Department of Ecological, Plant and Animal Sciences (EPAS)

School of Agriculture, Biomedicine and Environment

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

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

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About the School of Agriculture, Biomedicine and Environment

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

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

The 4 departments in the School are:

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

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

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

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

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

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

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

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

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

Or research centres:

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

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

Department of Ecological, Plant and Animal Sciences

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

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

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

We teach >3000 undergraduate students enrolled in 32 subjects.

Our courses include:

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

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

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

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

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

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

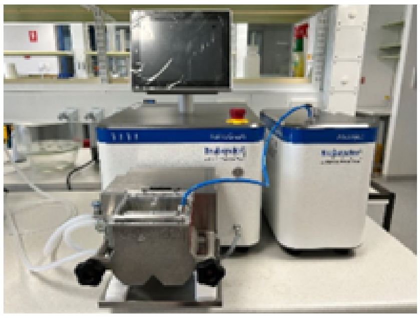
The Department's research environment is dynamic and growing, and includes several major Research Centres:

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

Research Centres

Centre for Food Science

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



Solid-State Fermentation of Foods

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

Oleosome Extraction: A Natural Solution

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

Plant-based Alternatives

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

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

Lab members:
Dr Deepa Agarwal
Dr Yakindra P Timilsena

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

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

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

ARC ITRH for Protected Cropping

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

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

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

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

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

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

ARC Centre of Excellence in Plants for Space

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

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

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

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

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

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

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

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

Centre for Freshwater Ecosystems

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

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

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

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

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

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

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

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

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

Our expertise is in:

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

We have facilities for:

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

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

www.latrobe.edu.au/freshwater-ecosystems

Research Centre for Applied Alpine Ecology

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

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

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

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

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

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

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

plant ecology, followed by four days of project-based work.

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

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

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

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

https://rcaae.org/

Research Centre for Future Landscapes

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

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

To do this, we foster research into:

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

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

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

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

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

We strive to be:

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

We have research expertise in:

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

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

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

Research Groups

Agriculture Bio-Solutions Lab

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

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

Cows (Photo credit: Travis Beddoe)

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.

Vaccine Development

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

Honey Bees, the most important livestock

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

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

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

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

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

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

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

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

Animal Behaviour Group

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

Motion vision in real environments

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

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

Ecology and behaviour of lizards across the globe

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

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

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

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

Multimodal signalling of anurans

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

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

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

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

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

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

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

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

Applied Animal Physiology Group

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

Murray River Turtle (Photo credit: La Trobe University)

Freshwater Turtle Conservation

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

Evolution and function of vertebrate placentas

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

Reproduction and environmental change

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

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

Fields of Study:
Physiology; Ecology; Evolution; Conservation

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

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

Applied Aquatic Ecology Research Group

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

Water Management and Environmental Flows

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

Aquatic Biodiversity and Ecosystem Monitoring

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

Improving aquatic restoration and management outcomes

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

Aquatic invasive species

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

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

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

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

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

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

Biodiversity and Ecology Group

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

Conservation, Biodiversity and Threatened species

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

Damselfly

Environmental DNA for monitoring species

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

DNA barcoding

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

Population genetics

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

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

Lab Members:
Dr Julia Mynott;
Ms Oliviah Lines.

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

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

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

Biogeochemistry and Ecotoxicology Group

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

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.

Alpine aquatic ecology and Peatlands

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

Characterisation and bioavailability of Dissolved Organic Matter (DOM)

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

Bioavailability and contaminant toxicity

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

Effects of abiotic factors on aquatic biota

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

Synchrotron-based techniques

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

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

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

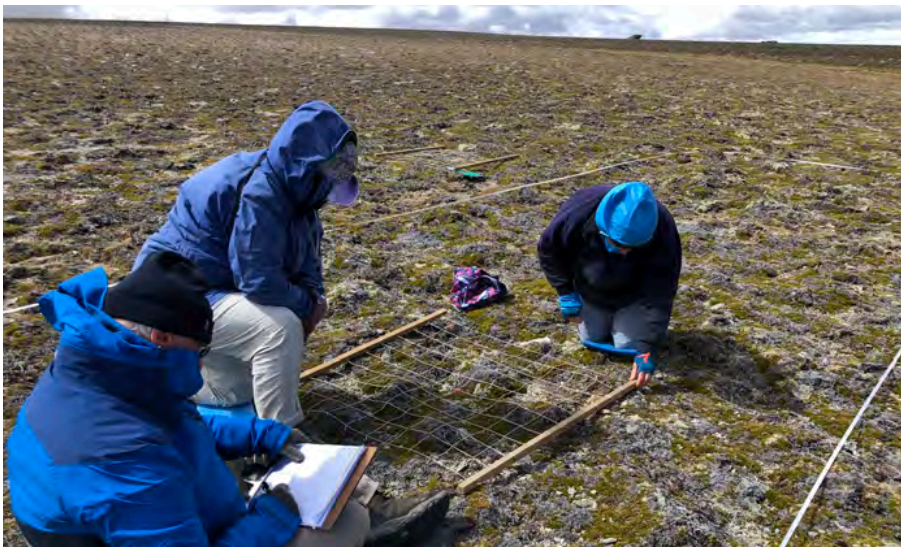
Fields of Study:
Freshwater Ecology; Environmental Chemistry; Biogeochemistry; Ecotoxicology.

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

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

Botany and Plant Ecology Research Group

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



Field work (Photo credit: John Morgan)

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

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

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

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

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

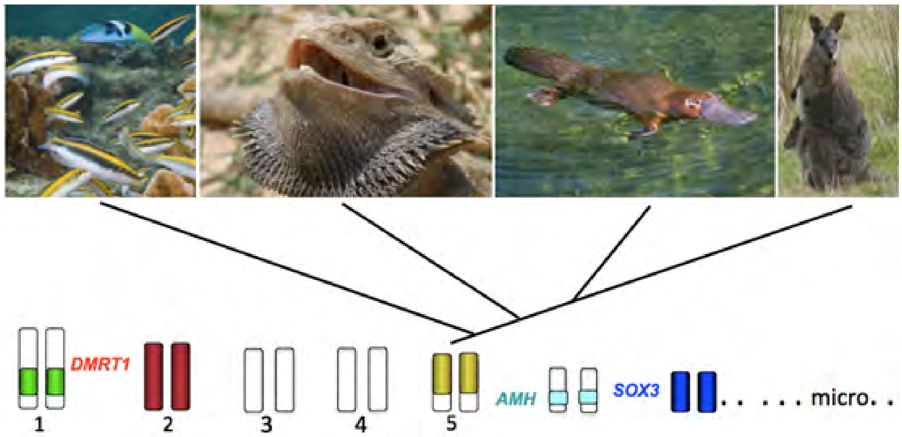
Fields of Study:
Ecological Applications; Global Change Biology; Landscape Ecology; Long-term Ecological Research.

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

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

Comparative Genomics

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



Comparative genomics cladogram (Diagram credit: Jenny Graves)

Sex in Dragons

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

Platypus sex and sex chromosomes

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

The origin of vertebrate chromosomes

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

The Earth Biogenome Project (EBP)

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

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

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

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

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

Crop Agronomy Group

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

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

Keyprojects:

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

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

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

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

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

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

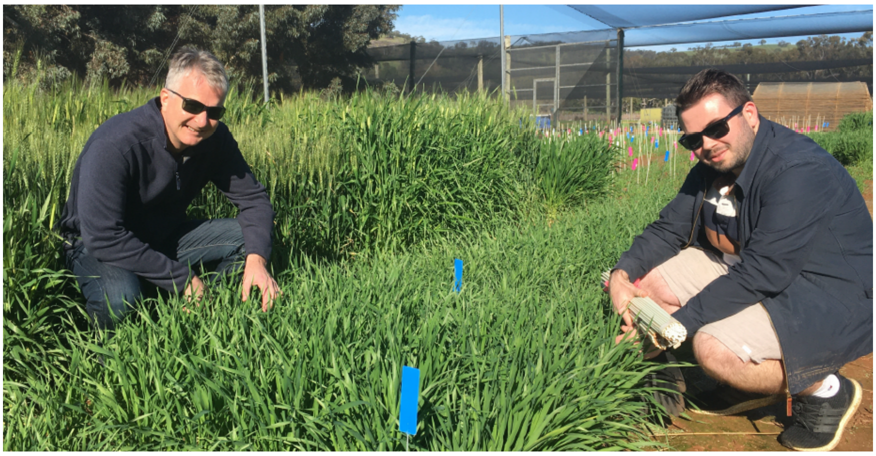
Fields of Study:
Farming Systems Research; Crop and Pasture Improvement (Selection and Breeding); Crop and Pasture Nutrition; Agricultural Production Systems Simulation; Agronomy.

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

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

Crop Plant Hormones Group

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



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

Crop Dwarfing

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

Plant Growth Regulators

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

Growth Versus Defence Trade-Off

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

Plant Hormone Biology

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

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

Fields of Study:
Plant biology; Agricultural biotechnology; Biochemistry and cell biology; Crop and pasture production.

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

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

Developmental Evolution Group

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

The Marsupial Advantage

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

"Only" Skin Deep?

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

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

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

Beyond Conservation Genetics

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

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

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

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

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

Fields of Study:
Evolution; Development; Genomics; Epigenetics

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

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

Environmental Impacts Group

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

In the field (Photo credit: Ian Porter)

Phase out of Methyl Bromide under the Montreal Protocol

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

Impact of Smoke Taint on the Wine Industry

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

Measuring Greenhouse Gasses to provide Sustainable Solutions for Industry

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

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

Lab Members:
Mr David Riches; Dr Scott Mattner.

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

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

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

Evolutionary Ecology Group

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

Using traits to predict species at risk

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

Evolution and plasticity in a changing world

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

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

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

Temperature and species interactions

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

Pollinators-native bees

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

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

Lab members:
Mr Matt Elmer;
Mr Harley Thompson.

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

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

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

Fish Ecology and Fisheries Group

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

Movement and migration

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

Population structure

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

Tagged Barramundi ready for release (Photo: David Crook)

Biochronological analysis

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

Traits and life history

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

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

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

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

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

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

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

Genome Regulation Lab

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

Ready, Set, Grow: Gene Expression During Seed Germination

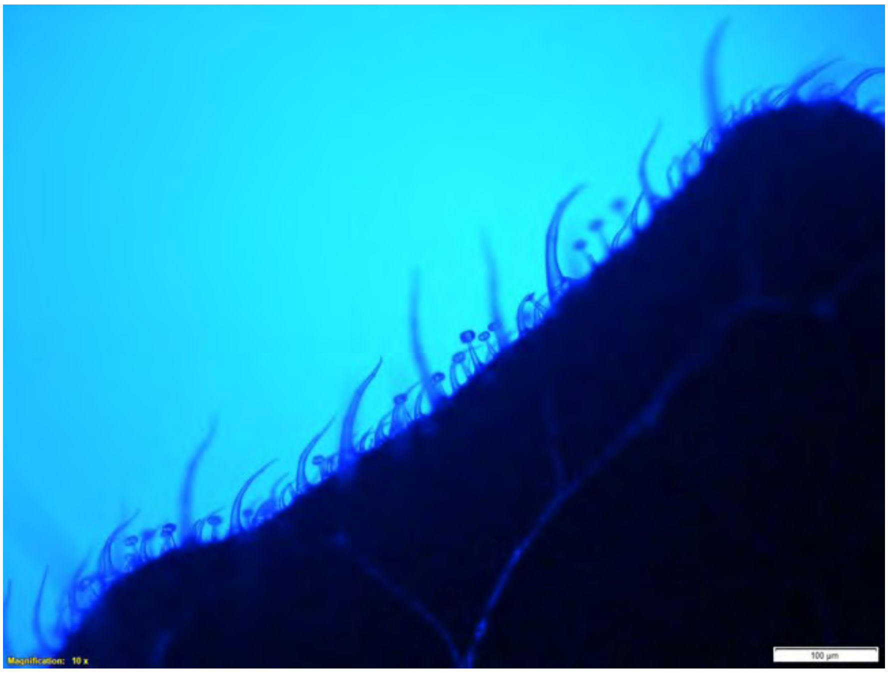
Seeds are the single most valuable output from plant production, providing 70% of global food resources. They are also a critical input to agriculture because the lifecycle of most crops begins each season from their seeds, which must germinate, grow and establish. We examine the temporal and spatial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

Grow-in-the-Dark: Systems Regulation of Hormone Responses

Our research in this area focuses on understanding how the different plant hormone signalling pathways interact one-another and exchange information. Ultimately, we analyse how this affects genome-wide gene regulation and seedling development.

Medicinal Agriculture: Cannabis and Opium Poppies

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



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

Plants on Film: High-Throughput Plant Phenomics

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

La Trobe Genomics Platform

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

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

Lab Members:

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

Fields of Study:

Plant biology; systems biology; bioinformatics; genomics; epigenomics.

Capabilities and Techniques:

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

Translational Opportunities:

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

Landscape Ecology Group

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

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

Conservation in rural environments

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

Natural Capital Accounting

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

Fire in the landscape

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

Conservation biology of wildlife

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

Ecology of woodland ecosystems

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

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

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

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

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

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

La Trobe University Herbarium

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

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

History

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

Database

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

Current operations

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

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

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

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

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

Legumes and Nitrogen Fixation Lab

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

Left: chickpea plant with nodules.

Right: cowpea plant roots with nodules.

The symbiosome membrane: the interface between legume and rhizobia

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

Role of metals in the legume: rhizobia symbiosis

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

Improving the efficiency and resilience of nitrogen fixation

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

Molecular analysis of legume seed components including allergens

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

Lab Head:

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

LabMember: Dr Frank Bedon

Fields of Study:

Molecular Biology, Plant Biology, Biochemistry, Cell Biology, Crop Production and Plant Genetics.

Capabilities and Techniques:

Molecular Biology, Proteomics, Plant Transformation, Protein analysis, Microscopy, Gene expression analysis, Plant phenotyping.

Translational Opportunities:

Molecular Biology; Proteomics; Plant Transformation; Protein analysis; Microscopy.

LISAF Mass Spectrometry Imaging Lab

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

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

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

Bruker timsTOF Flex MALDI-2 microgrid LC-ion mobility-MS/MS system. Example MALDI MS images (top to bottom, right to left) from phospholipid from barley root, cyanogenic glycoside from proteaceae floret & stem, honey bee, mouse eye and mouse brain phospholipids.

Lab Head:
Associate Professor Berin Boughton
(B.Boughton@latrobe.edu.au)

Lab Members:
Dr Myrna Deseo
Professor Tony Bacic

Capabilities

- Bruker timsTOF Flex MALDI-2 LC-ion mobility-MS/MS system
- Combined Microgrid and MALDI-2 capability allowing down to 5 μm spatial resolution
- Shimadzu IM Layer Matrix Vapor Deposition System
- Shimadzu IM Layer Aero Spray Deposition System
- Difficult sample preparation strategies & supporting equipment
- Leica CM3050 S Cryosectioning equipment
- Complementary biomolecule identification strategies via ion mobility and tandem-MS (nano-HPLC, microflow-HPLC)

Translational Opportunities

Improved opportunities across the spectrum of crop plants: the data and knowledge resources developed by this initiative provide novel knowledge that can be applied widely to a variety of situations to improve plant performance.

Position Australia as a leader in the Plant Cell Atlas Initiative: it is essential for both basic and strategic research that Australia maintains its position as research leader in plant agricultural science.

The IMS Lab provides researchers with the tools to do this in a national integrated system.

Provide unique opportunities across Biological and Biomedical research fields for fundamental and applied knowledge generation, enabling cross-disciplinary research and translational outcomes.

Marine and Ecophysiology Group

The Marine and Ecophysiology Groups seeks to address important research questions and issues relating to the passions of its members. In doing so, we actively encourage inter and intra-disciplinary research collaborations and industry partnerships to achieve translational outcomes. We undertake diverse research projects focusing on understanding the physiology of animals, and how physiology underpins their behaviour, diseases, conditions or performance etc. Ultimately, this can be integrated with other information to assist in conservation and management strategies for complex reef systems, establishment of artificial reefs and to understand various conditions or disease processes.

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.

Close up of the beautiful and fragile 'lace coral' (*T. umbonatum*) (Photo credit: Adrian Flynn)

As part of this large project we aim to:

- Investigate the biodiversity of bryozoans and co-occurring fauna
- Determine the age and growth rates of these reef systems
- Determine the extent of biogenic bryozoan reefs
- Identify and quantify the key threats to these biogenic bryozoan reef systems
- Understand the recolonization processes and connectivity to other populations

Muscle Physiology

The leader of the Marine and Ecophysiology Group is an expert in skeletal muscle physiology spanning over 20 years, publishing research articles on various aspects of muscle contractility and excitability. To understand how muscle function or performance may become aberrant under certain conditions, we must understand how it normally functions. Muscle plays a myriad of roles not just limited to power output or movement. Examining and comparing muscle's many roles and intricacies gives insight into muscle fatigue, muscle dysfunction and disease. Our world class muscle researchers have long-established collaborations locally and internationally.

Areas of interest include:

- Action potential generation and propagation
- Force development, maintenance and relaxation
- Calcium regulation and influence factors
- Physiological mechanisms and ultrastructure
- Protein analysis (quantification and modulation)
- Exercise physiology

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

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

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

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

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

Molecular Ecology Group

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

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

Freshwater Fish

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

Invasive Deer

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

Conservation Genetics

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

Trace DNA

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

Short Range Endemics

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

Lab Head: Dr Nick Murphy
(N.Murphy@latrobe.edu.au)
ARC DECRA Fellow: Dr Katherine Harrisson.
Lab Members: Ms Erin Hil; Mr Jude Hatley; Mr James O'Dwyer; Mr Zac Billingham; Mr Matt Quin; Ms Jess Taylor.

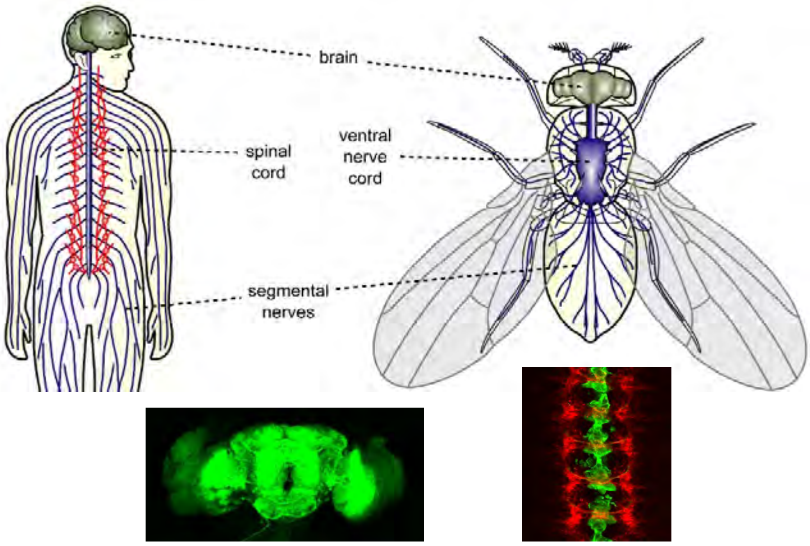
Fields of Study:
Population genetics; Conservation Genetics; Phylogenetics; Trace DNA; Evolution.

Capabilities and Techniques:
Amplicon sequencing; eDNA; qPCR; Species specific detection; Diet analysis; Metabarcoding genotyping; Next Gen Genotyping (ddRAD, SNP panels); Microsatellites; Bioinformatics; Species delimitation; Phylogenetics; Field sampling.

Translational Opportunities:
Threatened species conservation; Invasive species management; Cost effective biomonitoring; Water management.

Neural Cell Signalling Group

Our group studies how cells in the nervous system receive and respond to extracellular signals from their environment. An animal's nose can detect thousands of different chemicals in their environment. How does this occur, and how does the animal know what these represent and what the response should be? Other cells in the brain detect environmental signals that determine how fast an animal grows and to what size. How is this controlled? As well as these questions, we are also investigating how neuronal signalling goes awry in the devastating disorder motor neuron disease. We use the model genetic insect *Drosophila melanogaster* for most of our work, as cell signalling in the nervous system is highly conserved between flies and humans, and for flies we have many highly sophisticated genetic and molecular approaches available to study gene function and to interrogate the nervous system.



Drosophila melanogaster is a great model for studying the nervous system. GFP labelling of adult *Drosophila* brain and larval CNS (Photo credit: Dr Katherine Shaw)

Molecular basis of odour detection in insects

In insects the sense of smell is vital for detecting plant or animal hosts for feeding or laying eggs, and for detecting potential mates. We are studying the signalling mechanisms used by the very large family of odorant proteins in insects, and how they evolve across species. As well as fundamental studies, we are investigating the odorant receptor family of the Australian sheep blowfly, a damaging pest of sheep in Australia. We aim to identify receptors for ecologically relevant chemicals, which may in future lead to more environmentally friendly methods of pest control. This project is a collaboration with Dr Trent Perry at the University of Melbourne.

Neuropeptide regulation of developmental timing and growth

In animals developmental timing and growth are controlled by steroid hormones that are under complex regulation by both developmental and environmental cues. We are studying novel neuropeptide receptors involved in controlling steroid hormone production and growth in response to these cues in *Drosophila*. Many of these receptors have human counterparts, thus the knowledge we obtain may inform our understanding of growth in humans, and of disorders such as obesity.

Role of neuronal excitability in Motor Neuron Disease

Motor Neuron Disease (MND) is a devastating and universally fatal late onset disorder for which there are no effective treatments or cure. In MND progressive muscle weakness results in sufferers becoming unable to use their limbs, and eventually being unable to breathe. Development of therapies has been very challenging due to MND being a complex disease, with many genetic and environmental components.

Prior to symptom onset all patients initially exhibit hyperexcitability (over responsiveness) of the motor neurons. We are focused on understanding the mechanisms by which this develops, as its commonality to all patients makes it an attractive therapeutic target. *Drosophila* is an outstanding model for this question - fly models of MND recapitulate the pathology seen in humans and we have the ability to easily experimentally manipulate neuronal function and see how this impacts disease. This project is a collaboration with Prof Tracey Dickson and Dr Rosie Clark at the University of Tasmania.

Lab Head: Professor Coral Warr
(C.Warr@latrobe.edu.au)

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

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

Capabilities and Techniques:
Drosophila molecular genetics; All routine cell and molecular biology approaches; Many biochemical techniques; Many insect phenotypic assays (chemosensory behaviour and physiology, growth and developmental timing, embryo development and patterning, locomotory behaviour, immunity assays, microbiome assessment, ageing).

Translational Opportunities:
Our work is fundamental but may lead to targets for insect pest control methods; to future opportunities to develop better therapies for MND; and to novel targets for growth disorders in humans.

Neuroecology Group

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

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

Shark sensory systems and mitigation

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

Environmental impacts on the neural basis of behaviour

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

Sensory ecology of deep sea organisms

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

Sensory and bioengineering approaches to predict hearing abilities in fish

Using bioimaging and artificial intelligence to investigate the link between underwater soundscapes peculiar to the habitats of a range of fish species with the structure and function of their inner ear. This information can be used to predict the hearing abilities in fishes and the impacts of noise pollution.

Chemoreception in fishes: Anthropogenic impacts on brain and behaviour

Using a multidisciplinary approach, we assess the fundamental impacts of chemical pollutants on the detection, perception and behaviour in fishes and the impacts of these contaminants on sourcing food, avoiding predation and finding mates.

Plastic brains: Neural adaptations to changing environments in reptiles

Using cutting-edge micro-CT technology and advanced phylogenetic techniques, we investigate the evolution of brains of Australian goannas, dragons and venomous snakes, as these animals adapted to new habitats and climates.

Lab Head: Prof Shaun Collin (S.Collin@latrobe.edu.au)
Lab members: Ms Caroline Kerr; ARC DECRA Fellow Dr Lucille Chapuis; ARC DECRA Fellow Dr Jenna Crowe-Riddell; Mr Myoung Hoon Ha; Ms Hope Robins; Ms Paola Talarico; Mr Fernando Navea Bravo; Ms Alecja Greczynska; Ms Annalise Ceddia; Ms Isabella Kassa; Ms Mia Richardson.

Fields of Study:

Neurobiology; Marine Bioacoustics; Biomechanical Engineering; Molecular Biology; Behaviour; Ecology; Evolution; Development.

Capabilities and Techniques:

Electron microscopy (scanning and transmission); Electrophysiology; MRI; micro Computed Tomography (µCT); Behavioural testing; Artificial Intelligence.

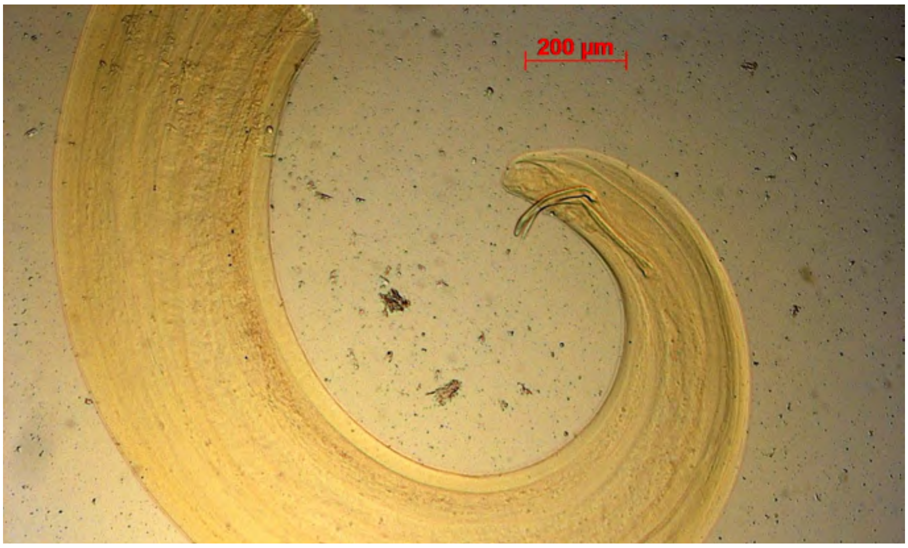
Translational Opportunities:

Shark mitigation; Aquaculture stress/welfare; species conservation; environmental and sensory pollution; biomimetics; climate change and animal behaviour effects; deep-sea exploration; the blue economy.

Parasite & Vector Genomics Laboratory

Over a billion people are infected by nematode parasite diseases, leading to poor childhood development, chronic physical disability, social ostracization, and ultimately contributing to economic and health disparities in rural and remote areas. These infectious diseases are preventable and treatable, but in many regions, people continue to be infected despite decades of drug administration to entire communities.

In collaboration with national and international stakeholders, we use genomics and modeling to figure out why drug therapies work well to eliminate the parasite in some communities but not in others. The lab's vision is to provide tools to aid in the elimination of parasitic diseases that are a public health threat, and to provide training for students and for workers in endemic countries to support the global use and development of these tools.



Dog heartworm tail (Photo credit: Haylo Roberts)

Identifying causes for persistent disease

Parasitic species of roundworms (nematodes) cause diseases such as river blindness and lymphatic filariasis (LF) and are transmitted through the bites of blood-feeding insects called vectors (blackflies and mosquitoes). We use population genomics and landscape modeling of parasites and vectors to determine whether migration of infected people or insects causes re-introduction of the disease in areas where the disease was thought to have been controlled, or whether the drugs used to control the parasites are no longer effective. Based on this knowledge, policy solutions for public health that effectively use the limited resources available are adaptively developed to target the causes of persistent transmission.

Predicting disease outcomes after change

Anthropogenic changes to the environment (e.g. from river dams or global climate), changes in human behaviour (e.g., refugee status or in compliance with health recommendations), and changes in policy (e.g. which drugs to distribute and where) impact efforts to eliminate infectious disease. We develop epidemiological models that incorporate geospatial ecological information and evolution of drug resistance to aid public health organizations in deciding when and where to safely stop drug distribution.

Exploring how genome evolution impacts disease transmission

There is a complex mosaic of parasite and vector genomes across the areas we work in Africa and the South Pacific: there are many species of vectors that transmit parasites—parasites that are evolving to drugs and to both human and vector immune systems. The vectors are also evolving in response to their environment and to insecticides used to reduce their numbers. We predict the functional impact of parasite and insect vector genome evolution on transmission by the vector, infection of the host, and control of the parasite. We identify genes that have evolved due to selection from field-caught specimens and test their functions using model organisms in the laboratory. We then develop sensitive molecular diagnostic tests for changes in these genes in treated populations.

Lab Head: Dr Shannon Hedtke (S.Hedtke@latrobe.edu.au)

Lab members:
Emeritus Prof Warwick Grant;
Dr Neha Sirwani;
Anusha Kode;
Sindew Feleke;
Millicent Opoku.

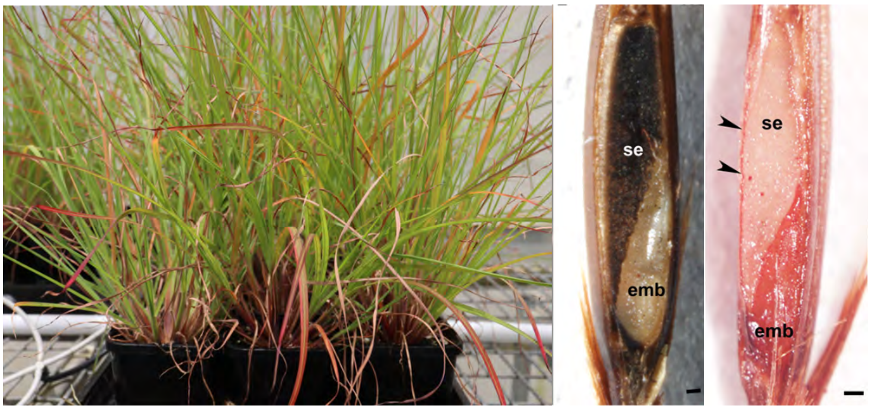
Fields of Study:
Evolution; genomics; epidemiology; parasites; bioinformatics.

Capabilities and Techniques:
Genomics; bioinformatics; DNA-based diagnostic assay development (qPCR/HRM, LAMP); experimental evolution; nematode transgenesis.

Translational Opportunities:
Improved parasite & pathogen detection diagnostic tools; improved models for predicting infection risk; zoonotic human health risk identification; effects of environmental changes on vector transmission potential.

Plant Bio-sensing Group

Our Group investigates how plants sense changes in their physical environment and ‘move’ their body and change shape to best adapt to the conditions. Our work investigates cell sensors that feel touch and activate response pathways that lead to changes in the cell wall and as a result, growth. This research aims to develop plants with greater plant biomass, optimize plant cell wall properties for food, fibre and biomaterials and enhance resistance to physical damage.



Kangaroo grass plants (left) and seeds (right) stained for starch (black) and fats (red) (Photo credit: Nitheeka Muthunuyake and Sarah Wilson)

Cell wall integrity sensors

Our Group has a strong track record of studying cell walls, dynamic structures that surround all plant cells, provide stability and shape and act as the interface between neighbouring cells and the environment. The structural integrity of the cell wall is essential for plant survival and as such plants have cell wall integrity sensors to monitor wall status. Detection of physical (also known as mechanical) ‘stress’ signals is important to adapt growth in response to the external and internal environment. Our group have identified several classes of cell wall integrity sensors involved in recognition of wall changes during development and in response to stress. These include Ca+ binding wall glycoproteins (AGPs) and wall-associated kinases (WAKs) and a Ca+ mechanosensing channel Defective Kernel 1 (DEK1). By investigating the molecular pathways involved in cell wall integrity responses we aim to use this knowledge to breed plants with improved growth and resilience to changing environments.

Soil compaction responses

Soil health directly impacts the ability of plants to access the water and nutrients they require to grow. Degradation of soils therefore impacts agricultural productivity and biodiversity. Compaction is one of the most important issues associated with soil degradation and occurs when soil is pressed together reducing pore size, for example by heavy vehicles, continuous cropping and climatic effects. Our group studies the cell wall responses and root growth of plants to the physical challenges of soil compaction. As part of a Herman Slade foundation grant, our group aims to determine how native grasses, including kangaroo grass, curly mitchell grass, evans wallaby grass and silky bluegrass, respond to compacted soils and investigate their use in restoration of compacted agricultural or marginal land.

Plant defense and disease diagnostics

Disease can cause up to 50% crop loss in susceptible crops. Our group are investigating the role of the cell wall in plant defence, use of microbial communities to reduce the need for chemical fertilizers and fungicides and development of rapid molecular based methods for early disease detection in controlled environment agriculture and broadacre settings. Replacing chemical-based fertilizers and fungicides with biological-based amendments aims to optimise plant health and enhance growth whilst reducing economic and environmental costs.
Working with regenerative agriculture groups we are assessing the impact of biological amendments on grain quality and soil health. We have developed environmental sampling and disease detection assays for a range of fungal pathogens that can be used as an early warning system for farmers.

Flowering and metabolite production

Plant based medicinal compounds are often found in specialized cell types called trichomes and predominant in flowering tissues. Together with Anthony Gendall and Matthew Welling, our group studies regulators of flowering time that balance the amount of time plants spend in vegetative or flowering growth stages. Our group also study the importance of the Oxylipin pathways as the proposed biosynthetic origin(s) of the carbon building blocks required for production of medicinal compounds.

Future foods

As demand for plant-based proteins increase there is potential to innovate locally produced and processed food products. Legumes are high protein grains rich in dietary fibre yet a challenge in legume-based food formulations are the ‘green’, ‘grass’ and ‘beany’ flavours and antinutritives. In addition, the influence of stress, such as drought and heat which are a feature of the Australian climate on grain quality have largely been unexplored. Together with Plants for Space and the crop agronomy and legumes groups, our work aims to optimize the nutritional profile of high protein plant-based foods and increase efficiency of growth for indoor and outdoor environments.

Lab Head: Assoc Prof Kim Johnson. (K.Johnson@latrobe.edu.au)
Lab members: Laura Steel, Aylwen Cotter, Gayathree Senevirathne, Oceane Perez, Louise Walker, Jiayue Wang, Ian Cullen.

Fields of Study:
Cell wall, Bio-sensing, growth, stress response, fibre.

Capabilities and Techniques:
Field-based disease diagnostics; Cell wall analysis; Grain nutritional composition; Fluorescence and electron microscopy; Phenotyping and genomics.

Translational Opportunities:
Sustainable agriculture practices, compacted land regeneration, crop disease resistance, plant-based foods, optimization of plant traits for different environments.

Plant Cell Walls and Bioactive Secondary Metabolite Group

The Plant Cell Walls and Bioactive Secondary Metabolite Group aims to understand how biopolymers are made and regulated. Biopolymers and secondary metabolites include some of the most abundant and renewable carbon-based molecules on earth and have a range of applications for biomaterials, food and medicines. By understanding how biopolymer levels are controlled, we can ultimately breed plants with optimal levels for specific end uses. Our Group is also part of the Medicinal Agriculture Hub that aims to improve production of plant-derived medicinal products, including cannabinoids, terpenes and other plant secondary metabolites.

Plant Cell Surfaces (Cell Walls)

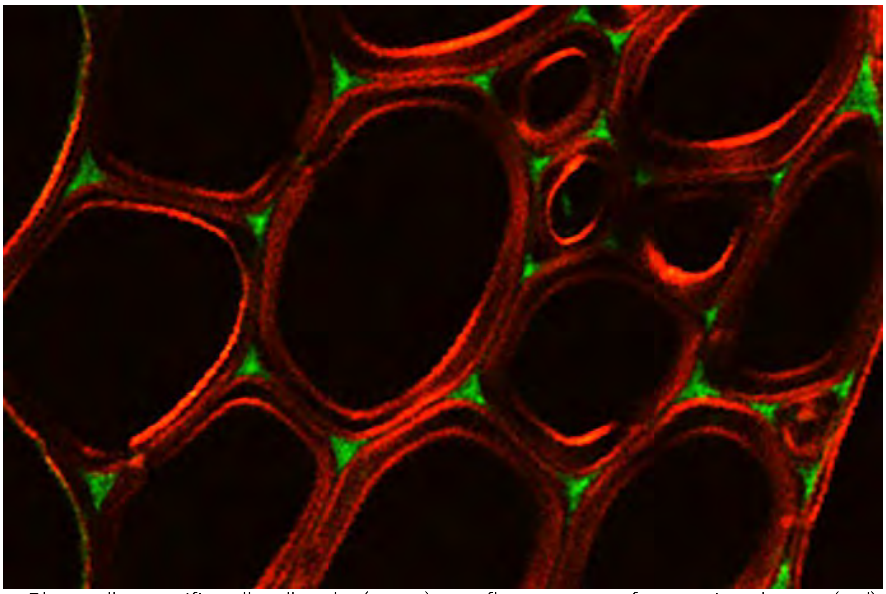
Most plant biomass consists of a carbohydrate-rich matrix present in cell walls. Cell walls, a major carbon sink, are our most renewable bio-resource and determine the products (food, fibre and fuel). Primary cell wall components are a key source of soluble fibre products. Secondary cell walls are the major constituents of insoluble fibre for textiles, pulp and paper manufacture and timber products and increasingly for fuel and biocomposite construction. Understanding how these cell walls are made, what they are composed of, and what determines their mechanical properties gives us the capacity to make 'designer walls'.

Dietary Fibre for Human Health

Mixed linkage glucan (MLG) is a soluble dietary fibre found in cereals. Chain structure strongly influences its solubility, with MLG in oat and barley being much more soluble than in wheat. Our research aims to understand how the biosynthesis, assembly and turnover of MLG is regulated. By understanding how MLG levels are controlled, we can ultimately breed cereals with optimal levels for specific end uses.

Cell Wall Sensing: Plants Have Feelings Too!

Plants can sense changes in their physical environment and 'move' their body and change shape to best adapt to the conditions. Our work investigates cell sensors that feel touch and activate response pathways that lead to changes in the cell wall and as a result, growth.



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

This research aims to develop plants with greater plant biomass, optimise plant cell wall properties for food, fibre and fuel applications and enhance resistance to physical damage.

Ambassadors of Agriculture Program

La Trobe University offers one of only two Bachelor level agricultural science degrees in Victoria and is the largest trainer of post-graduates. Our research team contributes to various outreach programs that run at La Trobe including the Ambassadors of Agriculture Program.

Group Leaders:

Professor Tony Bacic (T.Bacic@latrobe.edu.au), A/Prof Monika Doblin, A/Prof Kim Johnson and Prof Wei Zeng (Zhejiang A&F University (ZAFU) and Taizhou University, China)

Fields of Study:

Cellular Interactions; Plant Cell & Molecular Biology; Crop and Pastures Biochemistry and Physiology; Expanding Knowledge in the Agricultural and Veterinary Sciences; Medical Biochemistry and Metabolomics.

Capabilities and Techniques:

- Genetic transformation and Gene Editing for cereals and legumes.
- Extensive Growth Facilities (Glasshouses, CERs (PC2/QC2)).
- Sequencing Platform.
- Transcriptomics (small RNA, DNA methylation sequencing, protein-DNA interactions, genome sequencing).
- Omics (Genomics/ (Phospho) Proteomics/
- Metabolomics/ Glycomics) and associated bioinformatics platforms.
- 10x Genomics single cell sequencing analysis.
- Laser Capture Microdissection.
- Fluorescence Activated Cell Sorting (FACS).
- Mineral and chemical analyses of soil, plant and seeds.
- Plant Phenomics (3D, RGB, fluorescent and hyperspectral with cloud-based analytics).
- Big Data integration and analysis.
- High-end imaging mass spectrometry.

Translational Opportunities:

Improving crop productivity (yield and quality) and sustainability; Improving the nutritional quality of grains e.g. cereals and legumes/pulses; Stem fibre quality; Plant synthetic biology; Biomass utilisation and waste valorisation; Ameliorating soil constraints; Reducing environmental impacts; Supporting agricultural education.

Plant Development and Physiology Group

The Plant Development and Physiology Group (Gendall Lab) uses genetic and molecular approaches to study aspects of plant development and physiology, primarily using the model plant *Arabidopsis thaliana*. We are particularly interested in using the natural variation present between different varieties (ecotypes or accessions) as a starting point to identify and characterise genes that regulate particular characteristics.

Seed biology and biotechnology

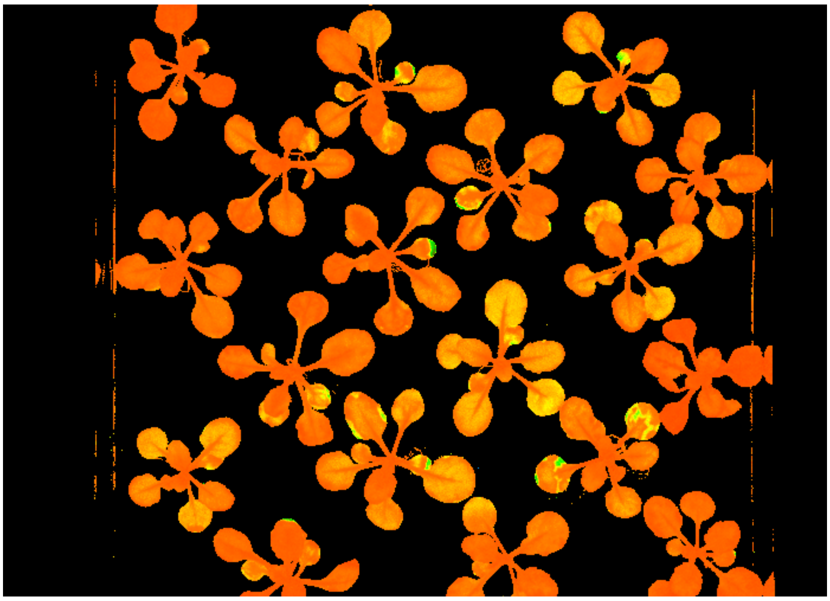
A major area of interest in the lab is the regulation of ion homeostasis by a family of intracellular Na+/H+ antiporters in the model plant *Arabidopsis*. Overexpression of many of these family members leads to increased salt tolerance, but the mechanisms for this resistance is poorly understood.

We have shown that two of these antiporters are required for normal plant development and have roles in intracellular protein trafficking. These antiporters regulate the pH of intracellular compartments, and influence ion sensitivity and protein trafficking by interacting with specific components of the protein trafficking, sorting and recycling machinery.

We have recently shown that these antiporters affect the processing an accumulation of seed storage proteins and other vacuole localised proteins, and this suggests that pH regulation is likely to be important for seed development and grain quality in crop species.

Plant Growth Regulators

Some soil bacteria are able to promote the growth of host plants and result in an increase in plant biomass and root length. In collaboration with Professor Ashley Franks, we are using QTL mapping and genetics approaches to investigate the genetic basis of host-specificity in the variable response to plant growth promoting rhizobacteria, with the long term aim of developing specific host-inoculum combinations that promote plant growth.



Arabidopsis thaliana's photosynthetic rainbow. (Photo credit: Lianna Sliwcyznski)

Herbicide Development

With herbicide resistance increasing, there is great demand for herbicides with new modes of action. In collaboration with Tatiana Soares da Costa, we have developed novel herbicides with new modes of action that target key steps of the lysine biosynthesis pathway in plants.

Improving Medicinal Cannabis

(as part of the ARC Industrial Transformation Research Hub for Medicinal Agriculture - MedAg Hub) We have a project to understand the regulation of flowering in cannabis by identifying the genes responsible for variation in flowering between different varieties, and characterizing their activity.

Lab Head: Dr Tony Gendall (T.Gendall@latrobe.edu.au)

Lab Members:
Ms Charlotte (PhD) Francois; Ms Lianna Sliwcyznski (MSc), Mr Cody Hall (PhD), Ms Laura Steel (PhD), Ms Emily Mackie (PhD), Mr Daniel Hawkins (PhD), Mr Ryan McClean (MSc), Dr Shamila Abeynayake (Honorary), Ms Nicole Ristevski (Hons)

Fields of Study:
Cell and Molecular Biology; Plant Development; Plant Breeding and Genetics; Plant Biotechnology; Plant Reproduction.

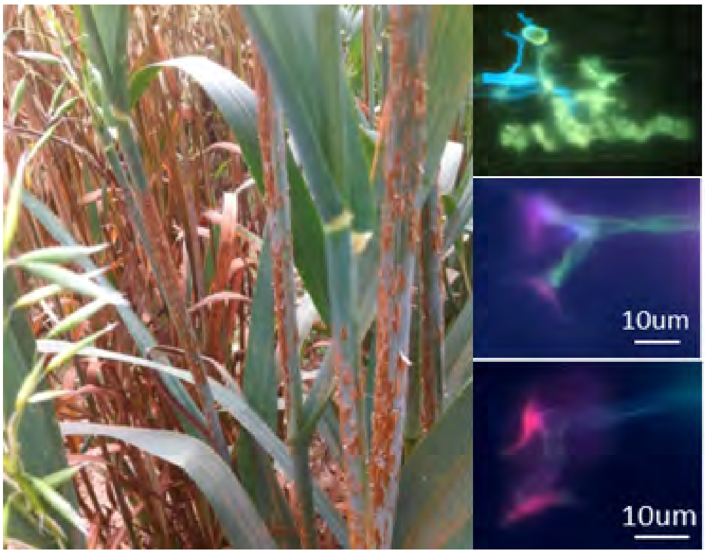
Capabilities and Techniques:
Confocal microscopy; in vitro plant analysis; plant genetics.

Translational Opportunities:
Herbicide development; contract/ consultancy for plant breeding.

Website:
https://www.latrobe.edu.au/animal- plant-and-soil-sciences/research/ gendalllab

Plant Disease Resistance and Immunity Group

The Plant Disease Resistance and Immunity Group (Dracatos lab) uses digital agriculture, genetics, molecular and genomic approaches to study how plants defend themselves to protect yield when challenged by plant pathogens. We mainly focus on identifying and characterizing diverse mechanisms of disease resistance to economically significant fungal diseases using the cereal grain barley as a model crop organism. Identifying the genes that underly and regulate fungal disease resistance mainly involves utilizing naturally occurring variation present in cereal grain accessions and landraces spanning diverse wild and cultivated gene pools. Our work combines a deep understanding of the molecular genetic basis of resistance and plant microbe interaction studies and uses the latest micro-phenomic approaches in digital agriculture to accurately assess and track disease progression in cereals. Our goal is to conduct research that informs improved disease management and ultimately alleviates pressures on global food security.



Stem rust infection on cultivated oats (left photo by Peter Dracatos) and on 3 different barley genotypes with nonhost resistance (photos by Peter Dracatos & Michael Ayliffe)

Barley Net Blotch and Scald Resistance

We have a research program funded by the Grains Research Development Corporation in collaboration with national pathologists and experts pioneering novel breeding technologies focused on identifying and further characterising durable genetic resistance mechanisms to necrotrophic diseases such as Net Blotch and Scald. The project involves developing the micro and macro-phenomic capabilities of a newly developed digital platform to accurately phenotype plant diseases at numerous stages after infection. The project will involve mechanistic mode of action studies to clone and functionally validate functionally diverse Net Blotch resistance genes. The project will also facilitate tracking these pathogens and the host response at early timepoints after infection.

Cereal Rust Resistance

Cereal rust diseases (caused by biotrophic pathogens in the genus *Puccinia* spp) have plagued farmer's fields since the domestication of cereal grain crops in the fertile crescent approx. 10,000 years ago. The plants immune system is multi-layered and complex. The focus of this project is to identify and characterise the function of diverse mechanisms of rust resistance in cereal grain crops such as wheat, barley, and oat. We use both forward and reverse genetic approaches and the latest genomic resources to identify the gene/s underpinning rust resistance in cereals. This knowledge can then be used to engineer crop plants with resistances that are less vulnerable to the forces of pathogen evolution preventing the slowing the breakdown of resistance in the field.

Nonhost Resistance

Plant species have diverged over millions of years, co-evolving with few specific pathogens. Therefore, most plant are resistant to most diseases they encounter during their growth cycle. This is partly due to genetic factors in the host and pathogen. Cereal rust pathogens display high host specificity because of ongoing co-evolution with a narrow range of grass species. In rare cases, some plant species are in a transition from host to nonhost or are intermediate hosts (near nonhost). We use the barley (near nonhost) -*Puccinia* rust model for molecular studies to understand the mechanistic basis of nonhost resistance in plants. This research is aimed at identifying genes in the plant that are involved in host specialization and genes in the pathogen that contribute to host jumps.

Nutritional Immunity

Biotrophic pathogens such as rusts develop feeding structures (haustoria) in the mesophyll cells of their preferred hosts to acquire nutrients they require to sporulate and maintain fitness. Our group studies how changes in the plants nutritional status affects the successful growth of fungal pathogens *in planta*. We aim to understand how diverse genetic mechanisms affect the supply of micro and macro nutrients to the pathogen and how this affects the outcomes of pathogen colonization. Our group targets naturally occurring mutations in nutrient transporter genes to functionally verify variants that may result in partial resistance to rust diseases.

Lab Head: Dr Peter Dracatos
(P.Dracatos@latrobe.edu.au)

Fields of Study:
Cereal Genetics, Plant Pathology, Genomics, Plant Molecular Biology/ Biotechnology, Digital Agriculture

Capabilities and Techniques:
Micro-phenomic disease assessment; Genomics, Gene Cloning, GWAS, RNA-Seq, Gene Sequencing, Pathogenicity studies.

Translational Opportunities:
Breeding Resistant Crops, Gene Editing, Enhanced Disease Management, Disease, Food Security.

Plant Reproduction and Conservation Genetics Group

Our research is diverse and includes aspects of plant conservation, demography, ecology, reproduction and genetics/genomics. The group has a strong research interest in the application of conservation genetics and genomics to management of native flora, as well as applied studies in relation to weeds and crops. A variety of techniques are used by the group including traditional field-based ecological approaches and morphological investigations, alongside next-generation genomic approaches.

We are collaborative and work with other research organisations, state and federal departments, NGOs and community groups.

(Photo credit: Susan Hoebee)

Unravelling the evolutionary history of iconic Australian plants

Using genomic approaches coupled with pollination studies, we aim to identify processes involved in speciation in a number of Australian plants genera with a strong focus on those within the Proteaceae and Myrtaceae. In these studies, the identification of processes underpinning population structure and driving species evolution will aid conservation management for several taxa.

eDNA approaches to pollination studies

Floral visitors leave traces of their DNA on flowers they visit. This environmental DNA (or eDNA) can be harnessed to build a picture of the community of animals visiting plants. Traditional approaches, including recording animal behaviour on the flowers and confirmation of pollen transport, are then applied to better identify pollinators from all floral visitors. We are using these approaches in a threatened grassland community.

Harnessing genomics to restore resilience

We are working in two spaces relating to resilience. Following the 2019/2020 Black Summer Bushfires, we embarked on an initiative to secure the future of East Gippsland's threatened flora by combining site surveys with assessment of the genomic diversity and structure of surviving, resprouting or emerging plants from a number of impacted species. Post-fire recovery and establishment of risk mitigation plans for the survival of select plant taxa are the focus of this collaborative work.

We are also involved in generating genomic data associated with provenance and maternal lines in established Climate-ready Revegetation plots to evaluate and enhance habitat resilience to the uncertain and unpredictable effects of climate change.

New ways to find old mates – rapid identification of sex genes in plants

Approximately 60% of plant species use a self-incompatibility (SI) system to prevent inbreeding caused by self-fertilisation. Although there are many SI systems, only three have been characterised at the molecular level, with the remaining systems very poorly described. Understanding these systems has implications for conservation and restoration programs, weed control, as well as crop and horticultural breeding programs. SI related research has involved internal collaboration supported by industry funding.

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

Lab Members:
Mr Mark Clifton;
Mr Stanislaw Wawrzyczek;
Mr Simon Heyes;
Ms Allison Menzies;
Ms Jennifer Longo;
Ms Amelia Mendes.

Fields of Study:
Conservation; Ecology; Evolution; Genetics/ Genomics; Plant Reproduction; Pollination.

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

Translational Opportunities:
Species conservation, utilisation and/or management; Plant breeding; Genomics for future climates.

Plants and Pollinators Group

We have a broad interest in the ecological and evolutionary consequences of the interactions between plants and pollinators. This topic is critical for understanding the incredible morphological and taxonomic diversity of both flowering plants and nectar feeding animals. Further, in Australia there are many cases of relatively specialised pollination systems, meaning that numerous plants are vulnerable to the loss of pollinators following the extensive modification that the Australian landscape has experienced. Studies of plant-pollinator interactions encompass a range of approaches including field experiments, analysis of plant and pollinator communities, studies of animal behaviour, and molecular approaches. At present, we undertake field research in both south-eastern Australia, and the south-west Australian biodiversity hotspot.

A honeyeater feeding on kangaroo paw, *Anigozanthos flavidus.* (Photo credit: Myles Menz)

Pollination biology in conservation and restoration

Despite widespread concerns about declining pollinator populations, pollinators are rarely considered when attempting to improve the conservation of threatened plant species. In a partnership with the Royal Botanic Gardens Victoria, we have developed a project aiming to optimise the establishment of new populations of threatened orchids based on knowledge of pollination biology. We are also interested in how incorporating pollinators into ecological restoration could lead to greater animal biodiversity and improved plant recruitment in restored landscapes.

The evolution of deceptive pollination strategies in Australian orchids

Australia is home to some of the world's most remarkable orchids, many of which use deceptive pollination strategies. This includes orchids that mimic rewarding flowers, but also species that attract male insect pollinators through mimicry of females. We aim to understand how deceptive strategies evolve, which floral traits attract pollinators, and how the evolution of deceptive pollination strategies has affected diversification of orchids. Through collaboration with Australian and overseas scientists, our research has already led to the discovery of new sexually deceptive systems and the chemicals involved in pollinator attraction.

Understanding the ecological and genetic consequences of pollination by vertebrates

The Australian flora is characterised by numerous plants pollinated by vertebrates, including many of our most iconic plants. Our research has focused on testing the hypothesis that, for floriferous shrubs and trees, pollination by birds rather may lead to greater pollen dispersal and more fit seed. However, many Australian plants that appear to be pollinated by birds or mammals are morphologically specialised understory species. Until now, the consequences of vertebrate pollination for this intriguing group of plants remains essentially untested, inspiring this to become a new research focus for our group.

Floral adaptations to pollination niches

As a requirement for plant reproduction, pollination is a critical component of a plant's ecological niche. We are interested in using plant-pollinator networks as an objective way of recognising groups of ecologically similar pollinators that could represent pollination niches. Having recognised such niches, we aim to test the role of visual and chemical cues in attracting these pollinators. This represents a potentially powerful new approach for understanding floral adaptation and how this might affect co-existence in plant communities.

Lab Head: Dr Ryan Phillips
(R.Phillips@latrobe.edu.au)

Lab Members:
Ms Amelia Mendes; Mr Andrew Bird; Mr Eamonn Culhane; Dr Linda Riquelme; Dr Marinus De Jager; Ms Rebecca Grinter; Mr Stan Wawrzyczek.

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

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

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

Reproductive Ecology and Conservation Biology Group

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

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.

Understanding the mechanisms and adaptive advantage of sex allocation

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

Ecological impacts of artificial lighting on wildlife

Artificial lighting fundamentally changed the earth's night-time environment, with a wide range of biological effects on animals. Organisms have evolved to respond to natural light cues to control or modulate behaviour, activity, reproductive timing and physiological function. We study artificial light impact on reproduction timing in seasonally breeding wildlife. Using our knowledge of the visual and non-visual sensitivities of our target species we workwith industry to develop and test wildlife friendly lighting options (LED lights that combine custom wavelengths) to mitigate the negative effects of light at night.

Captive breeding and reintroduction biology

Captive breeding is one aspect of threatened species conservation, however attempting to breed and raise species in captivity presents many challenges for recovery programs. Captivity results in various environmental modifications that can lead to behavioural, morphological and physiological changes that result in potentially detrimental effects upon release. Some of our research has focussed on maternal mate choice to improve both conception rates and offspring fitness in captive breeding programs. While other research is assessing predator recognition, behavioural, personality and cognitive traits linked to survival success post release. Another area we are working on is the integration of gut microbiome research for enhancing translocation of threatened species. Captivity has profound effects on the hosts microbiome which has been implicated as a cause of post release failure. If captive populations are to effectively act as insurance and source populations for threatened species, they must retain essential traits for survival post-release. As part of our reintroduction biology research we have also worked with engineering colleagues to develop a long range (LoRa) radio and Internet of Things (IoT) system for passive tracking of translocated wildlife. Our WildTrack system has gone through two development and testing phases and provides a non-invasive way to track difficult to monitor species. The system is highly scalable with 1000's of modules able to connect to a single LoRa gateway enabling the future use of long-distance arrays to increase detection rates, examine dispersal distances and determine home ranges of more mobile species.

Lab Head: Dr Kylie Robert (K.Robert@latrobe.edu.au)
Lab Members: Dr Zak Atkins, Dr Stephen Griffiths, Angela Russell, Kushini Kularatne, Angela Simms, Stacey Phillips

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

Capabilities and Techniques:
Animal field ecology (trapping, handling, monitoring, tracking); Behavioural observations; Sperm analysis; Respirometry; Endocrinology; Thermal biology; Captive animal colonies.

Translational Opportunities:
Reintroduction biology; Species conservation; Mitigation of artificial light at night; Threatened species biology; WildTrack network.

Website: www.robertlab.com

Riverine Landscapes Research Group

Our group, located in the Centre for Freshwater Ecosystems, has expertise in spanning hydrology, spatial modelling, GIS, ecology, ecosystem science, molecular and genetic techniques and has strong links to industry and research partners in Australia and worldwide. We study interactions between the physical environment, (climate, hydrology, fire and land-use), and how these affect ecological patterns and processes across the landscape, including species distributions, population dynamics, connectivity and food-webs.

The effects of climate-variability and change on species distributions
Australia has extreme patterns of interannual climate variability and frequent drought. We use field and modelling approaches to relate aquatic ecosystems species distribution to water stress, hydrology, fire, climate change and other physiographic variables. Our predictions of potential future shifts in species range, abundance and occupancy are combined with conservation planning models to prioritise areas for protection and targeted management interventions. We work with Melbourne Water and the University of Melbourne to develop the Habitat Suitability Models for stream and wetland fauna around Melbourne, and we are monitoring the 2020 bushfires impacts on the nationally endangered Alpine Stonefly (*Thaumatoperla alpina*).

Ecohydrology of intermittent stream networks
Up to 80% of river networks worldwide experience regular periods without surface flow. Dry period water habitats can contract to isolated waterholes along river channels which become critical refuges for aquatic biota. In human modified landscapes, sedimentation, groundwater extraction and runoff catchment interception cause declines in refuge quality and quantity. We study surface-groundwater interactions and food-web structure within individual waterholes, as well as, catchment hydrology roles roles determining waterhole persistence and metapopulation structure and dynamics

Aquatic biodiversity conservation and management
Freshwater ecosystems account for around 10% of global biodiversity, but are declining at a rate far exceeding terrestrial or marine ecosystems. We study the ecology and fundamental biology of aquatic biota, including threatened species and other significant species of management interest (e.g. fishing target species); with the goal of improving management decisions and actions for these species. Our research includes evaluating and improving conservation strategies for threatened species, threatened species detection and distribution, and assessment of population viability through modelling. We are currently compiling genetic databases of freshwater invertebrates to map species distribution and use DNA metabarcoding to assess biodiversity and inform conservation measures.

Aquatic ecosystem processes and food-web ecology
Our research explores how ecosystem processes (such as nutrient cycling, decomposition) and food-webs (ecosystem energy and matter flows) are influenced by human induced threats. We study how environmental change (such as altered river flows) affects connectivity, ecological processes and the trophic structure of aquatic food-webs. Our research, under field and laboratory conditions, often includes experimental manipulation in many aquatic ecosystem types.

Theme Head: Prof Nick Bond (N.Bond@latrobe.edu.au)
Theme Members: Assoc Prof David Crook; Assoc Prof Alison King; Dr Luke McPhan; Dr Michael Shackleton; Dr Sally Maxwell; Dr Julia Mynott.

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

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

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

Sleep Ecophysiology Group

Sleep is something we all do. We sleep for one-third of our lives; some animals are asleep much longer. We tend to look forward to sleeping; we feel, and perform, poorly when we don't get enough. Sleep behaviour reveals little about its function. For instance, we inhale to draw oxygen-rich air into our lungs. We eat to obtain energy for metabolism and growth. Conversely, the specific functions served by remaining outwardly inactive for long periods of time is less obvious. Our group studies sleep behaviour and neurophysiology in animals, including mammals, birds, fishes, and invertebrates, often in naturalistic or wild environments. Using this strong comparative approach that integrates classical behavioural ecology with neuroscience, we study: (i) evolution and function of sleep and sleep state components; (ii) the role of ecological factors and life history, including predation risk and breeding systems, respectively, in shaping where, when, and how long animals sleep; (iii) sleep-dependent cognition; (iv) effects of environmental pollution, e.g. light and urban noise, on sleep in wildlife.

Artificial light at night disrupts sleep in wildlife. (Picture credit copyright: Damond Kyllo)

Evolution of sleep

Unearthing the evolution of sleep can provide insight into its function. In humans and other mammals, there are two kinds of sleep: non-rapid eye movement (non-REM) and REM sleep which can be distinguished using various behavioural and physiological measurements. These sleep states serve different functions, but our understanding of those processes remains incomplete. We compare sleep across animals to learn how and why sleep has changed with the appearance of new 'types' of animal.

Ecology of sleep

The timing, amount, composition, and intensity (or depth) of sleep is also likely to be strongly influenced by an animal's ecology. Predators strongly shape the structure and organization of sleep in prey. Studies reveal that REM sleep is a particularly dangerous sleep state from an anti-predator point-of-view, perhaps because it is one of the deepest forms of sleep. Breeding systems in which males compete intensely for access to fertile females also favour great reductions in sleep, allowing the least restful males to secure additional paternity. Studies reveal sleep loss can be adaptive and favoured by selection, challenging popular notions that sleep loss is always detrimental to performance.

Sleep-dependent cognition

Sleep is known to maintain waking performance in diverse animals. When animals are kept awake, they perform poorly. Their motivation and attention are reduced, coordination and memory are impaired, and emotions become more reactive. We study sleep's role in cognition in ecologically-relevant situations, mostly (but not exclusively) on Australian magpies.

Disruptive effects of pollution on sleep

Humans have modified natural landscapes to contain sleep-disturbing pollution, such as artificial light at night, urban noise, and psychoactive pollutants in waterways. Until recently, we did not understand how sleep physiology was impacted by these forms of human pollution. Recent studies showed birds exposed to streetlights have a great reduction and fragmentation of sleep. Species responses to pollution appears to be species-specific, so we cannot endorse a single solution to ameliorate pollution effects on wildlife sleep.

Lab Head: Dr John A. Lesku (J.Lesku@latrobe.edu.au)

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

Capabilities and Techniques:
Electrophysiology; Behavioural testing; Endocrinology; Molecular Biology.

Translational Opportunities:
Modified landscapes disruption to sleep affect wildlife conservation and management. Animals sleeping near streetlights can sleep 40% less than those in darker areas. Sleep affects waking performance, immune system functioning, clearing of nervous system metabolic waste, DNA repair, early brain development and energy conservation. Sleep disruption may directly affect an animal's ability to survive and reproduce.

Soil-Plant Interactions Group

(Photo credit: Caixian Tang)

Soil degradation and nutrient deficiency in agro-ecosystems are worldwide problems and limit sustainable food production under current climate change settings. Our interdisciplinary and multi-institutional research focuses on management of soil constraints and nutrients, soil-plant interactions (including rhizosphere biochemistry) and impacts of elevated CO_2 and farming practices on soil processes and carbon sequestration.

Impact of elevated CO_2 on crop growth and soil nutrient dynamics

Climate change and increasing CO_2 are impacting food production. Although increases in [CO_2] are predicted to initially increase plant productivity, achieving these benefits will be limited by water and/or nutrient deficiencies. It is unknown how Australian grain production systems, which have low- rainfall and infertile soils, will respond to increased CO_2. We study the interactions between elevated CO_2, nutrient supply and water availability on biomass distribution, N_2 fixation, litter quality, chemical and microbial processes regulating the cycling of carbon, nitrogen and phosphorus. We provide evidence of elevated CO_2 impact on root exudation, soil phosphorus dynamics, and on the activity and structure of microbial communities.

Rhizosphere processes and phosphorus acquisition

Phosphorus (P) fertilizers are important in sustaining crop yields in modern farming systems. Each year, Australian farmers use about 450,000 tonnes of P as phosphate fertilizer. Only 10-30% is absorbed by crops, leaving unused P remaining in the soil. We study the impact of crop species, soil type and farming practice on chemistry and microbiology at the soil-plant interface (rhizosphere) to understand how to enhance the absorption of soil P by crop plants. We aim to identify crops that can access and absorb P from unavailable pools in soil, to improve P-use efficiency and to reduce P fertiliser use.

Impact of farming practice on soil carbon dynamics

Soils can potentially sequester 2/3 of global soil carbon as soil organic matter, which is about 3.2 times the size of the atmospheric pool. Small changes in soil carbon content could lead to a significant change in atmospheric CO_2 level. We study how crop species, and farming practices such as crop-residue addition and lime application affect decomposition, preservation and carbon composition of soil organic matter to provide insights into on-farm management impacts on soil carbon dynamics over the long term.

Amelioration of soil contamination

Land contamination is a serious worldwide issue and technologies such as applying biochar are being developed to address heavymetal contamination. We study the chemical and microbial immobilization of heavy metals in soils treated with biochar.

Management of soil constraints

Subsoil acidity and compaction limit crop production in Australia, and are costly and often impractical to fix. We have compared different crop species/genotypes in their adaptation to the constraints, and assessed many organic and inorganic materials such as crop residues, biochar, animal waste materials, and calcium nitrate for their ability to overcome these constraints and studied amelioration processes and factors that improve subsoil conditions and crop yields.

Lab Head: Prof Caixian Tang (C.Tang@latrobe.edu.au)

Lab members: Dr Gary Clark; Dr Jian Jin; Assoc Prof Peter Sale; Adj Prof Roger Armstrong; Dr Tharanga Bandara; Dominic Lauricella; Kate Carson; Zahra Latifi; Rachel Davis.

Fields of Study:
Nutrient cycles; Plant nutrition; Plant-soil microbe interactions; Rhizosphere; Soil Science.

Capabilities and Techniques:
AgriBio modern research & plant growth facilities; Fitotron CO_2 growth chambers; 13C-labelling devices; Perkin Elmer CHNS and ICP analysers; Lachat flow- injection analyser; Infra-red CO_2 analyser; TOC analyser.

Translational Opportunities:
Carbon sequestration; Soil contamination & constraints amelioration; Efficient fertilizer use; Carbon & nutrient cycling.

Weed Science Group

We deal with the 'bad guys' of the plant world. Weeds and invasive plant species, often labelled as 'unwanted plants', have far-reaching impacts on food security and environmental protection. These noxious plants cost the global economy billions of dollars each year. The cost of weeds to the Australian economy is over $4 billion per annum through reduced food production and expensive weed control practices. To better manage weeds, it is important to better understand them. Our research is focused on weed biology, invasion ecology and integrated weed management (IWM). The overarching goal of our research is to improve our understanding of weed biology and evolution to be able to develop sustainable management strategies. We study the ecological mechanisms driving weed adaptations to the changing climate, land use and management practices. Development of true IWM programs is at the core of our applied research.

Ali Bajwa with one of hundreds of weed species (*Gazania* spp.)

Tackling the 'Weeds–Climate Change' Nexus

Our Group has a strong focus on understanding and combating the confounding nexus between weeds and climate change. Climate change is not only increasing the number of weeds infesting natural and agro-ecosystems but also expanding the range of problematic weeds while making them more competitive and difficult-to-control. We are conducting cutting-edge, empirical research to understand adaptive mechanisms, especially phonological changes and their physiological and genetic bases in weed species exposed to different selection pressures. We study the individual and interactive impacts of key climate change elements, including high temperature, drought and elevated atmospheric carbon dioxide concentration on productivity, physiology, phenology, competition ability and reproductive output of problematic agricultural and environmental weeds. Our research also optimizes the existing chemical control options in the wake of a changing climate.

Understanding the Invasion Ecology and Competition Dynamics

Another major component of our research is understanding the invasion pathways, dispersal mechanisms and competition dynamics of weeds across different geo-climatic and land-use situations. We study how new weeds get introduced in novel environments, how they compete with the existing flora and what makes them so invasive. This work entails understanding the seed dispersal pathways, ecological and socio-economic impacts of weeds, functional traits as well as environmental and genetic factors enabling weed spread, establishment, and persistence. Empirical experimentation and modelling approaches are integrated to help understand the diverse interactions of weeds, host systems and management efforts.

Breaking the Dormancy

Seed dormancy is problematic trait many weeds possess making their management a very long-drawn task. We work to understand the physical, physiological, and genetic intricacies of this important phenomenon. Our research is exploring the levels of dormancy across different populations of many weeds and decoding ways to overcome dormancy. Efforts are also underway to explore the genetic control(s) of weed seed dormancy. We also study the effect of a range of environmental conditions such as light, temperature, moisture, and soil factors on seed germination dynamics of weeds. This helps us gain important insights into population dynamics and emergence timing of weeds that is crucial for developing strategic, timely weed management programs.

Systems Approach to Integrated Weed Management

The knowledge gained through our foundational research on weed biology, invasion ecology and weed evolution forms the basis of our strong applied research into developing IWM. We take a 'systems approach' to ecologically based weed management practices. We are optimising the current herbicide programs while incorporating innovative cultural or technological methods as feasible. This is all done in compatibility with agronomic, land-use or farming system practices.

Lab Head: Dr Ali Bajwa (A.Bajwa@latrobe.edu.au)
Lab members: Dr Babar Shahzad; Mr Muhammad Adnan; Mr Tyler Beale.

Fields of Study:
Weed Science; Invasion Ecology; Agronomy; Climate Change.

Capabilities and Techniques:
Seed biology and germination ecology; Farming systems & agronomy; Herbicide application and optimization; Plant stress physiology; Species distribution modelling; Climate-based weed invasion risk assessment; Genetic diversity; Metabolomics.

Translational Opportunities:
Crop productivity improvement; Resilient environment Biodiversity conservation.

Wildlife Conservation & Reproductive Endocrinology Lab

(Photo credit: Kerry Fanson)

The Wildlife Conservation and Reproductive Endocrinology Lab (WiCRE) is dedicated to advancing the understanding of endocrine function. Through our research, we strive to provide valuable insights about reproductive biology and stress physiology that will inform conservation strategies and enhance animal health and welfare.

WiCRE is one of the few labs in Australia that specializes in non-invasive hormone monitoring techniques. Using faeces, urine, and other biological samples, we can provide a window into animal physiology with minimal impact on the individual. These techniques are crucial for assessing the health and reproductive status of vulnerable or sensitive animals. We have developed and optimized non-invasive monitoring tools for a wide range of species.

WiCRE has a strong partnership with Zoos Victoria. We work with conservation biologists, ecologists, and medical researchers to bridge scientific knowledge with real-world impact.

Advancing reproductive physiology of Australian wildlife

Australia is facing an extinction crisis, endangering many of its unique species. To combat this, conservation breeding programs have been initiated. However, a significant hurdle is the lack of information about the reproductive biology of Australian species.

Our lab uses innovative, non-invasive hormone monitoring techniques to gain critical insights into the reproductive biology of threatened species in order to:

- Characterise reproductive physiology for priority conservation species
- Develop novel diagnostic tools to confirm and monitor pregnancy
- Analyse successful and unsuccessful breeders to identify causes of and potential treatments for reproductive dysfunction.

Stress and reproductive function

We are working to develop a more comprehensive understanding of how glucocorticoids influence reproductive function, with a particular focus on ovarian biology. By improving our understanding of how these hormones are involved in female reproduction, we hope to offer novel insights into causes of female infertility. Current projects in this area include:

- Mapping normative patterns of glucocorticoid expression across reproductive stages
- Examining changes in expression of glucocorticoid receptors in the ovary

Anthropogenic impacts

Human activities have substantially altered the environment and it is important to understand the impacts our actions have on wildlife. Our group investigates how environmental changes impact wildlife and why some species successfully adapt to these changes while others do not. Our group approaches this question from multiple perspectives, exploring questions such as:

- Do individual animals cope differently with anthropogenic stressors?
- What is the effect of artificial light at night on wildlife physiology?
- How do environmental pollutants disrupt endocrine signalling and reproductive physiology?

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

Lab members:
Dr Alica Dimovski, Andrea Bueno Pedraz, Thy Nguyen.

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

Capabilities and Techniques:
Non-invasive hormone monitoring; enzyme-immunoassays; behaviour assessments.

Translational Opportunities:
Understanding infertility in humans and animals and identifying potential treatments; enhancing success of conservation breeding programs; wildlife conservation; assessing human-animal interactions and implementing stress-reduction strategies to enhance welfare of captive animals; informing animal management policies.

School of Agriculture,
Biomedicine and Environment,
La Trobe University