark sensory systems and mitigation

Sharks and their relatives are apex predators and are an important part of aquatic ecosystems. However, very little is known about their behaviour. We assess the neural basis of behaviour in a range of species (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.

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.
Lab members: Ms Caroline Kerr; Dr Jenna Crowe-Riddell; Ms Hope Robins; Ms Maya McGuigan; Mr Mark Lee.

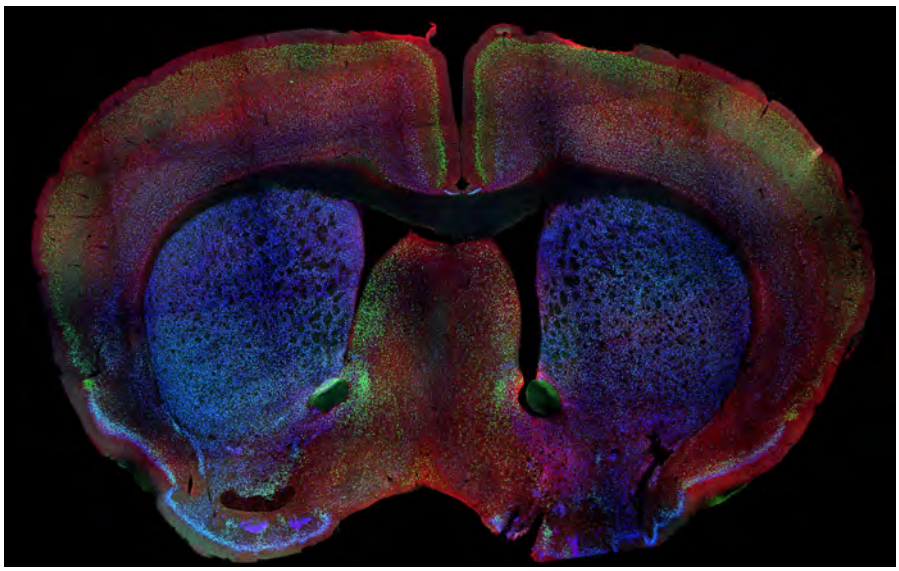
Fields of Study:
Neurobiology; Behaviour; Ecology; Evolution; Development.

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.

Neuropharmacology of Addiction Group

The Neuropharmacology Addiction Laboratory is interested in unravelling the underlying mechanisms in the brain involved in drug-seeking behaviour and relapse to drugs of abuse. We employ gold-standard techniques to assess drug-seeking behaviour in animal models, including the operant responding paradigm. In operant chambers, rodents learn to lever press for alcohol in the presence of cues, mimicking the experience of alcoholics in the real world. When the cues are removed, the behaviour is extinguished or reduced. The re-introduction of these cues is powerful enough to promote relapse (a process called cue-induced reinstatement or relapse). We are then able to investigate the potential of therapeutic drugs that may reduce lever pressing or cue-induced relapse. Our research also involves other behavioural neuroscience and neuropharmacological techniques using specialised equipment for behavioural phenotyping for assessing anxiety and depression, learning and cognition, and drug-induced changes.



Coronal section of rodent brain (Photo credit: Brad Turner)

Addiction and therapeutic targeting of pathways in the brain

Addiction is a chronic, relapsing disorder characterised by the use of a substance or act to the point of compulsion. There are several medical treatments available for the intervention of these disorders, however, the effectiveness of current therapeutics is far from adequate. Neuropeptides (biological molecules found in the brain) are known to modulate addictive behaviours and may provide new therapeutic targets for the potential treatment of substance abuse. Accumulating evidence suggests galanin as a potential important neuromodulator of addiction. Galanin is found in regions of the brain known to modulate reward-seeking behaviour. Both human genetic studies and animal models have also highlighted a role for this neuropeptide in affective disorders, as well as alcohol, nicotine, and opiate dependence. The main focus of our laboratory has therefore been on the role of galanin signalling in mediating alcohol-seeking behaviour.

Our group discovered that blocking the galanin-3 receptor in the brain using a compound called SNAP 37889, mitigated drug-seeking and cue-induced relapse, establishing this receptor as a therapeutic target in addiction.

Co-morbidity between addiction and mental health

There is strong evidence to suggest that a high number of people who suffer from substance abuse also suffer from an underlying affective disorder, such as depression and anxiety. Our laboratory is also interested in identifying new targets that may also improve symptoms of anxiety and depression, and therefore be beneficial in treating substance abuse. While we cannot fully model depression and anxiety in animals, we can model symptoms of these debilitating disorders. For example, the elevated plus maze is a gold standard technique for assessing anxiety-like symptoms in rodents. The elevated plus maze is in the shape of a cross and has two arms open to the environment and two arms that are closed to the environment. Rodents that are anxious will spend more time in the closed arm which is perceived as less of a threat than the open environment.

Many therapeutic drugs (e.g. diazepam, a benzodiazepine used for the treatment of anxiety) were originally identified using these behavioural tests. Our laboratory is interested in assessing all aspects of animal behaviour, including motor, cognitive and affective, which is fundamental for screening of new therapeutic drugs.

Lab Head: Assoc Prof Elly Djouma.
Lab members: Ms Shannyn Genders.

Fields of Study:
Neuroscience; Pharmacology; Addiction; Behaviour; Neuroanatomy.

Capabilities and Techniques:
Animal models of addiction including free-bottle two choice; operant responding; Behavioural testing including tests for anxiety and depression (elevated plus maze, open-field); brain histology.

Translational Opportunities:
Clinical trials for treatment of substance abuse and addiction.

Neurophysiology Group

The influence of the central nervous system (CNS) on long-term blood pressure (BP) levels and the relationship between BP and obesity and diabetes is a major focus of studies in the Neurophysiology Laboratory. Research in neurophysiology centres on cardiovascular neuroscience and fills a niche between the clinic and basic research. Work is carried out to understand the mechanisms that trigger cardiovascular diseases through environmental factors such as obesity. Obesity induced by a high fat diet is a main area of investigation and research is also being conducted into its effects in the CNS. We use animal models of obesity, programming of adult disease, as well as cutting-edge physiology, molecular biology, neuropharmacology and imaging techniques to address the most pressing questions in the field. Our work has provided new insights into the roles of neuronal signalling pathways such as leptin and insulin signalling pathways as key players of controlling sympathetic nerve system.

Brain (Photo credit: Joon Lim)

Role of brain neurotrophic factors in obesity induced cardiovascular disease

Obesity contributes to over 60% of newly diagnosed cases of high blood pressure (hypertension). While there have been many suggestions as to the cause of the hypertension, there is overwhelming evidence in experimental animals and humans to show that sympathetic nerve activity (SNA) is a major contributor. Using a rabbit, fed a high fat diet to induce obesity, we found that the ensuing hypertension can be abolished by either blocking SNA or by giving a leptin or melanocortin receptor (MC3/4R) antagonist into the ventromedial hypothalamus (VMH). We have shown that higher renal SNA is due to amplification of melanocortin receptor signalling within the VMH together with activation of brain derived neurotrophic factor (BDNF) and upregulation of MC4R. Increased release of alpha-melanocortin stimulating hormone (a-MSH) in the VMH and activation of MC4R is known to induce increased signalling related to other functions, but this is the first suggestion that this mechanism may be responsible for obesity hypertension. Our aim is to determine the mechanism responsible for the enhanced melanocortin signalling in the VMH and hence the cause of obesity induced hypertension.

Maternal obesity and programming of hypertension in offspring: Role of brain neurotrophic factors

It is not a secret that obesity is rapidly rising in both adults and in children world-wide. While in adults, behaviour promotes obesity and related cardiovascular disease, it is well established using animal models, that offspring of obese mothers undergo altered development and are more likely to develop obesity and hypertension even if their diet is not high in fat. This process, termed developmental programming, establishes a vicious cycle where maternal obesity "programs" offspring obesity in the absence of other risk factors, and this may explain the rapid rise in obesity in the past decades. A high fat diet (HFD) given to pregnant female rabbits and continued during suckling induces hypertension and increased sympathetic nerve activity (SNA) to the kidney in the offspring. This occurs even when they have been raised to adulthood on a normal fat diet. Our group have recently discovered an exciting finding by using microinjection of specific antagonists to the brain (hypothalamus). Our aim is to determine how changes in melanocortin signalling within the VMH of offspring from obese mothers cause hypertension and increased renal SNA.

Lab Head: Dr Joon Lim (Kyungjoon Lim).

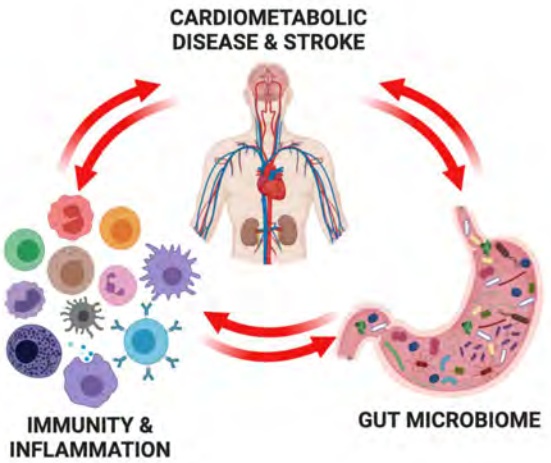
Fields of Study:
Programming; Physiology; Development; Cardiovascular disease; Obesity.

Capabilities and Techniques:
Sympathetic nerve recording in conscious animal; DEXA scanning; Echo cardiograph; immunohistochemistry; Molecular Biology; Stereology.

Translational Opportunities:
Treatment / prevention in maternal obesity and related development of obesity in offspring.

Vascular Biology and Immunopharmacology Group

Cardiometabolic disease claims 40,000 Australian lives per year due to events such as heart attacks and strokes. While current medications, which include blood pressure- and cholesterol-lowering agents, anti-arrhythmic drugs and blood thinners, reduce the risk of a deadly event in some patients, they are not effective in all cases. Thus, 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 study how disturbances to the immune system and gut microbiome promote inflammation and tissue damage in the brain, vascular wall, heart and kidneys. We use animal and cell culture models of cardiometabolic disease and stroke, as well as physiology, immunology, molecular biology, genomic and imaging techniques. We offer research projects for local and international students and postdocs.



Roles of innate and adaptive immunity in hypertension

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. Inflammasome enzymes are switched on in the kidneys, blood vessels and heart in the early stages of hypertension, triggering cytokines to activate immune cells (T cells, B cells and macrophages). This chronic inflammatory response leads to tissue injury, scarring and an inability to regulate blood volume and vascular tone. We test drugs and strategies that inhibit inflammasome activity or block cytokine effects to reverse hypertension and end organ damage.

Targeting inflammation in stroke and vascular dementia

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, as well as vascular-related dementia and stroke treatments using stem cells, vitamin D and estrogen-like agents.

Defining links between gut health and cardiometabolic disease

Gut health strongly influences our wellbeing and protection from chronic disease. Our gut microbiota comprises bacteria and viruses that communicate with our nervous and immune systems. Imbalances in the gut microbiota, termed 'dysbiosis', disrupt these communication networks, leading to impaired function of many organs throughout the body. We study how changes in the gut microbiota during the development of hypertension, obesity and diabetes impacts immune function and inflammation within the kidneys, blood vessels, heart and brain. We identify the bacteria and viruses that are most affected during these diseases in order to design pre- , pro- and anti-biotic therapies to restore a healthy gut microbiota and promote cardiovascular health.

Lab Heads:
Profs Chris Sobey and Grant Drummond

Lab members: Antony Vinh; Brooke Huuskes; Courtney Judkins; Helena Kim; Maria Jelinic; Michael De Silva; Narbada Saini; Quynh Nhu Dinh; Richard Zhang; Ashleigh-Georgia Sherriff; Cecilia De Silva; Drishti Gelani; Henry Diep; Holly Brettle; Jemma Gasperoni; Flavia Wassef; Hericka Figueiredo Galvao; Jordyn Thomas; Liz Baretto; Vivian Tran; Buddhila Wickramasinghe; David Zhang; Frances Deen; Nitesh Gulia; Tayla Gibson Hughes; Abdiweli Warsame; Christian Kuneski; Jake Robertson; Joshua Hicks; Lida Hanna; Maral Baghaei.

Fields of Study:
Hypertension; Stroke; Immunology; Pharmacology; Neurobiology

Capabilities and Techniques:
Animal models of hypertension, stroke and obesity; flow cytometry; histopathology; immunohistochemistry; biomedical imaging; confocal microscopy; genomic sequencing; mouse behavioural/ cognitive testing; in vivo cardiovascular function; renal function, oxidative stress & inflammation assessment; vascular reactivity/compliance.

Translational Opportunities:
New drug targets, discovery, validation; Pre-clinical hypertension/stroke/chronic kidney disease drug assessment; stroke/ hypertension/dementia cell therapy and dietary interventions.

Wildlife Endocrinology Lab

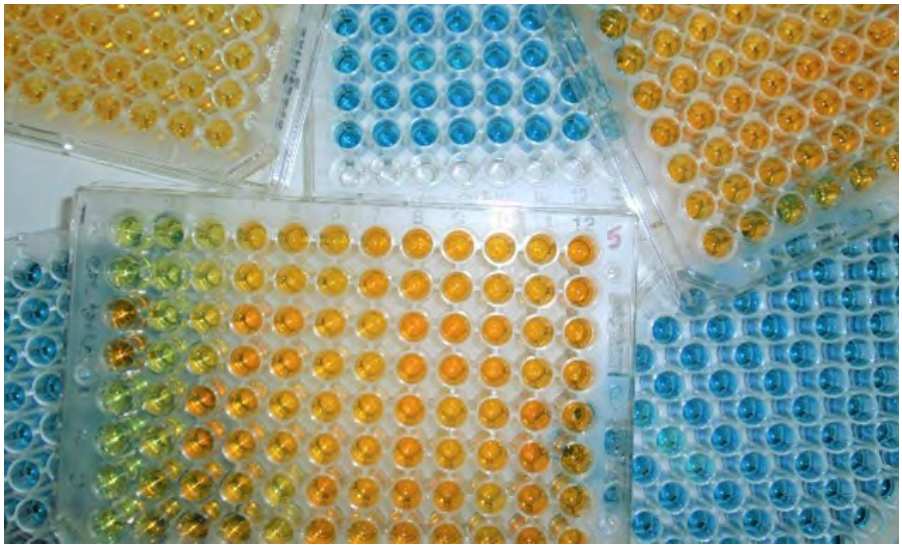
The Wildlife Endocrinology Laboratory examines the complex interactions between stress and reproduction in a wide range of species. Our research lies at the interface of endocrinology, reproductive physiology, animal behaviour, conservation, and animal welfare. We are international leaders in the field 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.

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.

Research Centre affiliated with School of Life Sciences

Mallee Regional Innovation Centre

The Mallee Regional Innovation Centre (MRIC) is a joint venture between the University of Melbourne, La Trobe University and SuniTAFE. The Centre drives research and development through innovation and collaboration in the Mallee region across the four focal areas of horticulture, water, energy and the environment. The Centre is striving to prioritize and fast track projects to strategically address key challenges of the region in these focal areas. The Centre is coordinating joint research and development projects and delivering contracts on a fee-for-service basis through pairing in-depth knowledge from local organizations with the world leading research capabilities of the Centre partners of the University of Melbourne and La Trobe University. Centre partner SuniTAFE is supporting MRIC through applied research and will deliver training to address emerging skill requirements.

Place based

MRIC has staffed offices in the regional city of Mildura in North West Victoria. The Centre operates in a footprint of the Mildura and Swan Hill Rural City Council areas, including along the Murray River from Swan Hill, through to Mildura and the South Australian border.

About the region

The Mildura and Swan Hill municipalities are home to a population of over 76,000 and combined have an annual economic output of over $9.5 billion. The region is noted for the high value of horticulture, agriculture and manufacturing sectors. These are supported through the key industries of irrigated horticulture (almonds, table grapes, citrus, dried grapes, wine grapes, vegetables, olives and other nuts crops like pistachios), dryland farming, tourism, food and beverage manufacturing, transport and logistics, retail, health and community services. Known for its great food and wine, festivals, and top-class arts and sports facilities and activated riverfronts confirms this to be one of Victoria's most popular river tourism destination regions. The region is also home to a spectacular array of natural resources and is on the doorstep of the Hattah Lakes National Park, the Sunset and Little Desert National Parks and Mungo National Park. The region also has a rich indigenous history and recently an office for the First People of the Millewa-Mallee opened in Mildura.

Research projects

The Centre provides a gateway for business and industry to access university academics, researchers and PhD candidates for specific projects that require specialized skills. MRIC coordinates research and development projects and delivers contracts on a fee-for-service basis through pairing in-depth knowledge from project collaborators of the local area with the world leading research capabilities of the University of Melbourne and La Trobe University.

How we work with you

We unite local stakeholders, including associated industries, with research expertise, to develop and adopt world's best practice in production, water, environmental management and agricultural innovation. MRIC works side-by-side with you to develop solutions to your challenges. We work on various initiatives from small projects (1 to 3 months) to complex multi-year collaborations.

World leading research capabilities

MRIC's academic panel is a collaboration between the University of Melbourne and La Trobe University. Our academics address tomorrow's global issues today. Our PhD and post-doctoral researchers work with you.

Collaborating for innovation

MRIC is adding value to the Mallee region, complementing established activities and seeking opportunities to foster new areas of development and bring new capabilities to the region. MRIC is a relationship broker bringing like-minded people together to problem solve.

For more information contact Chief Executive Rebecca Wells at MRIC-info@unimelb.edu.au or visit eng.unimelb.edu.au/mric/home

About

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

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.

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 outmore: visitvictoria.com

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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