LA TROBE
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Department of Animal, Plant and Soil Sciences

School of Agriculture, Biomedicine and Environment

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

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

Contents

Cover Photo:
Crops (Photo Credit: James Hunt)

About the School of Agriculture, Biomedicine and Environment

The School of Agriculture, Biomedicine and Environment is one of the largest in the University, with more than 170 continuing and fixed term staff across multiple campuses. Over the last three years the School has seen significant growth in both research and teaching revenue. Staff in the School currently generate a significant proportion of the University's teaching revenue and research income, and supervise more than 270 higher degree research students. The School is responsible for 7 undergraduate degree courses at the main Bundoora campus in Melbourne, and our regional campus at Albury-Wodonga. It is a leader in teaching innovation and student satisfaction within the university.

The School undertakes teaching and research across a broad range of disciplines, including: Agriculture, Botany, Soil Science, Animal Science, Plant Science, Ecology, Environmental Geoscience, Evolution and Genetics, Conservation Biology, Zoology, Neurobiology, Microbiology, Physiology, Pathophysiology, Pharmacology and Anatomy, Biochemistry, Chemistry and Cardiovascular Physiology. The School is a major contributor to research strengths in both the Biological and Agricultural Sciences, achieving the highest possible rating '5 - well above world standing' from the Australian Research Council in the fields of Ecology, Zoology, Plant Biology, Physiology, Microbiology, Biochemistry and Cell Biology, Crop and Pasture Production, Genetics, Soil Science, and Veterinary Science, and rated as '4 - above world standing' in Ecological Applications.

The 5 departments in the School are:

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

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

- La Trobe Institute of 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)
- Research Centre for Extracellular Vesicles
- Centre Research Biomedical and Environment Sensor Technology (BEST)
- Research Centre for Molecular Cancer Prevention
- La Trobe Institute for Molecular Science

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

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

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

Department of Animal, Plant and Soil Sciences

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

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

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

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.

In the field (Photo credit: Ian Porter)

Phase out of Methyl Bromide under the Montreal Protocol

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

Impact of Smoke Taint on the Wine Industry

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

Measuring Greenhouse Gasses to provide Sustainable Solutions for Industry

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

Lab Head: Professor Ian Porter

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.

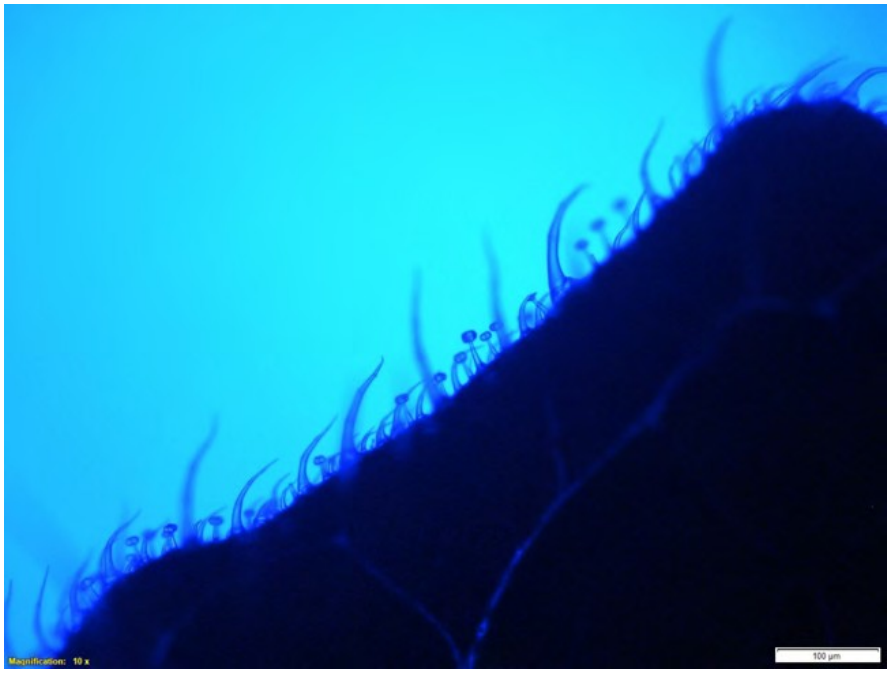
Genome Regulation Lab

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.

Neuroecology Group

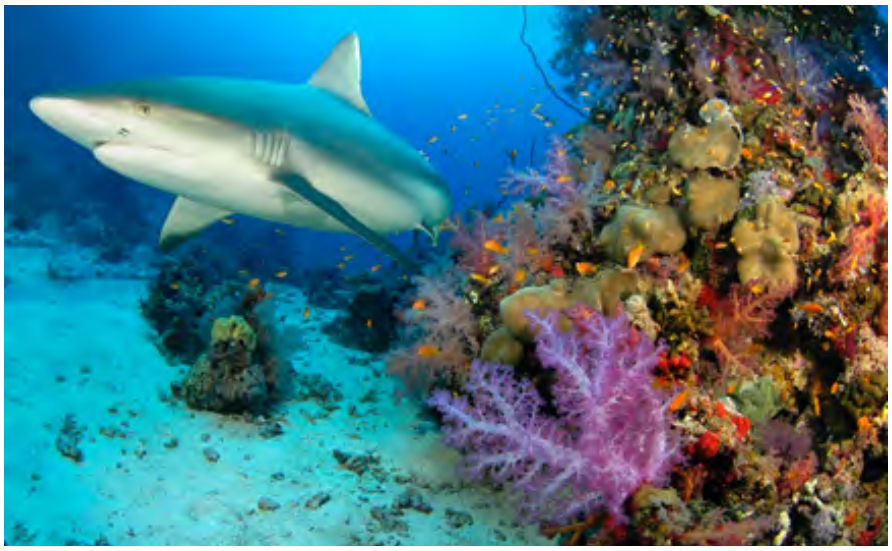
Neuroecology bridges the gap between our knowledge of the neural bases of behaviour in the context of an animal's habitat and ecology. Our collaborative research involves local, national and international partners using neurobiological techniques (molecular genetics, bioimaging, electrophysiology, anatomy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

Shark sensory systems and mitigation

Sharks and their relatives are apex predators and are an important part of aquatic ecosystems. However, very little is known about their behaviour. We assess the neural basis of behaviour in a range of species (e.g. manta rays and white sharks) by investigating the ways they sense their environment. Sharks, skates, rays and chimaeras have evolved over a period of 400 million years, and they are adept at detecting environmental signals that indicate the presence of food, mates, predators and anthropogenic activity. We study these behaviours by uncovering basic neuroecological principles and translating discoveries into mitigation strategies to protect both humans and sharks.

Environmental impacts on the neural basis of behaviour

Many living things rely on vision, olfaction, audition, lateral line, electroreception and gustation to find food and mates, avoid predation, orient within the water column and even migrate over long distances. We examine the importance of each of these senses by studying the peripheral sense organs and the brain and help environmental managers understand species vulnerability to environmental change and their capacity for sensory plasticity.



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

Sensory ecology of deep sea organisms

Finding food and mates, avoiding predation, social communication and navigation are critical for fish in the mesopelagic ('twilight' zones) of the world's oceans. Survival depends on the ability to detect and react to environmental stimuli (residual downwelling sunlight, odours, bioluminescent light flashes, sound and hydrodynamic disturbances). We study sensory systems (vision, chemoreception, audition and lateral line sense) by quantitatively assessing inputs (nerve axons) sending information from peripheral sense organs to the central nervous system, and the size of sensory brain regions receiving input. We also study the hearing and visual sensitivity of deep-sea fish species that are being targeted as commercially viable.

Sensory approaches to improving aquaculture and fisheries management

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

Brains frozen in time: vertebrate neural adaptations to invading land

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

Lab Head: Prof Shaun Collin.
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.

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.

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)

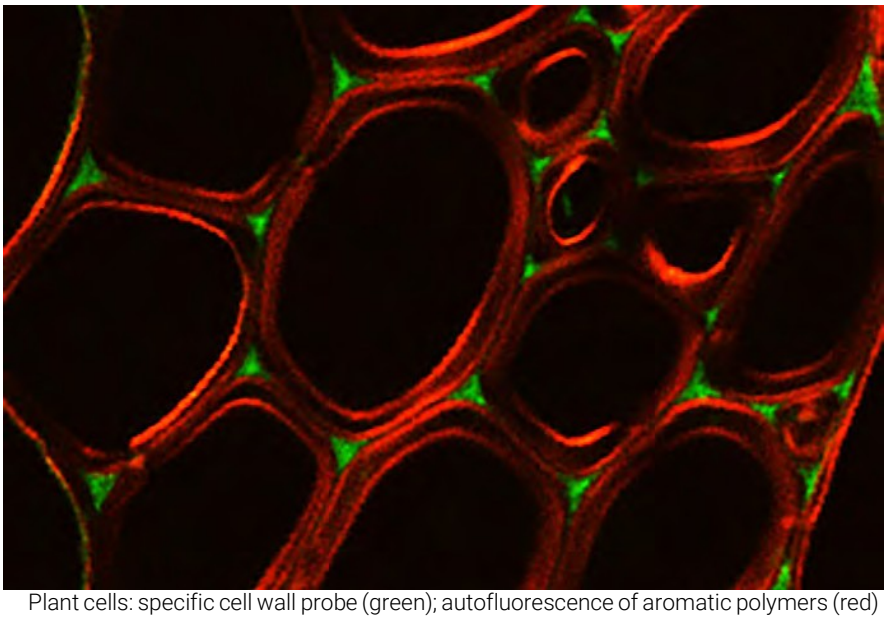
Most plant biomass consists of a carbohydrate-rich matrix present in cell walls. Cell walls, a major carbon sink, are our most renewable bio-resource and determine the quality and quantity of most plant-based products (food, fibre and fuel). Primary cell wall components are a key source of soluble dietary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

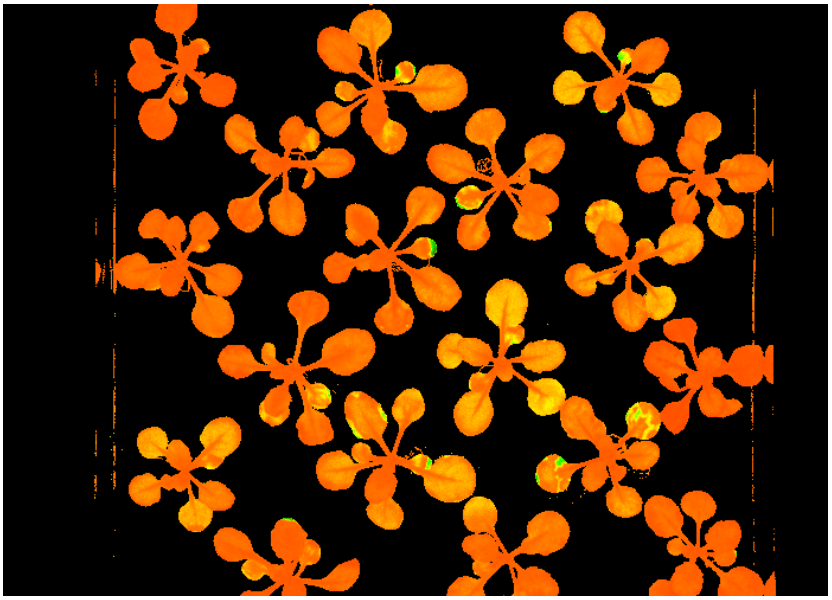
A major area of interest in the lab is the regulation of ion homeostasis by a family of intracellular Na+/H+ antiporters in the model plant *Arabidopsis*. Overexpression of many of these family members leads to increased salt tolerance, but the mechanisms for this resistance is poorly understood.

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.

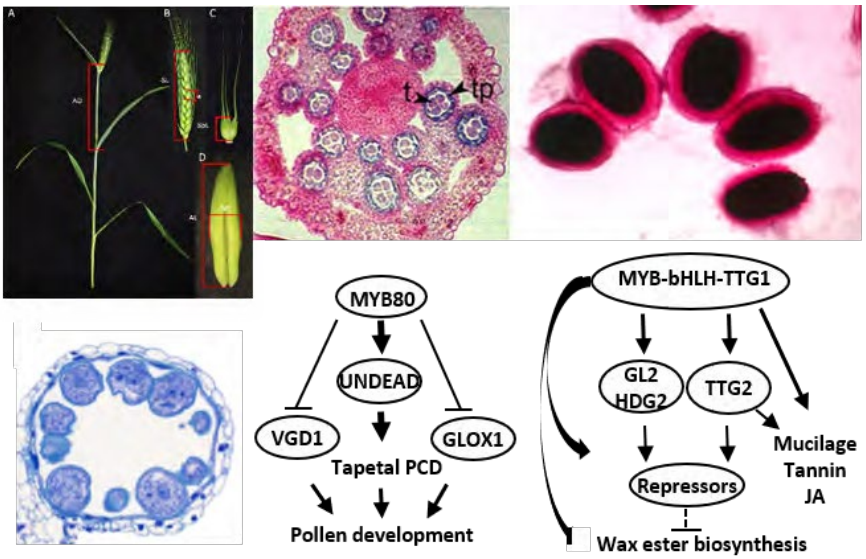
Heat stress and anther development

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.

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

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.

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.

Wildlife Endocrinology Lab

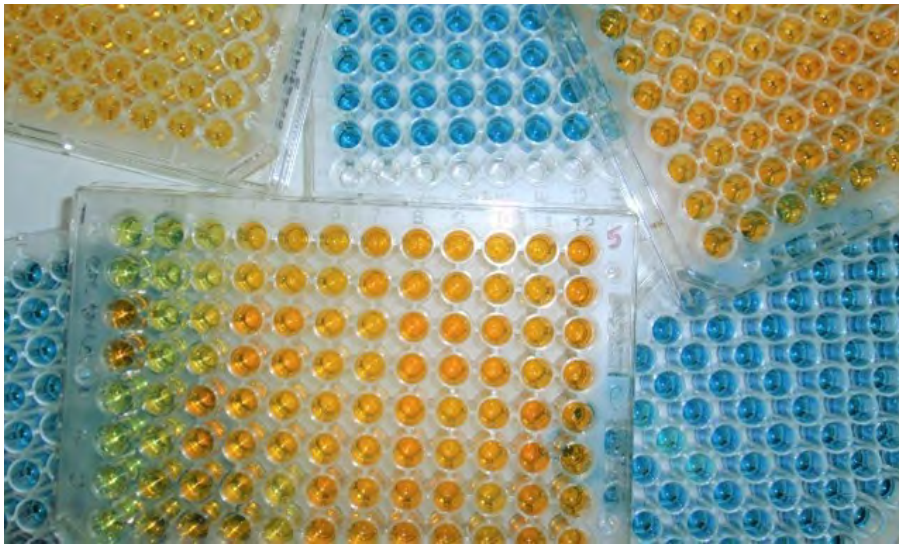
The Wildlife Endocrinology Laboratory examines the complex interactions between stress and reproduction in a wide range of species. Our research lies at the interface of endocrinology, reproductive physiology, animal behaviour, conservation, and animal welfare. We are international leaders in the field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

About La Trobe University

Our Mission

Advancing knowledge and learning to shape the future of our students and communities.

Our Vision

To promote positive change and address the major issues of our time through being connected, inclusive and excellent.

Our Values

Our early reputation as a radical and challenging institution continues to in uence the way we enrich the experience of our students and engage with our partners and communities.

We were founded half a century ago to broaden participation in higher education in Melbourne's north and, later, in regional Victoria. We have succeeded for many thousands of students who would otherwise have been excluded from the opportunities provided by a university education.

We continue to support access, diversity and inclusivity while undertaking world-class research that aims to address the global forces shaping our world and make a difference to some of the world's most pressing problems, including climate change, securing food, water and the environment, building healthy communities, and creating a more just and sustainable future.This approach is based on our values of:

- inclusiveness, diversity, equity and social justice
- pursuing excellence and sustainability in everything we do
- championing our local communities in Melbourne's north and regional Victoria
- being willing to innovate and disrupt the traditional way of doing things.

Of all Australian universities, we are the most successful at combining accessibility and excellence, and have become a place where social inclusion and globally-recognised excellence come together for the bene t of our students, our staff and our communities.

Our academics and researchers achieve national and international recognition, our public intellectuals demonstrate an enduring social conscience and in uence, and our alumni achieve extraordinary success and impact in government, industry and not for pro t organisations.

We strive to be exemplars for the sector in our commitment to gender equity and to inclusivity for marginalised groups; and we work with indigenous peoples and organisations to support their social, cultural and economic aspirations.

We embrace sustainable practices across all our campuses because we are committed to improving environmental, social and economic outcomes for our communities.

We contribute to economic development for our local communities, and our future activity will increasingly be international as we become a globally connected university in everything we do.

Our Culture

La Trobe Cultural Qualities

Our cultural qualities underpin everything we do. As we work towards realising the strategic goals of the University we strive to work in a way which is aligned to our four cultural qualities:

Connected

- We are Connected: Connecting the students and communities we serve to the world outside

Innovative

- We are Innovative: Tackling the big issues of our time to transform the lives of our students and society

Accountable

- We are Accountable: Striving for excellence in everything we do. Holding each other to account, and working the highest standards

Care

- We Care: We care about what we do and why we do it, because we believe in the power of education and research to transform lives and global society.

About Victoria and Melbourne

Experience Melbourne

Melbourne is the capital of the state of Victoria, and Australia's second largest city. It's a multicultural hub with 4.5 million people from over 153 countries. It's one of the world's best sporting cities, and is Australia's art and culture capital. Melbourne is a safe, well-serviced city in which to live. The main campus of the University at Bundoora is close to many world class hospitals, schools, research centres, shopping centres, bike paths and parklands. Melbournians enjoy, affordable healthcare, world-class education, reliable infrastructure, business opportunities and a healthy environment. In Melbourne you'll find just about every cuisine: French, Italian, Spanish, Greek, Chinese, Malaysian, Indian, Thai, Japanese, Moroccan and lots more. Melbourne has over 100 art galleries as well as theatres, international and local opera, ballet, comedy and live music.

Each year Melbourne hosts major international sporting events like the Australian Open Grand Slam tennis tournament, the Formula One Grand Prix, the Rip Curl Pro surfing championship, the Australian Masters golf tournament, the Melbourne Cup and the Grand Final of Australian Rules Football. As well as over 2500 festivals and events including the Melbourne International Arts Festival, Melbourne International Film Festival, Melbourne International Comedy Festival and the Melbourne Spring Racing Carnival.

Find out more: https://liveinmelbourne.vic.gov.au/discover

Victoria: The Garden State

Victoria has many notable gardens and 36 national parks covering two and a half million hectares. Victoria's many attractions include the Great Ocean Road, (stunning coastal views and the world-famous Twelve Apostles), the Grampians and the High Country.

Find outmorevisitvictoria.com

La Trobe University Campuses in Australia

Each of our seven campuses (Melbourne, Albury-Wodonga, City, Bendigo, Shepparton, Midura and Sydney) is a unique expression of place, people and history that play an important role in social, cultural and economic life. We are located in Victoria's major regional cities, creating a unique network of research, industry and innovation expertise that can be accessed across the state.

Melbourne Campus

La Trobe's Melbourne Campus has 27,000+ students and is surrounded by bushland. Students from across the world take advantage of state-of-the-art facilities, including our AgriBio Research Centre, the La Trobe Institute for Molecular Science and our very own Wildlife Sanctuary.

Albury-Wodonga Campus

La Trobe's Albury-Wodonga Campus has 800+ students and is home to our leading regional research centre, the Centre for Freshwater Ecosystems which focuses on water science and policy of the Murray-Darling basin. Here, undergraduate students work alongside Honours and research students on local issues.

School of Agriculture,
Biomedicine and Environment,
La Trobe University