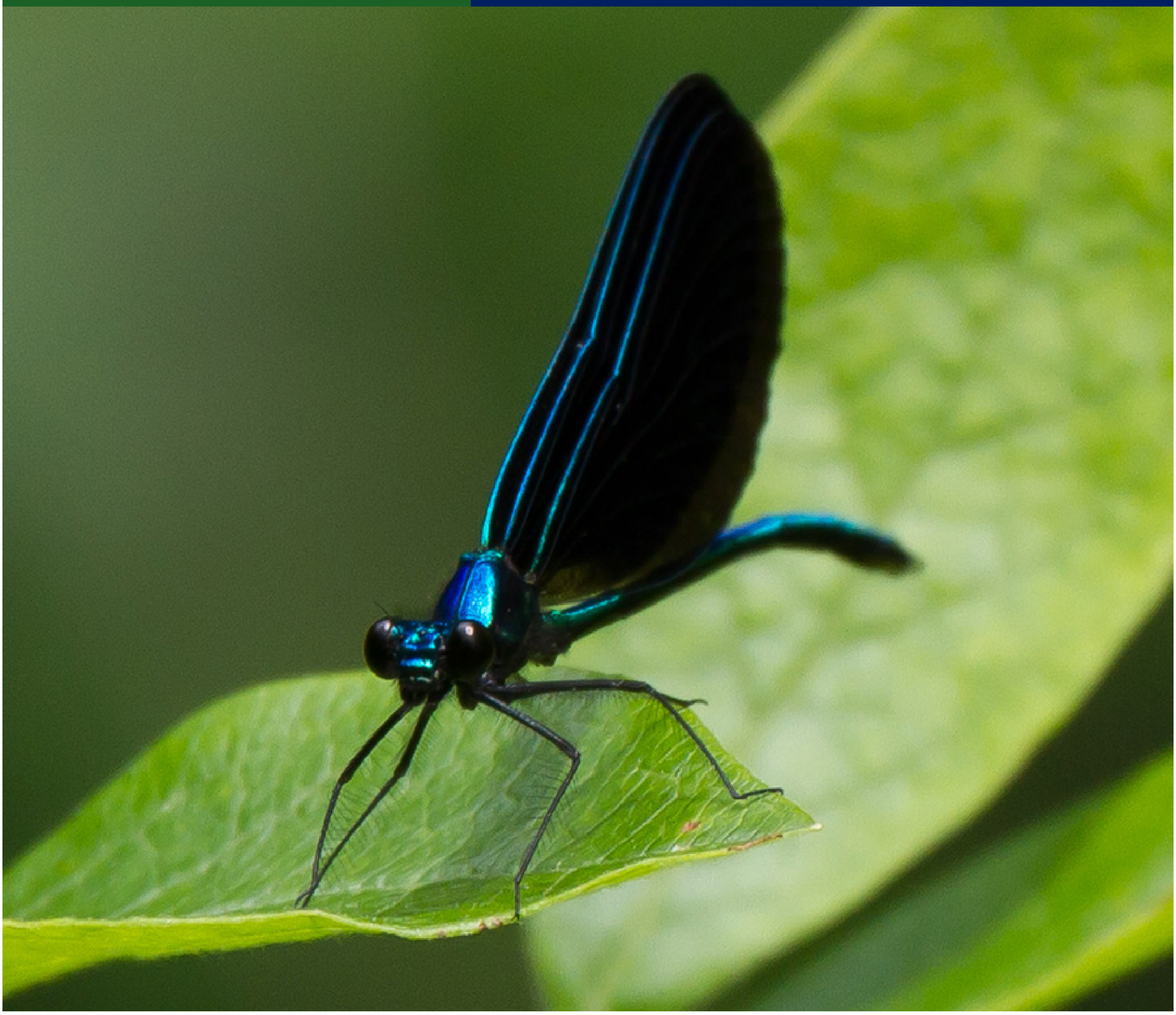
THE UNIVERSITY OF MELBOURNE

School of BioSciences

Faculty of Science

BioSciences Research Prospectus



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About the School

Our planet inspires us to understand how animals, plants, fungi, bacteria, and viruses work, how they evolve and how they interact. We are fascinated by the breadth and diversity of life and living systems from DNA to entire ecosystems, from a single molecule to the Amazon rainforest. We nurture the next generation of bioscientists and love sharing our passion for biology with young people and the community.

The School of BioSciences is a vibrant collective of academic and professional staff, as well as undergraduate and postgraduate students, and valued funders, collaborators, and alumni.

Our scholars and students explore questions of conservation and climate change, evolution and behaviour, genetics and development, marine biology, or plant biodiversity.

The School of BioSciences is a leader and participant in various collaborative centres, including the Australian government's Cooperative Research Centres (CRC) program which encourages collaborationbetween research institutions and industry, and Australian Research Council (ARC) Centres of Excellence.

The University of Melbourne's Faculty of Science acknowledges the Traditional Owners of the lands on which we work: the Wurundjeri Woi-Wurrung and Bunurong peoples (Burnley, Fishermans Bend, Parkville, Southbank and Werribee campuses), the Yorta Yorta Nation (Dookie and Shepparton campuses), and the Dja Dja Wurrung people (Creswick campus). We pay respect to their Elders, past and present. We also acknowledge and respect that Aboriginal and Torres Strait Islander people are this country's first scientists, with deep and enduring knowledge of the land, waters and skies.

Professor Margie Mayfield

Head of the School of BioSciences

Professor Margie Mayfield

- Community ecology
- Pollination
- Biodiversity conservation
- Plant functional ecology
- Restoration

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I am a plant community ecologist interested in how changes to the environment impacts plant and insect community structure and function. My work spans theoretical and applied questions about how biological diversity is maintained in general and in response to local to large scale environmental changes resulting from climate change, invasive species, urbanisation, agricultural intensification and restoration.

I am fundamentally interested in protecting biodiversity in a world dominated by human-caused environmental change. Much of our understanding of ecological systems is based on the study of "pristine" natural communities, not impacted by human activities. Over the last century the number of such "pristine" systems have declined dramatically and the modern state of most natural systems is one of constant disruption and change. Because the history of ecology focused on systems not impacted by human activities, we have a very limited understanding of natural communities, how they form, are maintained and change. I aim to improve this understanding through the development of new theory, and the study of specific environmental changes. Though my work focuses on plant and insect communities, the work I do is designed to expand our understanding of the mechanisms by which all natural communities change and are maintained in the modern world.

Most of my research falls into four related themes:
1) coexistence theory and diversity maintenance;
2) plant pollinator interactions;
3) functional ecology; and
4) ecological restoration.

I have worked in a wide range of natural systems during my career from rainforests in Costa Rica to crop fields in South Africa and India but my current research involves developing statistical tools in order to test ecological theory using the wildflower communities of SW Western Australia and Eucalyptus forests of Tasmania and Australia's east and south coasts.

I have several active research projects:

1. My ARC funded work currently aims to understand how facilitation - positive interactions (among plants and among plants and insects) alters coexistence of plant species and plant community diversity maintenance.
2. I am working with a Europe based global collaboration "Bug-net" assessing the impacts of invertebrate herbivores and pathogenic fungi on plant communities and ecosystems.
3. I am also working on understanding the responses of Australian Eucalyptus species to drought at different life stages, and how important community diversity is to drought responses.
4. Finally, I am involved in the development and assessment of forest restoration experiments, one in SE Queensland and the other in South Australia

Professor Mayfield in Perenjori Reserve Western Australia.

Professor Alex Andrianopoulos

Professor Alex Andrianopoulos

- Gene regulation
- Development and differentiation
- Human pathogen
- Fungal genetics
- Host-pathogen genomics

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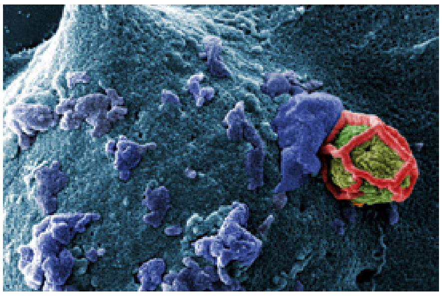
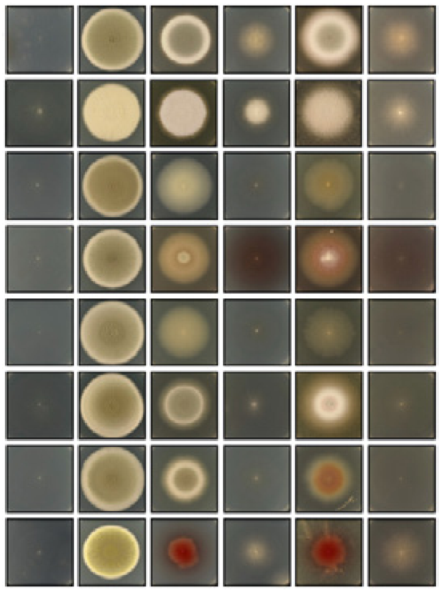
My research is focused on understanding fundamental molecular mechanisms of how genes are controlled and applying that understanding to controlling and combatting fungal diseases, as well as developing new or improved applications for the use of fungi in biotechnology.

Fungi are everywhere. They are the major recyclers of waste — from the backyard composite bin to the forest floor — are in the air and are both on and in our bodies. They are important for food, chemical and pharmaceutical production and are being developed as building products. However, some fungi are also pathogens that infect and kill many plants and animals, including humans. Infectious diseases are a major health burden in society leading to morbidity, mortality and immense health care costs. Amongst all the infectious diseases, fungi are the hidden killers. Fungal infections affect about 25% of the world's population, with mortality rates often higher than 50% and death rates over 1.5 million people a year. The increasing incidence of invasive fungal infections over the last few decades has followed the increasing population of immunocompromised individuals due to AIDS, immunosuppressive drug treatments for transplant recipients, anti-cancer chemotherapy treatments, prolonged antibiotic therapy, and other factors such as steroid use in COVID-19 recovery. The high mortality rate is a consequence of many factors, including our poor understanding of these pathogens, the lack of rapid and reliable diagnostics and a very limited arsenal of effective antifungal drugs. Using an array of genetic and genomic approaches, the research in the lab aims to understand how fungi infect humans, get around the immune defence systems and cause disease.

Both pathogenic and non-pathogenic fungi, like all organisms, respond to their environment. These responses can be transient, allowing for rapid adaptation to changing conditions, or permanent, as in the case of development. Responding to external and internal signals, which is fundamental to all life, involves detecting these signals and responding with changes in gene expression. Understanding how cells and organisms control their responses to these signals is another key area of research in the lab. Using fungi as the model organism, the work is focused on how genes control these responses and how these controlling genes are themselves controlled. The research is of basic biological importance but also has implications in understanding and treating disease, and improving biotechnological processes that use fungi that are important in industry and have direct economic impacts as pathogens.



Macrophage engulfing a fungal spore.



Growth of various mutants under different conditions.

Dr Edith Arndt

Dr Edith Arndt

- Biosecurity risk management
- Alpine biogeochemistry
- Monitoring

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My research expertise is in soil biogeochemistry of alpine and sub-alpine ecosystems in Australia and Austria, and my focus is biosecurity risk analysis.

My project experience includes optimising resource allocation into risk controls, reviewing factors influencing marine vessel biofouling, and developing a performance evaluation framework for the Australian biosecurity system.

I am also interested in how temperature and fire influence alpine soil biogeochemistry, including soil microbial communities.

Dr John Baumgartner

Dr John Baumgartner

- Biosecurity
- Computation
- Modelling

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I am interested in the effects of environmental change on biodiversity and biosecurity, and deeply invested in research with real-world impact. My work blends technology and environmental science.

As an expert in quantitative ecology and spatiotemporal ecological modelling, I create software tools to tackle research questions in biosecurity and collaborate with government stakeholders to create computational solutions for biosecurity issues.

Dr Simon Baxter

Dr Simon Baxter

- Genetics
- Biosecurity
- Entomology
- Evolutionary biology

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I aim to develop sustainable solutions for pest management using genetic approaches.

Controlling invasive fruit fly in Australia

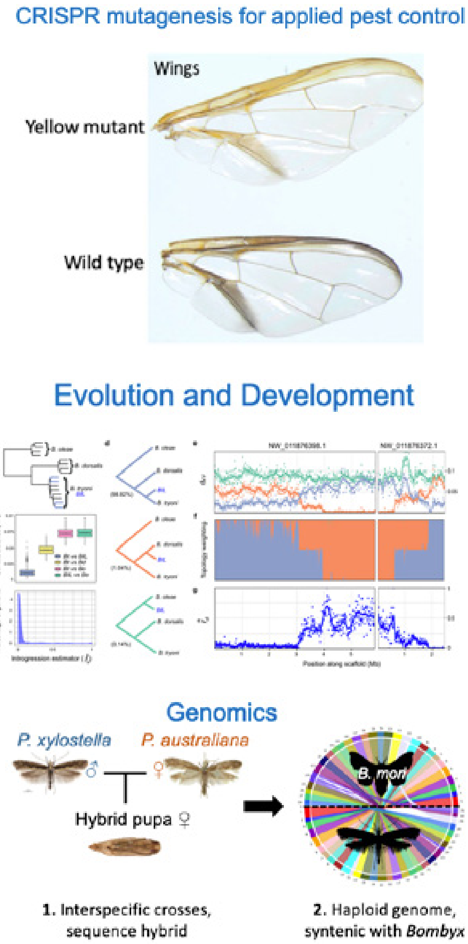
Releasing sterile male insects into the environment on a massive scale can reduce and eradicate insect pests through an approach called the sterile insect technique (SIT). Sterile males seek out and mate with wild females, who can't lay fertile eggs, causing the population to rapidly decline. We're actively working with research partners (University of Adelaide, Macquarie University) to develop improved SIT factory strains of Queensland Fruit Fly, which is an oppressive and persistent burden to the horticultural industry. Separating males from females in the factories is an ongoing challenge we're trying to solve by making genetic sexing strains that enable males to be mechanically sorted from females based on pupae colour, or through heat sensitivity genes that conditionally kill females. We're also introducing visible markers to flies in the laboratory to make it simple to distinguish our sterile flies from wild ones.

Insecticide resistance

Insecticides are the frontline defence many farmers use to control crop pests, yet the way in which they kill is often poorly understood. We're working with natural bacterial toxins produced by Bacillus bacteria (Bt) that target and kill specific pests (including the diamondback moth), to understand how they work and why they are harmless to so many beneficial insects. This work has led us to focus on insect ion transporters, aquaporin water channels, and cellular pathways involving cell death. Sometimes mutations can arise in the insect genomes, causing insects to become resistant to toxins or chemicals. Genetic and genomic approaches have enabled us to understand how resistance to Bt toxins and diamide insecticides in particular can evolve in the field, and we're trying to develop kits for early detection of resistance.

Gene drives and genomics

Gene drives are selfish genetic elements passed on to offspring at rates much higher than expected by chance. We're collaborating with other research groups to overcome some major challenges associated with developing synthetic gene drives. This laboratory-based research has the potential to impose a fitness cost or benefit to a population and therefore may have applied outcomes in the future.



Research projects.

Plutella xylostella, the diamondback moth, is the most destructive pest of brassica crops (cabbage, canola) worldwide.

Dr Michael Bayly

Dr Michael Bayly

- Genetics
- Biosecurity
- Entomology
- Evolutionary biology

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My mission is to improve understanding of the diversity of the Australasian flora so that this knowledge can underpin its conservation, management and utilisation.

I work on the diversity, evolution, classification and biogeography of Australasian flora, with particular emphasis on flowering plants and ferns. This research relies heavily on genetic markers and generally involves field work, molecular lab work, comparisons of plant morphology and use of herbarium specimens. It provides fundamental data on genetic variation in native plants to test and refine their naming and classification.

This knowledge of plant taxonomy and relationships underpins the management and conservation of biodiversity because it defines the units (species, subspecies, areas of genetic diversity) that are the objects of management.

Flowers of Philotheca pungens.

The SABRE experiment and its component.
Sabre is 4 m high and 4 m wide.

Dr Joanne Birch

Dr Joanne Birch

- Tree of life
- Evolution of the Australian biota
- Southern hemisphere biogeography
- Plant taxonomy

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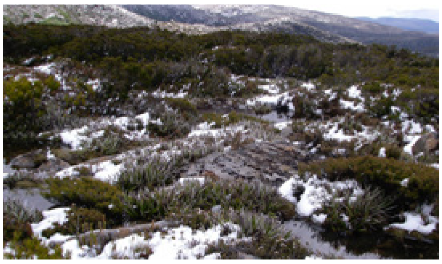
In the Plant Systematics Research Group we aim to describe and understand large scale patterns of evolution within the Australasian flora (plants) and fauna (fungi). Our research investigates possible explanations for patterns in the distributions of diversity. Our research informs descriptions and distribution mapping of the plants and fungi for the flora of Australia.

Plant evolution

We reconstruct the tree of life for native Australasian lineages using genetic and genomic data, estimating the timing of plant diversifications using molecular dating techniques. We use morphological and genetic data to distinguish species so that they can be accurately identified in the field.

Plant biogeography

Our research investigates how distributions of extant taxa have been shaped by evolutionary processes over time, particularly focusing on lineages with distributions in the Southern Hemisphere. We are interested in identifying traits that have enabled Australian taxa to adapt to changing climatic conditions and habitat availability during the Tertiary Period.



Alpine herbland dominated by Astelia alpina (Asteliaceae) in Mount Field National Park, Tasmania.

Caesia parviflora (Asphodelaceae) flowers. Image credit: A.Webb.

Professor Linda Blackall

Professor Linda Blackall

- Microbiology
- Phylogeny
- Symbioses
- Wastewater
- Environment

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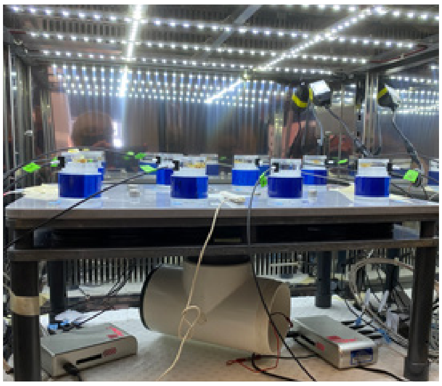
I study anything microbiological. I am fascinated by microbes since they rule Earth and have done so for 3.5 billion years. Microbes control all biogeochemical cycles and facilitate the persistence of all of life on Earth.

I am a microbiologist who has pioneered and championed procedures that reveal microbes and their functions in many natural and engineered systems. I have been instrumental in discovering microbial contributions to practical aspects of water (eg algal blooms on the Darling River), wastewater and solid-waste treatment, which have led to improvements in treatment and energy savings. My work with host-associated microbes has substantially explained animal conditions, including equine and ruminant gut upsets and microbes involved in coral larval settlement and bleaching.

I have extensively trained non-microbial professionals in new microbial procedures to facilitate industry upskilling and founded collaborations with arts-science experts to disseminate microbial knowledge via children's books.



A respirometer for measuring oxygen production or utilisation. Photosynthetically generated oxygen by animals (eg corals, anemones) containing photosynthetic algae is measured under light conditions (see lots of lights).

Sampling for cyanobacterial bloom material following the fish kills in 2019 in the Darling River at Menindee, NSW.

Associate Professor Anthony Boxshall

Associate Professor Anthony Boxshall

- Marine ecology
- Environmental impacts

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I focus on enabling and enhancing transfer of environmental science knowledge to decision-makers, environmental monitoring, pollution detection, and community involvement in marine and coastal adaptation to climate change.

I am a Melbourne Enterprise Fellow. Among other initiatives, I am involved in the Centre for Anthropogenic Pollution Impact and Management and the National Centre for Coasts and Climate Change.

Dr Richard Bradhurst

Dr Richard Bradhurst

- Computational epidemiology
- Agent-based modelling
- Biosecurity

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I develop advanced computational models of animal disease emergencies that assist animal health authorities to plan and prepare for outbreaks.

I work closely with the Australian Department of Agriculture, Fisheries and Forestry, the Food and Agricultural Organisation of the United Nations, and animal health authorities in New Zealand, Canada, the USA, and across Europe.

Dr Elizabeth Bromfield

Dr Elizabeth Bromfield

- Reproductive health
- Cellular homeostasis
- Ageing

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I am a reproductive biologist interested in cellular homeostasis and redox biology. My expertise includes germ cell biology, fertilisation, reproductive health, contraceptive development, medically assisted reproduction, and ageing. I use lipidomic and proteomic strategies to better understand germ cell development and responses to environmental oxidative stress.

My research group examines connections between reproductive health and body-wide health to improve early detection of diseases, and to design strategies that enhance cellular defences against oxidative stress to prevent infertility. We use mouse transgenic models and human clinical samples to study lipid and protein biochemistry, protein-protein interactions, the formation of cytotoxic protein aggregates, and reactive oxygen species.

Dr James Camac

Dr James Camac

- Biosecurity
- Data science
- Quantitative ecology

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I aim to (i) understand and forecast impacts of climate change and changing fire regimes on biodiversity, and (ii) enhance post-border surveillance networks to protect Australia's environmental, social, and economic capital from exotic pests and diseases.

As a trained quantitative and applied ecologist, I have extensive experience in field ecology, long-term ecological monitoring, experimental design, ecological statistics, reproducible data science, biosecurity risk analysis and project management.

I am a Senior Research Fellow and Chief Investigator within the Centre of Excellence for Biosecurity Risk Analysis, and Associate Editor for The Australian Journal of Botany.

Associate Professor Richard de Rozario

Associate Professor Richard de Rozario

- Computer Science
- Artificial Intelligence

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I model, design, and evaluate socio-technical information systems. I focus on systems of collaborative and AI-based analysis in risk and intelligence, especially the quality, value, and defensibility of information.

Previously, I modelled extreme operational risk scenarios such as natural disasters, cybercrime, and class actions in the finance industry.

Associate Professor Andrew Drinnan

Associate Professor Andrew Drinnan

- Plant evolution
- Palaeobotany
- Plant morphology

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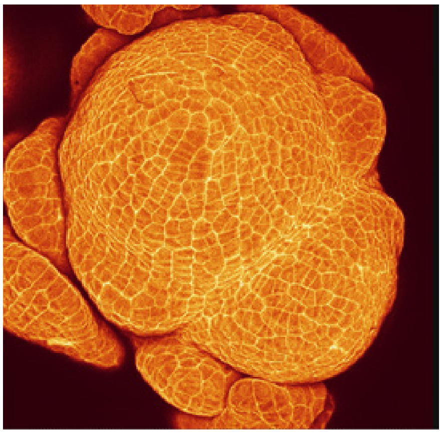
I investigate the fundamental bases of the evolution of plant structure and form.

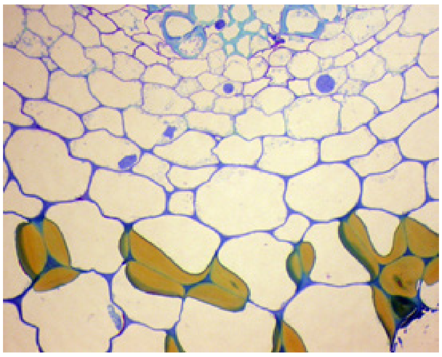
My research group investigates the embryology and development of all land plants – from liverworts to flowering plants – to build a consistent model of plant architecture and evolution that enables more meaningful comparison of morphologically diverse plants.

We test phylogenetic hypotheses by using light microscopy, scanning electron microscopy, and laser scanning confocal microscopy to study vegetative and reproductive morphology. This includes the cellular configuration of shoot apices, cell divisions leading to stem segments and leaf initiation, and branch, flower and root development.

The lycopod Huperzia squarrosa.



Confocal microscope image of lycopod apical meristem.



Cells of a fork-fern stem with distinctive cell wall thickenings.

Professor Mark Elgar

Professor Mark Elgar

- Mating behaviour
- Social behaviour
- Chemical communication
- Insects
- Spiders

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My research contributes to understanding how the evolution of biological adaptations are shaped by natural and sexual selection.

Chemical communication

My research aims to understand how biotic and abiotic factors influence chemical communication and thus shape receptor (antennae) morphology in insects. We address these questions in diverse systems, including reproductive behaviour, social systems, and inter-specific associations, typically of insects and spiders. Our methods include inter-specific comparative analyses, field and laboratory experiments, chemical analyses, and various modelling techniques. Pheromones, like other organic compounds, are degraded by ozone, UV light, and radicals.

While we know that pheromone plumes attenuate through the dispersal of molecules, the additional impact of pheromone degradation is poorly understood. Thus, one focus of our research is to highlight the significance of odour survival for insect chemical communication by examining how atmospheric conditions, including air pollution, affects signal integrity, antennal morphology and signal perception.

Collective signalling in meat ants: hundreds of ants deployed each, every day, for what purpose?

The spider Saccadomous formivorous builds this remarkable web, which retains its structural integrity without support, to capture ants.

Beetles also have beautiful antennae.

Dr Nancy Endersby-Harshman

Dr Nancy Endersby-Harshman

- Insecticide resistance
- Aedes mosquitoes
- Wolbachia
- Sodium channel
- Population genetics

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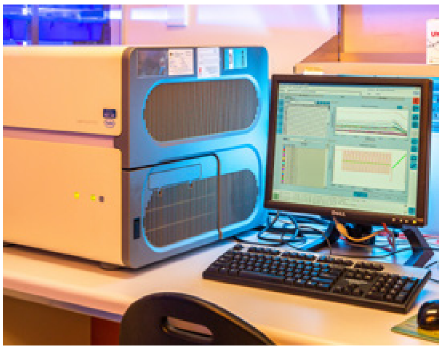
Transmitted between people by mosquitos, the dengue virus causes an influenza-like illness. I aim to understand the population structure, invasion history, and insecticide resistance of dengue vector mosquitoes in different regions of the world to inform dengue control programs involving the Wolbachia bacterium.

Reducing dengue transmission by releasing Wolbachia-infected mosquitoes

As demonstrated by trials in north Queensland and Malaysia, we can reduce dengue cases by replacing wild mosquito populations with mosquitos that cannot transmit dengue due to infection with Wolbachia bacteria.

I conduct stress tests on mosquitos carrying different Wolbachia strains to determine the fittest mosquitoes for various release sites (subtropics, tropics, arid desert). I test their responses to temperature, desiccation, antibiotics and insecticides to develop quality control protocols that improve the survival of released mosquitos.

My focus is on comparing the insecticide resistance of released mosquitoes to those reared in the laboratory for release. I'm also using genomic data from mosquito populations to investigate whether resistance mutations arise through local selection or by invasion of resistant mosquitoes. I aim to include more Australian species of mosquitoes involved in arbovirus transmission.



Real-time PCR assays for Wolbachia detection.

Preparing mosquitoes for insecticide resistance mutation screening.

Dr Alexandre Fournier-Level

Dr Alexandre Fournier-Level

- Genomics
- Quantitative genetics
- Adaptation
- Weed
- Biosecurity

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Natural ecosystems are degrading at a dramatic pace, and this is primarily due to the consequence of anthropogenic climate change and widespread land degradation. Our research focuses on finding the DNA markers of ecosystems' vulnerability or resilience across multiple plant species.

We combine experimental and computational approaches to study the effect of environmental variation and stress on natural population. We use a range experimental models (Arabidopsis, Drosophila, ryegrass) to test hypotheses related to climate change and pesticide exposure.

Climate change-proof population management

Active population management will be increasingly indispensable to mitigate the effect of human perturbation. However, the perfect management scheme, either to restore or suppress a species, is yet to be designed. In particular, we are interested in using genomics tools to make sure the restoration will be successful, retains a maximum of genetic diversity and is climate change-proof.

Controlling pests and weeds

The emergence of pesticide resistance is evolution in action. Weed populations in Australia have been particularly good at emerging resistance to all the chemicals they have been exposed to, providing a fascinating model for the study of evolution to a well-defined selective agent.

Genomics of native Australian fruits

Australia is a megadiverse country and hosts a large amount of plants with immense potential benefits for medicine and agriculture. Unfortunately, native fruits have rarely been considered crops and their potential remains largely untapped. With emerging genome technology, we aim to fill the gap so that native fruits can represent a sustainable alternative to conventional crops.

Experimental evolution in response to high temperature.

Ryegrass infestation is the major cause of yield loss in Australian cropping systems.

Dr Stephen Frankenberg

Dr Stephen Frankenberg

- Development
- Reproduction
- Genomics
- Marsupials
- Synthetic biology

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My laboratory aims to understand many aspects of marsupial reproduction and development, partly in appreciation of their position in mammalian evolution and partly to develop technologies that will enhance their future conservation. Additionally, we are developing synthetic biology strategies for both marsupial conservation and for eliminating invasive vertebrate pest populations that threaten much of Australia's native fauna.

Early development, reproduction and stem cell biology of the fat-tailed dunnart (in collaboration with Professor Andrew Pask's laboratory)

Early development of marsupials contrasts markedly from that of eutherian ('placental') mammals in many fundamental aspects that reflect their early branching within the mammalian evolutionary tree.

Our research uses methods such as gene expression analysis and cell culture to examine the regulation of pluripotency and development of the germline in marsupials. We use a small dasyurid marsupial — the fat-tailed dunnart — as a model, since it offers similar advantages to the laboratory mouse by being small and easy to breed in captivity. While our research aims to develop the dunnart as a genetically manipulable marsupial model, it also has the potential for applications in conservation of threatened marsupial species, such as by restoring genetic diversity from cryopreserved cell lines.

The potential for gene editing to protect the northern quoll from cane toad toxin (in collaboration with Professor Andrew Pask's laboratory)

Northern quoll populations have declined markedly due to predation on the introduced cane toad. Outside Australia, natural predators of bufonid toads (including cane toads) are resistant to their toxin due to known sequence differences in genes encoding certain isoforms of the alpha subunit of Na/K-ATPase. We are investigating whether introducing these sequence changes will confer bufotoxin resistance in our marsupial model, the fat-tailed dunnart, and thus whether a similar edit will protect northern quolls from further population declines due to cane toad predation.

Genetic biocontrol (in collaboration with Dr Patricia Jusuf's laboratory)

Numerous introduced pest species in Australia threaten native species and reduce agricultural productivity. Recently developed gene drive technology could allow humane, targeted elimination of almost any vertebrate pest population. Our research aims to use the zebrafish as a model for optimising the design of gene drives in any vertebrate, including mammals, fishes and cane toads. We are also optimising gene editing methods in two target species — cane toads and European carp — to facilitate future production of suppression gene drives for these two species.

Cane toad, northern quoll and fat-tailed dunnart.

Invasive populations of numerous vertebrate species severely impact Australia's natural ecosystems.

Dr John Golz

Dr John Golz

- Seed development
- Seed size control
- Plant development
- Plant genetics

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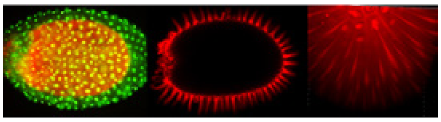
Seeds are a major source of food for a large portion of the planet's inhabitants — hence understanding how seeds develop, particularly the factors that influence the size and shape of seeds, is of fundamental importance. My research addresses a fundamental question in seed biology: how does an embryo within the seed develop and what are the genetic factors that govern final seed size? We aim to use knowledge gained from our studies to improve crop yields by altering the size and shape of seeds.



Images of seeds from the model plant Arabidopsis. Left image: activity of a gene in the seed coat of the developing seed. Middle image: staining of the mature seed following exposure to water revealing structures of the seed coat. Right image: close-up of cellular structures that arise when Arabidopsis seeds are placed in water.

Embryo formation during seed development

The formation of specific cell types during plant embryogenesis depends on the generation of precise spatial patterns of gene expression. How these gene expression patterns are established remains poorly understood and hence is of major biological interest. My research group aims to identify new pathways involved in gene regulation and show how these are involved in establishing cell identity during the early stages of embryogenesis. Our work involves using a range of genetic, genomic, molecular and cell biological approaches.

Image of an embryo arising in seeds of the model plant Arabidopsis showing activity of a gene in the developing embryonic leaves.

Seed size control

Seed size is a major driver of plant yield, and yet the genetic pathways regulating seed size are poorly described. In partnership with international colleagues, my group is investigating the mechanisms that control seed size by focusing on the role played by the seed coat in regulating seed growth. Achieving a better understanding of seed size control will enable us to use this knowledge to potentially improve crop yields.

Plant transformation technologies

In collaboration with colleagues in the School of BioSciences, my research group is looking at developing or improving genetic transformation technologies for crops such as canola and chia. Being able to quickly and cheaply generate transgenic plants will enable the agricultural industry to use gene-editing technologies to develop crops that have superior nutritional qualities, as well as be better able to withstand changing climate and the emergence of new pathogens.

Dr Dean Goodman

Dr Dean Goodman

- Malaria
- Transmission
- Evolution
- Drug resistance

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I aim to apply understanding of biology, genetics, metabolism, and evolution to eliminate malaria.

Control of life-stage transitions in malaria parasites

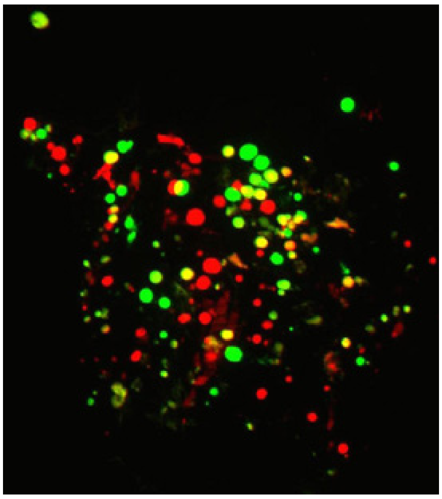
Using human and rodent malaria models, I am investigating how gene expression and splicing control the development of malaria parasites as they are transmitted via the mosquito vector.

Development and transmission of drug resistance

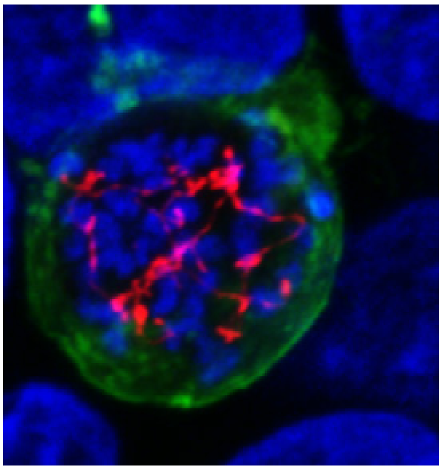
I use human and rodent malaria models to uncover new mechanisms of drug resistance and describe their impact on parasite biology and resistance spread through parasite populations.

Drug treatment during malaria transmission

I am investigating the basic biology and metabolism of the malaria parasite as it develops in the mosquito and identifying new compounds and delivery mechanisms to block malaria transmission by killing the parasite in the mosquito vector.



Mosquito stage parasites (oocysts) from a cross of two fluorescently labelled parasite strains.



Malaria parasite during liver stages showing nuclei and internal organelles.

Associate Professor Mark Green

Associate Professor Mark Green

- Reproductive biology
- Fertility
- Sex ratio

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I focus on how environmental factors – endocrine disruptors (PFAS and atrazine), light pollution and heat stress – and reproductive technologies affect fertility. Specifically, I focus on how these factors affect eggs, sperm and the development and metabolism of the early embryo, as well as the long-term health of subsequent generations.

My research involves humans, cattle, pigs, birds, rodents, and invertebrates. I am currently working on establishment and validation of the 'exposome' (the environmental exposures that an individual encounters throughout life) as a prognostic predictor of female fertility, as well as using male fertility as a biomarker of health to understand the biological effects of PFAS.

Dr Lara Grollo

Dr Lara Grollo

- Biotechnology
- STEM education
- Higher education
- Student engagement
- Meaningful learning

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I aim to use meaningful learning and educational research to improve student academic success, employability and improve student engagement in STEM higher education.

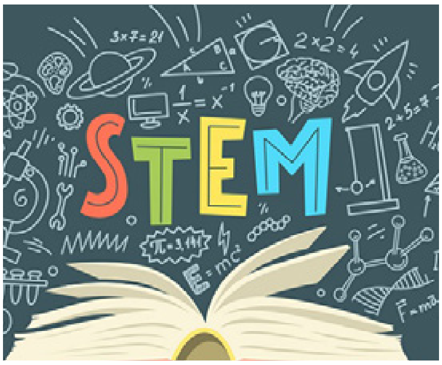
Meaningful learning is the interaction between a student's past knowledge and the new information they are attempting to learn, and focusing on this is key to improving student engagement in higher education. My research focuses on the use of meaningful learning in Biosciences undergraduate and postgraduate education. I study the way in which learning by doing and the use of real-world contexts can assist students understanding of complex ideas within Biology and Biotechnology.

I am currently working on several projects within the School of Biosciences and in collaboration with the Melbourne School of Graduate Education to investigate meaningful learning in different student cohorts at the University of Melbourne.

My projects include:

- Industry Perspectives on Project-Based Learning as a Form of Work-Integrated Learning in Science
- Comparing the Impact of Medically Relevant Contexts on the Learning of Biology Higher Education Students Who Have Different Prior Levels and Experiences of Biology Learning
- Enhancing Conceptual Understanding of Biotechnology: A Study on the Efficacy of practical Applications and Hands-on Experiments
- Making the best of a bad situation: Using COVID as a teaching opportunity.

These projects aim to determine if students see meaningful learning as beneficial and whether integration of meaningful learning strategies can improve academic success and employability.



STEM education research.

Medical microbiology.

Associate Professor Anca Hanea

Associate Professor Anca Hanea

- Uncertainty quantification
- Probabilistic risk and decision analysis
- Structured expert judgment

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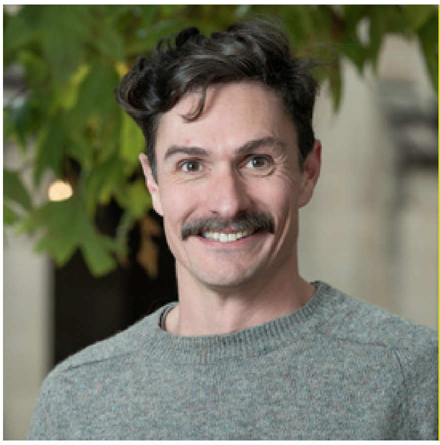
My research in applied mathematics covers three main, interrelated themes: risk and decision modelling, structured expert judgement, and the theory behind the methodologies used by the former two.

The application areas for these themes are biosecurity, ecology, engineering, and replicability of science.

Dr Mike Haydon



Dr Mike Haydon

- Circadian rhythms
- Metabolism
- Nutrition
- Signalling
- Plant science

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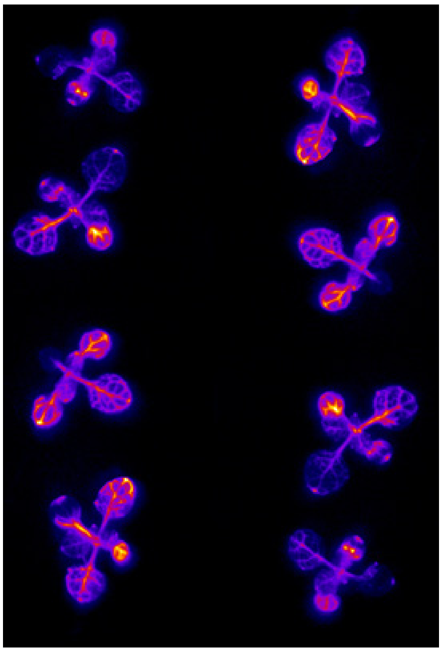
Plants rely on circadian clocks to integrate daily and seasonal environmental cues to coordinate growth, physiology and metabolism. A mismatch between the circadian clock and the local environment is detrimental to growth and fitness. Optimisation of circadian clocks in crops for new environments can contribute to enhanced food production.

Plant circadian rhythms

The circadian system is a biological time-keeper comprised of inputs (light, temperature, stress), an oscillator (a gene regulatory network) and outputs (physiology, metabolism, development). It influences almost all aspects of the plant and allows them to anticipate daily changes in the environment and adapt to seasonal conditions. Our main interest is to define the roles of metabolism and nutrition within the plant circadian system. We consider mechanisms of gene transcription, translation and post-translational control that influence circadian rhythms. Our research aims to make advances to understand fundamental aspects of plant cell biology, and also generate opportunities to develop crops or agricultural practices that match specific growth environments.



Watching the clock. A circadian clock gene driving a firefly luciferase reporter in Arabidopsis seedlings.

Metabolic signals in the circadian system

Sugars, which are the major product of photosynthesis, adjust circadian rhythms by modifying clock gene expression and protein levels. We use the regulation of the circadian system by sugars to define mechanisms of dynamic metabolic signalling in plant cells, and transcriptomics and chemical biology to reveal these metabolic signals. We are currently investigating how sugars generate these signals, and how they control gene expression.

Circadian control of leaf senescence and seed nutrition

Leaf senescence is a controlled developmental process which drives nutrient remobilisation in ageing leaves according to seasonal cues. Ethylene is a plant hormone that controls plant development, promotes leaf senescence and can adjust circadian rhythms in plants. We are investigating the mechanism by which ethylene affects circadian rhythms and the impact on leaf senescence and seed nutrition.

Dr Sean Haythorne

Dr Sean Haythorne

- Geospatial
- Biosecurity
- Ecological modelling

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I am a multidisciplinary researcher and educator with a background in computer science and ecological modelling. I have developed biological computational modelling solutions in collaboration with researchers at the University of Adelaide.

As a Research Software Engineer at the Centre of Excellence for Biosecurity Risk Analysis, I am helping to develop cloud-based software tools for biosecurity research and operations via the EcoCommons and Biosecurity Commons projects.

Associate Professor Alexander Idnurm

Associate Professor Alexander Idnurm

- Mycology
- Genetics
- Diseases
- Biodiversity

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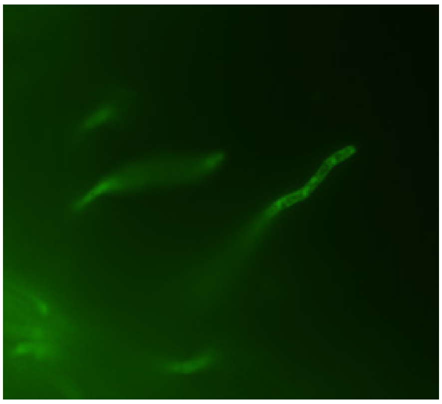
We are doing research to provide a more secure planet for all people and the environment. A better understanding of how organisms can attack other organisms should provide new strategies for protection, which has wide implications for the deleterious impacts that fungi can have in plant disease, human health and degradation of products.

Our research focuses on the biology of fungi and aims to discover the genes found in these diverse organisms that enable them to cause diseases in plants and animals. The fungi are one of the most diverse groups of organisms on the planet, and while our focus is primarily on those that cause problems, other fungi are highly beneficial to humans as sources of food or pharmaceuticals. Research in the Parkville campus laboratory uses a full spectrum of approaches, from classical genetics and mapping through to genomics, gene editing and other molecular biology approaches.

Our strong partnerships with others, particularly at Grains Innovation Park in Horsham, complement the plant pathology aspects with field studies. Specific aspects of the research in cases are orientated around specific fungi or problems (eg blackleg disease of canola, cryptococcosis in humans) but often intersect through comparative approaches to explore fundamental aspects or emerging concepts in biology.

Blackleg lesions on canola caused by Leptosphaeria maculans.



Neopseudocercosporella capsellae, agent of white leaf spot of canola, expressing green fluorescent protein.

Professor Gregory Jenkins

Professor Gregory Jenkins

- Genomics
- Quantitative genetics
- Adaptation
- Weed
- Biosecurity

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My mission is to undertake novel research that advances our understanding of aquatic environments. The aim of this research is to support the rational and ecologically sustainable use of marine resources. I aim to make a substantial contribution to research that can help resolve issues in the marine environment that are significant to broader society.

Fish ecology and the relationship between fish and the environment

I conduct research on a wide variety of topics related to the ecology of fish in marine, estuarine and freshwater systems. These topics include larval dispersal, recruitment of young, movement and migration, feeding and growth, and relationships with habitat (eg seagrass, mangrove, algae, reefs). Studies are focused mainly on important fishery species in marine and estuarine waters and the factors that influence fluctuations in the populations.

A variety of tools are used to conduct this research, in particular the chemistry and structure of fish otoliths (ear bones) that can provide information on age, growth, recruitment, movement and migration. Other tools include various methods of tagging to study movement and migration. Computer modelling is used to study the patterns of larval dispersal of fish.

Detailed studies are also conducted on the environment that influences fish. These include food chain impacts such as the input of nutrients to the marine environment and subsequent plankton productivity through the food chain to fish. This research involves the application of ecosystem modelling, supported by field studies on phytoplankton and zooplankton. Detailed studies are also conducted on key habitats for fish, in particular the biology of seagrass and factors that influence growth and cover.

Associate Professor Alex Johnson

Associate Professor Alex Johnson

- Nutrition
- Functional food
- Climate change

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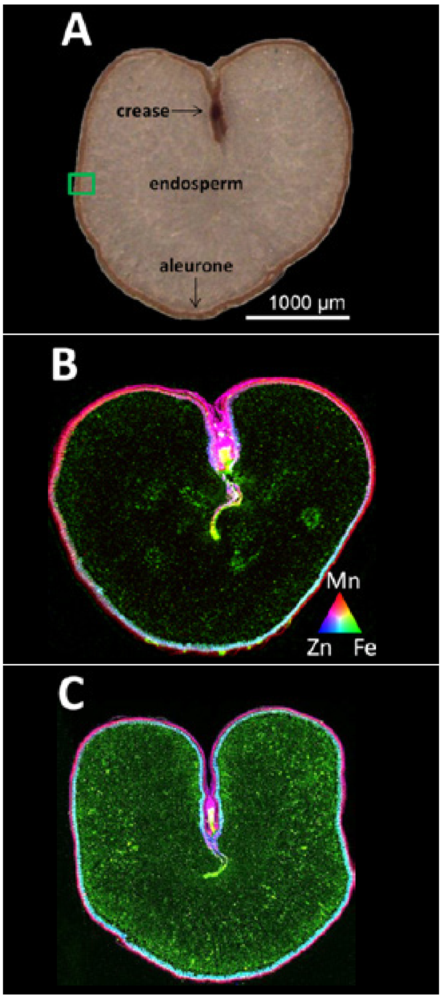
Designing more nutritious crops to better feed the world.

Plant nutrition and biofortification

My research group investigates nutrient metabolism in plants with the aim of producing 'biofortified' crops that improve human nutrition. We are particularly interested in iron and zinc because many of the world's most important food crops contain low amounts of these essential micronutrients, and more than two billion people suffer from iron and zinc deficiencies.

Our research focuses on how plants absorb nutrients as well as the factors affecting nutrient bioavailability in edible parts of plants. We are also interested in understanding the nutrient decreases that occur in cereal crops under elevated atmospheric carbon dioxide and determining if certain biofortification strategies can counteract these decreases.

Biofortified rice grows as well as conventional rice in the field.



A biofortified wheat grain, pictured in panel C, has two-fold more iron (Fe) and zinc (Zn) than a conventional wheat grain (panel B).

Associate Professor Theresa Jones

Associate Professor Theresa Jones

- Urban light pollution
- Behaviour
- Life histories
- Evolution

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My work is cross-disciplinary and will aid our understanding of the long-term evolutionary impact of artificial light at night. The data will be of significance and provide much-needed data for a wide range of stakeholders involved in the areas of urban planning and biodiversity monitoring, including government agencies, the lighting industry and the wider public. It will increase the profile of Australia in the burgeoning field of ecological light pollution and create an outstanding international networking and research platform.

The lights from Melbourne as seen from 60km away at Serendip Sanctuary. Image: Joanna Durrant.

My main area of research is in the field of behavioural ecology, with a particular focus on the impact of artificial night lighting on individual fitness and community structure. Since the introduction of electrical street lighting, many species live in environments with no period of 'true darkness'. Scattered light from urban areas may extend beyond city boundaries, resulting in regions that have no street lighting but that are still exposed to unnaturally long periods of light. Accumulating evidence suggests that such 'urban light pollution' has catastrophic health implications for all species (including humans) and puts ecosystem function at risk. To date, the mechanism underlying this remains unconfirmed.

One of our current aims is to investigate whether artificial light at night drives evolutionary change using a combination of field observations, laboratory experiments and advanced genetic techniques. This is a multi-disciplinary study involving several masters and PhD students that will provide a significant advancement in the understanding of the impact of light at night for animals and will enhance our capacity to predict the outcome of future urban expansions for all species. The outcomes will have broad implications for estimating the future biodiversity and health of our urban areas and will benefit both globally and within Australia by providing much-needed data regarding the likely resilience of species currently residing in our major cities.

Dr Patricia Jusuf

Dr Patricia Jusuf

- Developmental neuroscience
- Regenerative neuroscience
- Visual disease modelling
- Zebrafish phenotype pipeline

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The brain is one of the most complex organs in the human body, composed of over 80 billion nerve cells that need to be made, specialised, and connected correctly for the brain and associated central nervous system organs to function properly. In the Neural Development and Regeneration lab, we study how the nerve cells in the central nervous system are normally correctly generated, what exactly goes wrong when specific genes are not functioning correctly, and what can be learnt from related, highly regenerative animals that might help us to allow missing, damaged or lost human nerve cells to regenerate.

Development of the central nervous system

As an extension of the central nervous system, the retinal nerve cell sheet in the eye of all vertebrates contains the same types of nerve cells as, for example, the brain and spinal cord. By taking advantage of the rapid development of the genetic zebrafish vertebrate animal model, we can easily combine functional gene manipulation with phenotypic analysis using live imaging and fixed tissue to understand how individual genes affect the development of nerve cells, their gene expression, their anatomical connections and, ultimately, their function.

By combining gene function with live imaging of the temporal sequence of genes expressed within each of the distinct nerve cells, we can start building a network map that explains how the development and proper specialisation of vastly different types of nerve cells is coordinated.

Regenerating adult nerve cells

Humans have very limited capacity to repair damaged nerve cells caused by trauma or neurodegenerative disease. In our lab, we aim to decipher how highly regenerative related animals are able to regenerate damaged nerve cells.

The zebrafish vertebrate shares most of the same genes as humans, yet zebrafish are able to activate a distinct set of genes to coordinate highly efficient regeneration of nerve cells from stem cell types that also exist in humans.

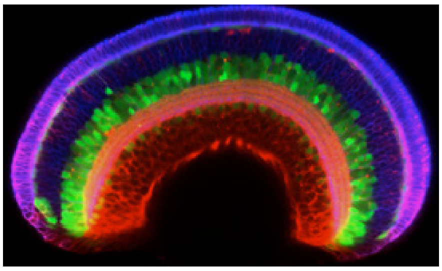
If we can understand and re-activate these genes in humans, we may be able to teach the brain and related organs to self-regenerate.

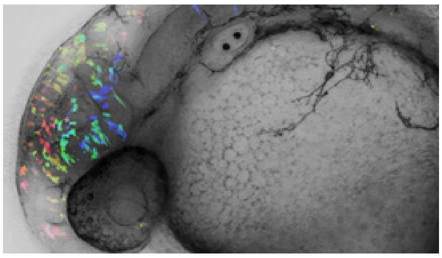
Visual disease modelling and treatment screening

To our knowledge, we have developed the only interdisciplinary visual zebrafish phenotyping pipeline that allows us to assess anatomical, electrophysiological and behavioral phenotypes of hundreds of zebrafish larvae each week.

We are using our pipeline to screen through the hundreds of novel human genes implicated in childhood myopia to identify the few important causative gene candidates that will need to be targeted for focused prevention and treatment strategies.

We are also using established zebrafish glaucoma models to screen for the potential of novel Australian plant-derived antioxidants in preventing or treating the visual nerve cell loss that ultimately leads to blindness in glaucoma patients. We work with clinicians and neuroscientists to take forward our findings towards clinical translation.





Professor Michael Kearney

Professor Michael Kearney

- Biophysical ecology
- Ecophysiology
- Species distribution modelling
- Metabolic theory
- Climate change

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My research aims to develop and apply mechanistic models of how species respond to environmental change based on how individuals experience and respond to their environments across their whole life cycles. Compared to the more traditional statistical modelling methods, mechanistic models can make reliable and robust predictions under complex and novel environmental settings. They can also reveal 'management levers' that can be used to improve or hamper species of applied interest.

Ecological forecasting

I have pioneered the field of 'mechanistic niche modelling' for forecasting species responses to environmental change. This involves the development of modelling tools that apply first-principles models of energy and mass exchange between organisms and their environments to predict their behaviour, life cycles, life histories and, ultimately, distribution and abundance.

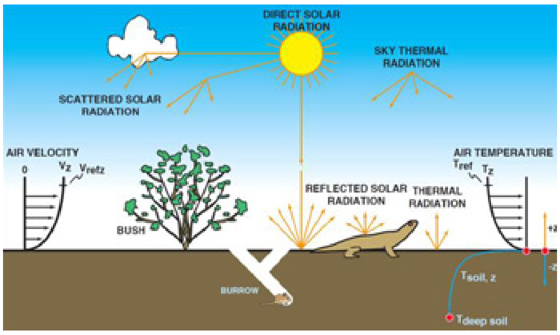
My research in this area involves laboratory work to measure functional traits required by the models and field work to test the models. A large part of this work has involved the development and testing of microclimate models. The approach is highly general, and we apply it to animals (including humans) and plants in both terrestrial and aquatic environments. It is powerful because it can infer species' responses to novel environmental change as occurs during species invasions and under climate change.

Metabolic ecology

One of the most fundamental characteristics of living things is the way they take up resources from their environment and use them to grow, maintain, develop, and reproduce. Metabolic theory aims to characterise this process from first principles, and I work with one particular theory, the Dynamic Energy Budget theory, to study the life cycles and life histories of organisms.

Conservation biology

Our research on ecological forecasting is applied to conservation in many organisms to predict suitable habitat (western swamp turtle, greater glider, koalas, great desert skink) or forecast stress events (flying foxes). But we also have a research program to recover native grasshoppers, including the nationally listed Key's matchstick grasshopper. We integrate field ecology with genetic approaches and captive studies to develop conservation strategies for these species.



Our theoretical work involves modelling how organisms respond to their physical environment.

The best part of research — being in the field (grasshopper resurvey with Hojun Song, Anwar Hossain and Steve Sinclair).

Dr Edwin R. Lampugnani

Dr Edwin R. Lampugnani

- Plant biology and development
- Aerobiology
- Evolutionary biology
- Cell biology

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Plants are an essential pillar for all life on earth. The shape and chemical composition of individual plant cells have significant implications for the food we consume and many of the everyday materials we use, as well as our health. Our research is focused on two areas. First, we are dissecting the pathways and mechanisms mediating plant cell wall biosynthesis. Second, we are applying our understanding of plant biology and development to better forecast the levels of airborne pollen in Victoria.

Melbourne Pollen Count

Every spring, Victorians in their thousands are affected by grass pollen allergies that trigger their hay fever and asthma, serious conditions that reduce quality of life by disrupting day-to-day activities such as work and school. Not surprisingly, spring is a bad season for asthmatics, because this difficulty with breathing caused by a narrowing of the airways in the lungs and hay fever are strongly associated conditions. People with hay fever are more likely to have asthma, and most asthmatics also have hay fever.

In Victoria, when the weather conditions are right these seasonal grass pollen allergies can turn into something far more serious: thunderstorm asthma. Thunderstorm asthma is a sudden increase in asthma in the community after a thunderstorm to the point where an epidemic takes place that places health services under extreme stress. We use innovative and cutting-edge interdisciplinary research, digital technologies and citizen science to deliver a valued service that helps Victorians better manage their allergies by counting and forecasting pollen levels around Victoria. We are also working towards identifying factors that contribute to epidemic thunderstorm asthma events.

Understanding how plant cell walls are made

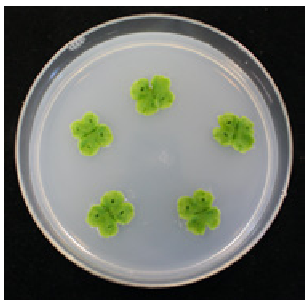
Plant cells are surrounded by a polysaccharide-rich cell wall that has a similar role to an animal's skeleton in determining the overall form, growth and development of the plant. The properties of the plant cell wall also have significant implications for the food we consume and many of the everyday materials we use including paper, textiles and wood.

Yet despite the importance of the plant cell wall, relatively little is known about the functions of many of the polysaccharides it is composed of and the molecular components involved in its synthesis. In part this is because most studies have focused on higher-order plants such as Arabidopsis thaliana, which have significant levels of genetic redundancy, making it difficult to assign a function to a specific gene.

To address this, we have been developing a simpler model plant system to study cell wall biosynthesis. The basal land plant Marchantia polymorpha is in one of the earliest diverging land plant lineages still alive today. Its genome contains little or no genetic redundancy making it ideal to study complex molecular and cellular processes. We use these two genetic model systems from opposite ends of the evolutionary spectrum of land plants — the flowering plant Arabidopsis and the liverwort Marchantia — to better understand how plants make their cell walls to further our knowledge of polysaccharide synthesis not only in plants, but all eukaryotes.

MELBOURNE POLLEN COUNT AND FORECAST

The Melbourne pollen count and forecast.



Marchantia polymopha, the common liverwort.

Dr Tyrone Lavery

Dr Tyrone Lavery

- Native vertebrate biology
- Taxonomy
- Museum collections

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I am a mammalogist with interests spanning taxonomy, systematics, biogeography, ecology, and conservation biology. I use a wide range of tools to examine species' distributions and relationships and how these are shaped by geographic, environmental and biological variables, to determine conservation threats and inform best practice.

I love tracking down incredibly rare mammals, whether they be undescribed, documented by just a single museum specimen, missing or extinct. This work takes me from the field to museum collections, to the laboratory. Wherever possible, I use my research to support the aspirations of Indigenous peoples, and complement their existing deep knowledge.

Dr Deidre Mattiske

Dr Deidre Mattiske

- Reproduction
- Developmental biology
- Endocrine disruptors

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I am a reproductive biologist, with a background in developmental biology, epigenetics, and marsupial reproductive biology. I have extensive experience in molecular biology and mouse genetics.

I focus on the development of mammalian male and female reproductive systems and the mechanisms behind disorders of sexual development. I am investigating the impact of environmental endocrine disrupting chemicals, such as plasticisers and pesticides, on the reproductive system. I aim to determine how exposure to these chemicals during pregnancy can impact development of the gonads and external genitalia of the fetus, and if these exposures result in heritable changes in future, unexposed generations.

Dr Iliana Medina

Dr Iliana Medina

- Behaviour
- Macroevolution
- Ecology
- Evolution

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I am passionate about understanding our natural world, in particular how animals interact with their environment and with other species. Knowing our world and having a deep understanding of how and why it is the way it is can help us connect better to our surroundings and ultimately promote the importance of protecting our wildlife and ecosystems.

My research interests combine the worlds of behavioural ecology and macroevolution. I am curious about the evolution of animal behaviours and the adaptations that these have to their habitat. Why have these strategies evolved? How do they affect the evolutionary destiny of the species? For most of my research, I combine work in the field, laboratory or museum with broad-scale comparative analyses. This integrative approach allows us to understand in-depth the evolutionary drivers of the diversity of forms and colours we see in nature.

The two main research areas in my group are the ecology and evolution of bird nests and the evolution of colours in animals, mainly birds and insects. By looking at the evolutionary history of traits like nests or colour we can understand the diversity in our world. Nests are fundamental for the reproduction of birds and they can vary significantly from species to species, adapting to the particular lifestyle of each species. We explore which environmental pressures have driven the evolution of particular nest features, such as the size or shape of the nest.

Colour is used by animals for defence, mate attraction and to control their temperature. As such, it is a critical trait for survival. In my group we also use museum collections and information from the field and laboratory to reveal why the incredible colours we observe in nature have evolved.

The Cotton Harlequin Bug (Tectocoris diophthalmus) is an Australian insect that presents warning colourations to advertise its repellent odour to potential predators. It is one of our research model systems.

Grey fantail (Rhipidura albiscada) sitting on its nest.

Dr Rebecca Morris

Dr Rebecca Morris

- Marine ecology
- Restoration
- Nature-based solutions

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My research expertise is in applied marine ecology, with particular focus on habitat restoration. I focus on nature-based solutions for the management of erosion and flooding along the coast.

Working in interdisciplinary teams of ecologists, engineers, and social scientists in close collaboration with stakeholders and end users, I investigate the physical and ecological processes at multiple scales to inform successful restoration of coastal habitats such as shellfish reefs and mangroves.

Dr John Morrongiello

Dr John Morrongiello

- Fish ecology
- Life history
- Climate change
- Evolutionary ecology
- Fisheries

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I am a quantitative ecologist working in marine and freshwater systems, investigating how animals respond to environmental change on contemporary and evolutionary time scales. I am keenly interested in the impacts of, and adaptations to, fishery activity, natural and human-induced flow variability, and environmental change. I ask questions at different levels of biological organisation, ranging from individuals to assemblages, using field-based and experimental techniques.

Climate change and fishing impacts in aquatic environments

My research primarily focuses on understanding the evolutionary causes of within-species phenotypic diversity and its ecological consequences in individual fitness, species persistence and assemblage composition. Understanding these fundamentals allows me to explore more applied questions.

An important part of my work has focused on quantifying the impacts of climate change on fishes and predicting likely impacts of this on fishery productivity. I have used otolith-based data to recreate global-scale oceanographic dynamics, and I am currently investigating the role of fishery activity in inducing trait selectivity and density-dependent processes (additive and synergistic effects of fishing and warming).

Statistical modelling

I have developed novel models to analyse individual-level thermal reaction norms and species-wide thermal responses in fish, and the environmental drivers of life-history trait variation, in particular growth, recruitment and movement. I use sophisticated analytical techniques to provide inference at different levels of biological organisation (often concurrently), ranging from within individual variation to among-population, regional and species-wide trends. My reseach is often directly implemented by end users.

Professor Raoul Mulder

Professor Raoul Mulder

- Evolutionary biology
- Behavioural ecology
- Communication
- Mating systems
- Student learning

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My dual aims are to improve our understanding of the natural world and take an evidence-based approach to understanding what makes for impactful learning in the University.

I am fascinated by the causes and consequences of variability in mating systems, particularly the relative importance of sexual and natural selection, the role of visual and acoustic signals and the way in which cooperation and conflict interact in complex social groups. Much of my work combines field studies of behaviour with the use of molecular markers to assign parentage, to better understand the fitness outcomes of different individual strategies.

Why birds?

They exhibit remarkable variation in their life histories, their reproductive success is neatly contained in a nest and they can be readily marked for individual identification. And of course, they are endlessly engaging and surprising in their natural history and behaviour.

Raoul Mulder removing a Madagascar paradise flycatcher from a mistnet.

Raoul Mulder measuring a black swan.

Dr Michael Murray

Dr Michael Murray

- Morphogenesis
- Epithelial plasticity
- Drosophila development
- Wound healing
- Epithelial homeostasis

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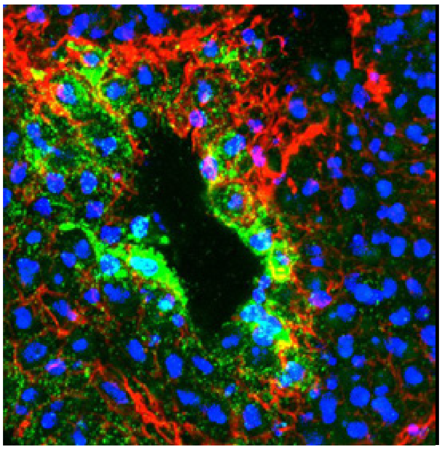
I use the biomedical model organism the fruit fly Drosophila melanogaster to discover and understand the role of genes that control the behaviour of epithelial cells. These genes typically play conserved roles in humans, and so the lessons learned in flies can provide crucial understanding of their role in human embryonic development, cancer and wound healing.

Netrins and wound healing

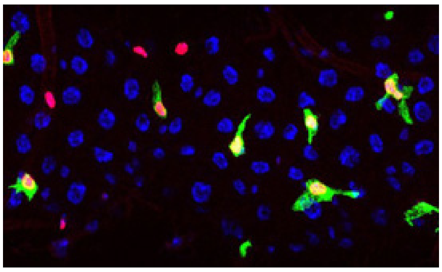
Netrins are versatile proteins best known as secreted axonal chemoattractants, but have more recently shown to be potent regulators of epithelial plasticity during development, cancer and wound healing. We have found that Netrins can stimulate epithelial cells to undergo a transition to a mesenchymal, migratory state (undergo EMT), but also can polarise migrating cells to help them reform epithelia. Recently we've also found that Netrin expression is rapidly upregulated at the edge of epithelial wounds in humans, zebrafish and flies, and is required for fly thorax closure, a developmental model for wound healing. We are currently exploring the signalling pathways that activate Netrin expression in response to epithelial damage and those that act downstream to effect Netrin-dependent closure.



NetA-GFP (green) upregulation at a wound margin.

Epithelial homeostasis in the adult midgut

Maintenance of an adult gut involves the constant replacement of cells that die or are damaged. New cells are provided by intestinal stem cells, which divide to produce progenitor cells called enteroblasts. We are studying how enteroblasts detect and respond to damage and subsequently differentiate into the absorptive enterocytes that line the gut. Our focus is on the morphogenetic mechanisms by which enteroblasts maintain their spatial distribution, how they collaborate to seal wounds and how they incorporate into the epithelium.



Enteroblasts (green) in the fly adult midgut.

Professor Moira O’Bryan

Professor Moira O’Bryan

- Male infertility
- Germ cell biology

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Approximately four per cent of young Australian men are infertile. For the majority, no cause can be identified. Similarly, numerous epidemiological studies have revealed that infertile men have a higher morbidity and die younger than their fertile counterparts. The reasons for this burden are unknown. Within the Male Infertility and Germ Cell Biology lab, we aim to define how sperm are produced, the causes of infertility and the implications of infertility for health more broadly. Insights obtained from this research will inform human and animal health, evolutionary processes, contraceptive development and cell biology.

Male infertility and germ cell biology

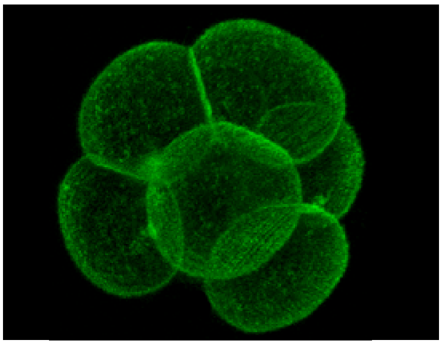
My research group aims to identify key mechanisms required for male germ cell development, the aetiology of human male infertility and the interplay between fertility and health. This is achieved using a range of genomic, biochemical and cell biological methods, including the development of unique model systems and state-of-the art imaging methods.

Building a functional sperm

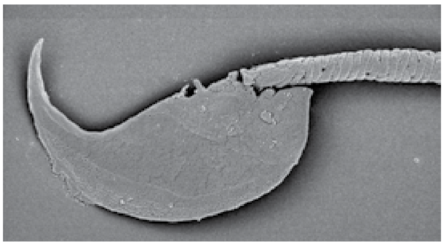
Sperm are a triumph of design. While their development is complex, the final sperm cell is elegant in its simplicity. The shape of the sperm is dictated by a range of cytoskeletal elements and their regulatory pathways and is a key determinant of function and ultimately evolutionary processes. Within our lab, we aim to identify these processes and ultimately harness this knowledge to identify causes of infertility, contraceptive targets and to understand fundamental mechanisms of cell biology more broadly.

The genetic causes of human male infertility

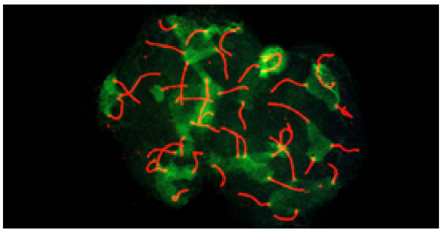
In partnership with the International Male Infertility Genomics Consortium, we are identifying genetic mutations that lead to human male infertility. In order to validate causality, we are modelling these genetic variants in animal models. In doing so, we are providing diagnostic certainty and identifying novel pathways required for fertility.



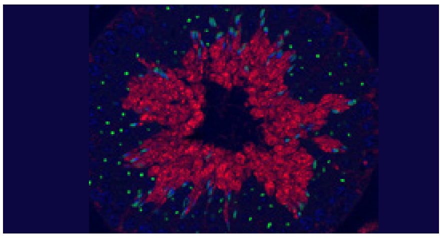
Eight-cell stage mouse embryo: cell membranes are marked with green fluorescent protein (GFP). Image credit: Gemma Stathatos.



Scanning electron micrograph of a mouse sperm head. Image credit: Denis Korneev.



Mouse spermatocyte meiotic chromosome spread: chromosomes are shown in green and synaptonemal complexes in red. Image credit: Jo Merriner.



Mouse testis section stained for cell nuclei (blue), acrosomes (green) and ACRV1 (red). Image credit: Jessica Dunleavy.

Professor Andrew Pask

Professor Andrew Pask

- Reproductive biology
- Evolution-development (Evodevo)
- Genetics and genomics
- Developmental biology

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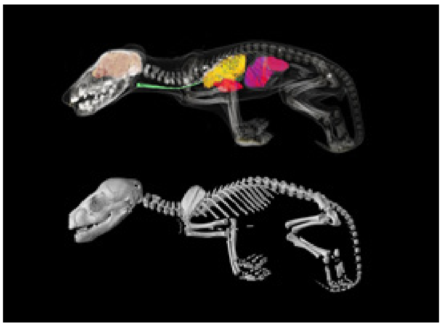
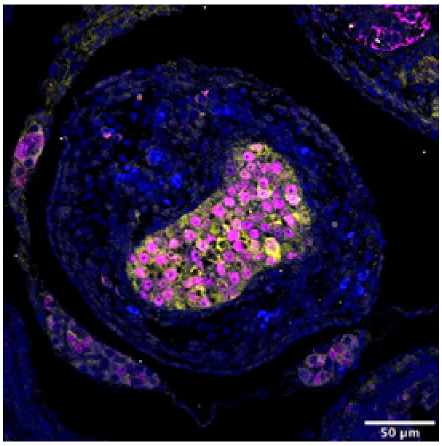
Australia has one of the world's worst track records in mammalian extinctions. We are working to develop much needed genetic and assisted reproductive technologies to help save our threatened and endangered wildlife and maybe even think about bringing them back after extinction. Human fertility is also dropping at an alarming rate, with an unprecedented increase in reproductive disorders attributed to exposure to chemicals in the environment that interfere with our natural hormones. My lab examines how these chemicals impact our development and cause both short and long-term impacts on our reproductive health.

I head the Evo-Devo-Repro group. My research uses comparative mammalian genetics to identify critical and conserved genes driving development, particularly of the craniofacial region and reproductive tract. My work in reproduction has uncovered novel roles for estrogen in male development and helped define the impacts of environmental contaminants on male reproductive health.

My comparative genetics work has led to the sequencing of several marsupial genomes, including that of the extinct Tasmanian Tiger. I use genome-wide, cross-species comparisons to define regions of the genome targeted by evolution to drive diversity and adaptation.



Tasmanian Tiger micro CT scan depicting internal structures.



Marsupial dunnart testis on day 2 post partum showing the first testis cord (yellow) with germ cells (pink).

Associate Professor Suzie Reichman

Associate Professor Suzie Reichman

- Pollution
- Ecotoxicology
- Soil chemistry
- Environmental risk assessment

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Globally, pollution is widespread and a substantial problem that compromises human and environmental health as well as the ecosystem services we rely on for clean air and water, agriculture and recreation. While we have achieved substantial global economic growth over the past few decades it has often been associated with large amounts of pollution. In Australia, it is estimated we have over 160,000 contaminated sites containing about 75,000 different chemicals and with clean-up costs of approximately $160 billion. Our pollution problem is substantial and we need safe, effective and evidence-based approaches to assess and sustainably manage it.

Effects of contaminants in the terrestrial environment

My research group aims to reduce the risk of contaminated land to humans and the environment, focusing on the effects of contaminants in the terrestrial environment such as in soil, plants, invertebrates and human health. We use ecotoxicology and soil chemistry principles to solve knowledge gaps in the environmental risk assessment and remediation of contaminated land. My research group covers traditional pollutants (eg metals and hydrocarbons) as well as emerging chemicals such as per and poly-fluoroalkyl substances (PFAS) and microplastics. Currently, we have a focus on urban pollution and Antarctica.

The outcomes from my research group have been incorporated into government guidance and policy used by industry to make more accurate risk assessments of contaminated land and by the community to garden more safely.

Some of my areas of research include:

- Environmental risk assessment relating to potentially contaminated land
- Ecotoxicological testing of plants and invertebrates (eg earthworms, springtails, tardigrades, rotifers and nematodes)
- Bioavailability processes in soil systems
- Heavy metal and trace element biogeochemistry
- Phytoremediation and phytomining; biosolids and land application of wastes; mining remediation.

Eucalyptus grown in mine tailings.

Research to support soil remediation targets.

Antarctic moss collection for tardigrade and rotifer ecotoxicity research.

Professor Marilyn Renfree

Professor Marilyn Renfree

- Reproduction and development
- Sexual differentiation
- Environmental endocrine disruptors
- Genomic imprinting
- Comparative genomes

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Australia has led the way in the field of reproduction for decades, initially from the breeding of sheep and cattle and more recently with its exceptional IVF and assisted reproduction techniques. However, while we have the highest extinction rates of our wildlife in any developed country, few resources have gone into understanding how reproduction is controlled and the disastrous effects that environmental toxins and land clearing have had. Additionally, because they are mammals, understanding their reproduction has led to some aspects being translated into human medicine. We have an amasing resource in this country, yet relatively few study these unique and iconic animals.

Our research focuses on understanding reproduction and development in mammals (including humans), primarily using marsupials as biomedical models. Australian mammals are especially interesting and provide a unique opportunity for the study of the development of the embryo, foetus and young because they are born after a very short pregnancy and do most of their development after birth, usually in the pouch supported by a long and sophisticated lactation.

Our studies are wide-ranging and cover a number of related but distinct topics. Our team investigates sex determination, sexual differentiation, epigenetics and genomic imprinting, the molecular and hormonal regulation of testis, ovary and phallus development (including sex reversal and hypospadias), as well as the effects of environmental toxins (environmental endocrine disruptors) on reproduction, the control of embryonic diapause and gene expression during early embryonic development and placentation, post-natal growth and lactation. We also research reproduction and development of monotremes in collaboration with the University of Queensland and Currumbin Wildlife Sanctuary. We have been involved in the genomes of several Australian mammals, namely the tammar wallaby, koala, platypus and echidna. Our work is supported by the National Health and Medical Research Council, the Australian Research Council and ARC Linkage grants.

The newborn tammar wallaby pouch young. It weighs only 400mg and will stay in the pouch for 9-10 months to complete its development.

Tammar wallaby with young.

Associate Professor Charles Robin

Associate Professor Charles Robin

- Population genetics
- Molecular evolution
- Insecticide resistance
- Gene drives
- Detoxifying enzymes

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How do we control pest insect populations without damaging biodiversity?

My research is motivated by two general questions:

1. What is the genetic basis of the adaptation that shapes the wonderous biodiversity observed on planet earth?
2. How can we control pest insects without damaging that biodiversity?

More specifically, my lab group focuses on the microevolutionary processes of adaptation, the molecular evolution of gene families, especially those involved with detoxification processes in insects, and genetic methods of pest control such as RNAi and gene drives. The approaches we take are typically genetic (linkage mapping, association studies, transgenic manipulations, and allele frequency change in lab populations) and are explicitly couched in an evolutionary context where we often examine within and between species variation in genomic datasets to identify the genetic targets of natural selection.

The lab also deploys population simulation analyses (eg for gene drive modelling), has contributed to some theory (eg to account for recombination among paralogs in gene family evolution) and has an interest in the history of invertebrate taxonomy.

Much of our research has focused on the model insect Drosophila melanogaster but we have also focused on major insect pests of agriculture, such as the cotton bollworm but we also study major insect pests Helicoverpa armigera and the green peach aphid Myzus persicae.

Two Drosophila melanogaster males fighting. We can understand so much biology by working with this species because of the sophisticated genetic tools, deep literature and ease of manipulation in the lab.

Helicoverpa armigera is the chief reason why transgenic cotton is grown. We have been involved in characterising the genome of this major agricultural pest.

Professor Andrew Robinson

Professor Andrew Robinson

- Biosecurity risk management
- Applied statistics
- Forest modelling and inventory

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Biosecurity is a critically important function of national government but also a shared responsibility with state governments, industry, other stakeholders and every citizen. The Centre of Excellence for Biosecurity Risk Analysis (CEBRA) strives to support the national regulators in managing biosecurity risk by identifying or developing new tools and ways of thinking. Since its inception in 2006 the Centre has worked closely with the Department of Agriculture, Water and the Environment (DAWE) (and and the Ministry for Primary Industries (MPI), since 2013) to help traverse the maturation as science-based regulators.

Biosecurity risk management

Biosecurity is the suite of activities undertaken by national and state regulators and other stakeholders to protect Australia's environment, agriculture, economy, health and social and cultural amenity from invasive pests and diseases — in short, to protect our way of life! Biosecurity risk management demands a delicate balance between enabling travel and trade and all the benefits that these activities bring and protecting the values that we hold dear. Science to support biosecurity risk management calls on a wide range of skills, including statistics, applied mathematics, economics, biology, ecology and sociology.

With our primary stakeholders, namely Australia's Department of Agriculture, Water and the Environment and New Zealand's Ministry for Primary Industries, CEBRA works across these areas to co-develop and deliver problem-centred research projects. Our primary motivation is to help our stakeholders deliver more efficient, robust, science-based biosecurity outcomes. These projects range from estimating the market and non-market value of the biosecurity system to Australia or the utility of bulk milk testing for diseases to developing risk-based inspection schemes that reward compliance and can change stakeholder behaviour, and efficient surveillance systems for invasive pests.

An example of a container ship in Port Philip Bay piled high with sea containers. Sea containers are a known pathway for invasive pests and pathogens.

A biosecurity greenhouse. These plants are being grown out to see if they are infected by pathogens. This check can take years.

Associate Professor Nicholas Robinson

Associate Professor Nicholas Robinson

- Genomics
- Disease resistance
- Aquaculture
- Genomic selection
- Gene editing

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My mission is to develop knowledge that can be applied to solve or help mitigate against some of the world's largest disease problems for aquaculture, thereby improving the sustainability of worldwide aquaculture.

Fish and shellfish are healthy sources of protein and nutrients, and aquaculture production is growing around the world. But there are many challenges faced by these industries. Access to reliable, fast growing, disease resistant and stress resilient seedstock is needed to ensure ongoing sustainability. My research concerns the application of genomics to the genetic improvement of fish and shellfish in aquaculture.

White spot syndrome virus disease

White spot syndrome virus (WSSV) is a contagious and lethal disease that causes billions of dollars of losses globally. It can decimate whole prawn farms within a few days of infection and preventative measures have proven ineffective. Our research demonstrated that genomic selection could be used to achieve more than 10% improved resistance within one generation of selection and that there is high potential for future genetic improvement using this technology.

Sea lice infestations affecting Atlantic salmon

Sea lice are a major pest species affecting fish welfare in many countries. Current preventative measures and treatments are not completely effective. We know that Atlantic salmon vary in their ability to resist infection by lice and that some species of salmon are particularly resistant to lice. I am leading two research projects working closely with industry and a team of overseas collaborators to better understand the genes involved in conferring resistance to sea lice and developing strategies for creating a more resistant strain of Atlantic salmon. These projects are using the latest transcriptomics, CRISPR-Cas9 (molecular scissor) and gene-mapping technologies.

Barramundi seedstock

Barramundi is an iconic tasty fish species growing in popularity around the world. I have been working with the main supplier of seedstock to barramundi farmers to implement genomic selection for creating an elite strain of fast-growing resilient stock.

I investigate the genetic mechanisms affecting the ability of Atlantic salmon to resist sea lice infestation.

I work with major aquaculture industry partners around the world, such as Atlantic salmon producers in Norway.

Dr Vanessa Rossetto Marcelino

Dr Vanessa Rossetto Marcelino

- Microbiome
- Metabolic modelling
- Microbial ecology

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I focus on the ecology of microbial networks, to develop therapies and microbiome engineering, and answer fundamental questions about the eco-evolutionary processes underlying biological interactions.

I have used a range of model systems to investigate the spatial and functional distribution of organisms including frogs, seaweeds, microalgae, and human-associated microbiomes.

Professor Devi Stuart-Fox

Professor Devi Stuart-Fox

- Animal colouration
- Biological optics
- Sensory ecology
- Macroecology

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The vivid colours of the natural world are one of the most striking and beautiful aspects of life's diversity. Our team studies the biology of light and colour. How are these colours produced and perceived in different animal groups, and what is their biological function? We tackle questions at different scales of biological organisation – from optical properties at the nanometre scale to global patterns of colour diversity.

Biological optics and visual ecology

We study the mechanisms that produce vivid colours and diverse optical effects, such as iridescence, metallic appearance and highly reflective surfaces. The biological function of these complex optical effects depends on how they are perceived, so we also study visual perception using a combination of visual physiology, behavioural experiments and computational modelling.

Biological optics and visual ecology: an iridescent jewel beetle (Temognatha chevrolatii) feeding on mallee flowers in Western Australia. Image credit: Amanda Franklin.

Near-infrared properties and thermal control in animals

More than half of the energy in direct sunlight falls within near-infrared (NIR) wavelengths, beyond the limit of human and animal vision. Absorption of solar radiation in these wavelengths significantly affects heat gain, yet almost nothing is known of the diversity and mechanisms of near-infrared properties in animals, let alone their adaptive value. We are investigating the relationship between climate and reflectance of both visible and near-infrared light in a range of taxa, from reptiles and birds to butterflies and beetles.

Near-infrared properties and thermal control in animals: human-vision (left) and near-infrared (right) photos of butterflies. Image credit: Joshua Munro.

Bio-informed technologies and design

Structural colourants are used in a vast array of manufactured goods, from banknotes to plastics and paint, but are produced unsustainably from non-biodegradable materials. Nature produces the most vivid structural colours of all using just a few abundant, biodegradable materials. Natural materials have simultaneously been fine-tuned for other essential properties such as wear resistance, water-repellence and thermal control. We are collaborating with scientists in several other discipline areas to design better, multi-functional and more sustainable coloured materials informed by biology.

BIO INSPIRATION

Bio-informed technologies and design: Hallmark Research Initiative in Bio-Inspiration.

Professor Michael Stumpf

Professor Michael Stumpf

- Theoretical systems biology
- Cell fate decision making

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I want to understand how living cells function. Mathematical models allow us to study their dynamics and explore their complexity and the origins of this complexity. Developing such models, however, is challenging and requires new mathematical and statistical tools. Combining mathematical and biological research is a rewarding intellectual challenge, but from the understanding of cellular processes we will also gain important knowledge with applications in health and sustainable life more generally.

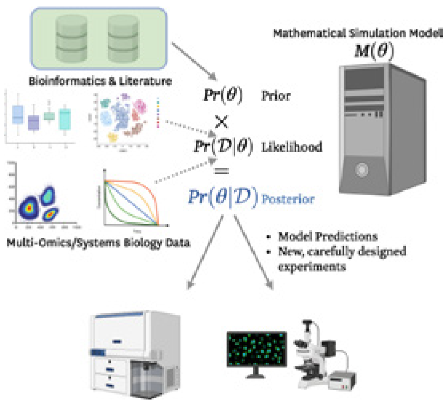
My research is focused on developing better predictive and mechanistic models of biological systems. My work is characterised by methodological breadth and development of state-of-the-art statistical and reverse engineering methods that allow biological and biomedical scientists to develop mechanistic models of biological systems. Mechanistic models capture our knowledge, and unlike statistical or machine learning models, which can strictly only interpolate available data, they also allow for extrapolation, thereby testing our knowledge.

Developing such mechanistic models described by systems of ordinary differential equations, stochastic differential equations, (stochastic) partial differential equations, Markov Jump processes or hybrids thereof is computationally and conceptually demanding. To meet these challenges my group and I have been developing:

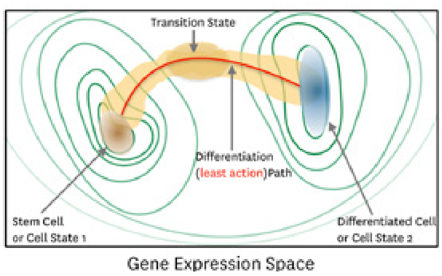
1. Stochastic simulation approaches and computationally efficient approximations
2. Statistical and reverse-engineering approaches to learn the structure of models that describe cellular function from data and determine kinetic parameters of such models
3. Model selection approaches that explore potentially large model spaces in order to identify sets of models support by available data and background information
4. Multi-scale modelling methods which allow us to investigate processes ranging from molecular interactions inside cells to processes underlying tissue formation, and
5. Statistical approaches for the analysis of in vivo live cell and tissue imaging data.

I have been applying these methods in a range of systems and synthetic biology applications, including:

1. Inference and analysis of biological networks, such as protein-protein interaction networks, gene regulation networks and metabolic networks and processes
2. Model development and analysis of signal transduction processes and their effects on cell physiology in bacteria as well as in eukaryotic systems (especially mammalian cell lines, but also yeast)
3. Multi-scale modelling of immunological and developmental processes in the fruit fly Drosophila melanogaster and zebrafish Danio rerio as well as murine and human stem cell systems, and
4. Design of novel pathways and cellular phenotypes in synthetic and engineering biology applications, especially in bacterial synthetic biology.



LEFT Developing mathematical models, for example from single-cell data, requires integration of different data sources and new computational techniques.



LEFT We are using mathematical modelling to understand from single cell data how cells make decisions and how we can control these decisions.

Professor Stephen Swearer

Professor Stephen Swearer

- Environmental impact assessment and management
- Fish and fisheries ecology
- Habitat restoration
- Climate change adaptation

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There is an emerging global crisis arising from the increasing concentration of economic and population centres in coastal areas leading to rapidly increasing environmental change and risk. Solutions to the environmental impacts resulting from climate change, habitat loss, pollution, resource extraction and invasive species in marine and coastal ecosystems require solutions-focused science that co-produces knowledge, technologies and practices. This must be done in conjunction with relevant stakeholders to inspire and enable local communities, industry and government to act in ways that support their values and sustainable development goals.

Nature-based solutions to climate change

We undertake research into the ecological and socio-economic effectiveness of harnessing nature to combat the causes and impacts of climate change in the coastal zone.

Maximising the biodiversity benefits of habitat restoration

We identify the behavioural responses and fitness consequences of habitat restoration projects to improve outcomes for wildlife.

Improving marine conservation planning and fisheries management

We combine empirical field studies, biophysical modelling and analytical chemistry to investigate what causes the large fluctuations in replenishment of marine fish stocks.

Associate Professor Paul Umina

Associate Professor Paul Umina

- Sustainable agriculture
- Entomology
- Food security
- Biosecurity

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The overuse of chemicals in agriculture leads to ecosystem degradation, threatens the resilience of our food systems and contributes to the evolution of insecticide resistance in many invasive insect pests. Our mission is to develop sustainable agricultural pest management practices for healthier ecosystems and improved food security.

Our research aims to improve the health and resilience of anthropomorphised and natural ecosystems. In particular, our work supports Australian farmers in managing their production systems, with a view to achieving long-term sustainability and environmentally beneficial outcomes.

Novel pest management

Each year insect pests lead to billions of dollars in lost productivity in Australian agricultural industries. Our work is exploring novel approaches to utilise endosymbionts (bacteria, associated with insects, living in host cells) for the management of plant pests. This includes exploring ways to block plant virus transmission, influence host plant utilisation and increase the impact of beneficial organisms in farming systems.

Resistance modelling and management

For the first time, we are working to create a national insecticide resistance prediction and diagnostic capacity for the Australian grains industry, which could be extended to other agricultural industries. We are applying risk analysis to determine key resistance risks, including the identification of new threats of resistances entering Australia. Molecular markers underpinning chemical resistance are also being explored in order to support farmers to proactively manage insecticide resistance.

Beneficial insects

Chemicals remain the predominant means by which to manage insect pests attacking Australian food crops. But what happens to all the beneficial insects that get sprayed too? Despite being an important part of Integrated Pest Management (IPM), beneficial insects are mostly killed through the routine application of insecticides. Our research aims to build greater capacity for the stewardship of beneficial species and reduce Australia's reliance on insecticides to control plant pests.

Dr Allison van de Meene

Dr Allison van de Meene

- Plant cell biology
- Algae
- Cell wall
- Microscopy
- Imaging

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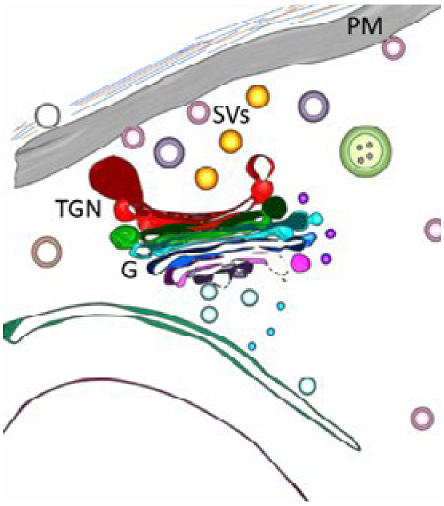
Plants and algae provide the food, clean air and environmental quality on which we depend. Our overarching goal is to improve crop quality and better understand adaptations to environmental change through research that investigates the cell biology processes by which plants and algae form and modify their cell walls, traffic cargo throughout the cell and subsequently adapt to the environment.



Cell biology of plants and algae

My research seeks to identify the processes by which the cell walls of plants and algae are developed, maintained and changed throughout the life cycle and during interactions with the environment. My lab uses state-of-the-art microscopy techniques, including live cell imaging and electron microscopy, to localise sub-cellular components and relevant molecules and structures to understand structure-function relationships. This work is complemented by molecular-genetic, biochemical and biophysical techniques.

Advanced microscopy and imaging

Advanced microscopy techniques and imaging are remarkable tools to understand processes and functions at the cellular level. Utilising imaging techniques ranging from optical to electron microscopy and associated analytical technologies, this research develops insights into the microscale adaptations that occur during the life cycle of organisms and also during adaptations to the environment. My research also contributes to the development of cutting-edge techniques for investigating biological processes at the micro to nanoscale.

Dr Angela van de Wouw

Dr Angela van de Wouw

- Plant pathology
- Canola production
- Blackleg disease
- Genetic resistance

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Our research focus is to develop sustainable strategies for growers to minimise the impact of crop diseases. Few agricultural diseases can be eradicated, and many are constantly evolving; our research is aimed at staying ahead of blackleg disease to give growers the best yields possible.

Minimising the impact of fungal diseases in agricultural crops

My research focuses on blackleg disease, the most devastating disease of canola worldwide. With industry partners, I use a 'genome to paddock' approach to development management strategies for growers to help minimise the impact of this disease. Specifically, this research has led to the development of:

- Molecular and glasshouse tools to characterise the resistance genes in all Australian canola cultivars
- A novel disease management strategy for canola growers — viz. rotation of cultivars with different sources of resistance over time
- Assays that monitor levels of disease in canola paddocks with the findings communicated to farmers who then implement appropriate disease control strategies
- The biannual Blackleg Management Guide (in collaboration with industry leaders) which farmers use to select cultivars to sow each year, and
- Assays to show that blackleg fungal isolates are becoming resistant to fungicides with increased fungicide usage.

Angela with the Marcroft Grains Pathology team, based in Horsham. We screen all Australian cultivars with a set of well-characterised blackleg isolates to determine which resistance genes are present in each cultivar. This information is then provided to growers so that they can select appropriate resistant varieties for their region. Image credit: Thea jane Photography.

Example of the new upper canopy infection symptoms caused by blackleg. Infection of the flowers results in direct yield loss as no pods, and therefore seed, are produced from these infected flowers.

Associate Professor Tim van Gelder

Associate Professor Tim van Gelder

- Intelligence analysis
- Critical thinking
- Reasoning
- Argumentation

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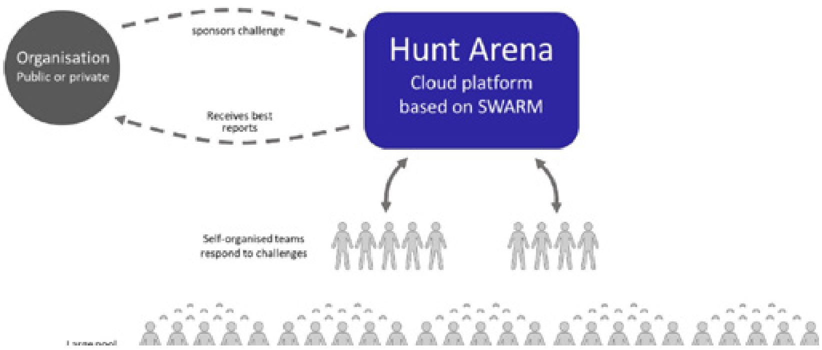
Good intelligence analysis is critical for national security but is difficult, and errors or gaps are inevitable. My goal is to help improve the quality and efficiency of analysis by harnessing academic knowledge and expertise and working in close collaboration with the intelligence community.

My research is focused on how to improve intelligence analysis and analytical or critical thinking more broadly. It is a sub-field of applied epistemology (the study of knowledge). My research group, the Hunt Lab for Intelligence Research, is involved in a variety of projects covering topics like the nature of analytic rigour, how to improve critical thinking in intelligence analysis and how to obtain high-quality analytic reasoning through teamwork or crowdsourcing.

Much of our work makes use of the SWARM platform for collaborative analysis, developed with major funding from the US Intelligence Advanced Research Projects Activity. Recent or current projects include delivering the first major report on analytic rigour in intelligence; studying how training in structured argumentation impacts the quality of reports and decision making in large organisations; and studying ways of measuring the quality of reasoning in intelligence reports. We have a particular interest in the potential for generating high-quality open-source intelligence from crowds of citizens, a capability we call the ‘Hunt Arena.’



Schematic depiction of the operation of the ‘Hunt Arena’ for crowdsourcing citizen intelligence.

Dr Belinda van Heerwaarden

Dr Belinda van Heerwaarden

- Evolutionary biology
- Thermal adaptation
- Phenotypic plasticity
- Endosymbionts
- Drosophila

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Current and future climate change poses a major risk to species persistence and biodiversity. Successfully managing biodiversity for conservation, agriculture and human health-related purposes hinges on accurately predicting how species will respond to climate change. My research aims to understand the potential for different species to respond adaptively to environmental change and identify what factors underpin climate change resilience and vulnerability.

Can endosymbionts alter climate change resilience in insects?

Heritable endosymbionts — microscopic bacteria living exclusively within host cells — are widespread in insects. A handful of studies indicate that endosymbionts may influence the thermal tolerance of their host, yet whether they alter the upper thermal limits, adaptive potential and climate change risk of insects is unknown. We are currently investigating whether endosymbionts alter climate change vulnerability, and exploring the potential for endosymbionts to be used as a tool to modify climate change resilience in insects.

Male fertility and climate change

Estimates of climate change vulnerability typically use the temperature at which adults stop moving or die (known as critical thermal limits) to forecast climate change risk across species from different habitats. However, my research suggests that male fertility may be more sensitive to warming than critical thermal limits, and is therefore a better predictor of climate change vulnerability. Sadly, many species are already experiencing temperatures precariously close to their upper fertility limits. I am currently interested in further exploring plastic and evolutionary genetic responses in male upper thermal fertility limits.

Drosophila are a great model for exploring complex evolutionary and ecological questions. They have short generation times and can be easily reared and manipulated under laboratory environments. There are also many different species, adapted to a range of different climate niches and with differing range sizes.

A lot of my research has focused on examining limits to adaptation in rainforest species.

Professor Madeleine van Oppen

Professor Madeleine van Oppen

- Coral-microbe symbioses
- Coral reef restoration
- Assisted evolution
- Ecological genomics
- Climate change impacts

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To enhance coral thermal bleaching tolerance via bioengineering approaches and assist corals in surviving this century while climate warming is brought under control (ie to 'buy time' for coral reefs).

Assisted evolution to enhance coral climate resilience

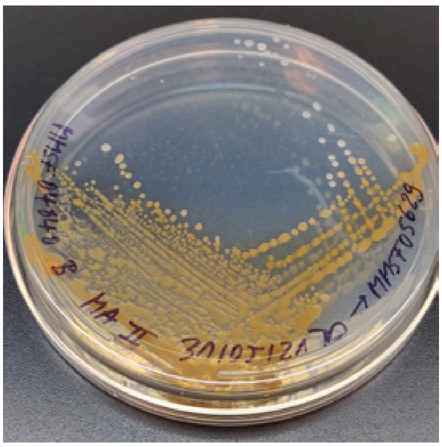
Climate change causes an increase in the frequency, intensity and duration of summer heatwaves, which are the main drivers of the rapid decline of coral reefs worldwide. Sustained periods of elevated temperatures cause the loss of microalgal endosymbionts from coral host tissues (coral bleaching), resulting in coral starvation and ultimately death. Climate models predict most reefs in the world will experience summer heatwaves and associated mass coral bleaching every summer before the end of this century. Many researchers and reef managers therefore argue that in addition to strong action to reduce the emission of greenhouse gases, active reef restoration is required to ensure coral reef persistence into the future. My team is using bioengineering methods to enhance thermal bleaching tolerance of corals aimed at producing tolerant coral stock for reef restoration. We use a range of approaches, including the experimental evolution of microalgal endosymbionts outside the host followed by reintroduction of heat-evolved strains into hosts, the development of bacterial probiotics, coral hybridisation and preconditioning.

Deciphering the roles of coral-associated microbes

Corals associate with a wide diversity of microbes, including photosynthetic dinoflagellates, fungi, bacteria, archaea and viruses, many of which are critical for coral health and survival. While we have a reasonable understanding of the identity of some of these microbial organisms, their functions within the coral holobiont are poorly understood. My team applies a diversity of methods ranging from metabarcoding, proteomics, metagenomics, metatrascriptomics and metabalomics to advanced visualisation, phenotyping and experimental manipulation to decipher the roles of coral-associated microbes.

Reefscape. Image credit: Ray Berkelmans © AIMS.

Algal cultures. Image credit: Marie Roman © AIMS



Bacteria on a plate. Image credit: Talisa Doering.

Associate Professor Heroen Verbruggen

Associate Professor Heroen Verbruggen

- Algae
- Evolution
- Genome biology
- Coral holobiont
- Microbial symbiosis

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We advance the knowledge in our field of research on a daily basis by doing solid basic research and training undergraduate and postgraduate students. In doing so, the basic science we do can contribute to applications in the seaweed industry, the algal-based biotechnology sector and coral reef conservation. Students gain a thorough understanding of the scientific process and highly desired skillsets in bioinformatics and other fields of biology.

Algal evolution and biodiversity

Eukaryotic algae have a rich evolutionary history. Originating more than a billion years ago through a series of primary and secondary endosymbiosis events, they have diversified in almost all imaginable directions. We reconstruct phylogenetic trees of different algal groups and use those trees to study their diversification and evolution, focusing on a range of topics, including speciation, evolution of traits through geological time, the emergence of important cellular and physiological innovations and plastid endosymbiosis events.

We also conduct taxonomic research asking how molecular and morphometric data can complement one another in algal species delimitation. Morphological species delimitation tends to be problematic, and some algal species boundaries are blurry. We combine morphological and DNA data to accurately pinpoint these boundaries.

Algal biology and genomics

We are interested in how our favourite algae function in their environment, and we work on their physiology and genome biology to understand this better. One species we focus on is Ostreobium, a genus of green algae endolithic (rock-dwelling) in calcium carbonate substrates. Because it lives in a rock, it shows a range of adaptations to the low-light conditions it experiences there. Much of our genome sequencing work is focused on green algae, with the recently completed nuclear genome of Ostreobium and several studies on the structure and evolutionary dynamics of organelle genomes.

We are also interested in how algae associate with bacteria: while it is well known that algae rely on bacteria for certain vitamins and other compounds and that some bacteria deter grazers, there is much more to learn about these interactions.

Coral holobiont biology

Coral reefs are spectacular ecosystems held together by the calcium carbonate skeletons secreted by corals. The functions of the microbiota residing in the skeleton are barely understood, but it is clear that drastic changes happen in the skeletal microbiome during bleaching. Our research aims to develop better insight into this understudied skeletal side of the coral holobiont.

The lab's work on microbial symbiosis focuses on corals, such as those seen in this image. Our work aims to improve our understanding of interactions among the coral animal and the thousands of species of bacteria and other micro-organisms that make up the coral holobiont.

With the Great Southern Reef at our doorstep, Melbourne is a phenomenal place to study the biodiversity, evolution and genomics of algae. The picture shows a giant kelp at Point Lonsdale, one of our favourite field sites.

Professor Michelle Watt

Professor Michelle Watt

- Plant roots
- Plant physiology
- Water productivity
- Root microbiomes

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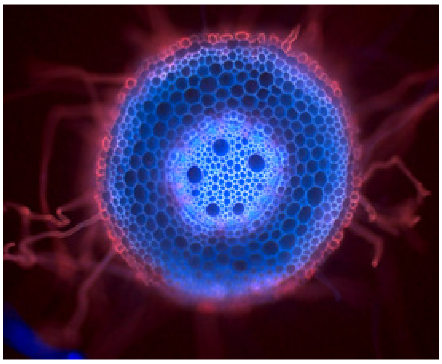
Our mission is to discover and engineer how the root systems of plants grow and function to sustain healthy life on Earth and in future in space — because plant roots are the foundation of plants, and plants are the foundation of humanity.

My group discovers how the root systems of plants, including their microbiomes, grow and function in natural and agricultural environments. We want to improve root water use and carbon functions for food and environmental societal challenges. Roots are the ‘hidden half’ of plant science because they are below ground and out of sight of the human eye.

My group works with national and international collaborators and the University of Melbourne Imaging Centre to use advanced imaging technologies for our discoveries of roots. These include real-time live imaging, miniature ecosystems that fit under a microscope and 4D visualisation of roots in soil using computed tomography. We study root systems of diverse plants, from plants native to the Australian deserts to advanced breeding lines to plants for space habitation. The outputs of our research are new knowledge that we publish and root system designs for new plant types and growing environments that save water, land and energy.

Root system of a barley plant, grown by Dr. Vera Hecht at the Forschungszentrum Juelich.
Image credit: Michelle Watt.



Cells inside a plant root. The different colours and sizes are related to the functions of the root like absorbing nutrients, transporting water to the shoot and returning carbon to the soil. Image credit: Dr. Pan Dong.

Professor Nina Wedell

Professor Nina Wedell

- Evolutionary Biology
- Sexual Selection
- Selfish Genetic Elements
- Insects

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I work on aspects of sexual selection and conflict, particularly the role of selfish genetic elements (SGEs) in reproductive biology and mating system evolution in insects.

SGEs and sexual selection

SGEs such as transposable elements, segregation distorters and maternally inherited symbionts are found in all organisms and can cause reproductive incompatibilities, feminisation, and male deaths that distort the sex ratio. Females may mate multiple times to promote sperm competition and avoid fertilisation by SGE-carrying sperm. I examine the impact of SGEs on male fertility in flies and sex-ratio-distorting endosymbionts in butterflies.

Sexually antagonistic (SA) alleles

SA alleles are genes expressed in both sexes that are advantageous to one sex but detrimental to the other. SA alleles can accumulate even when the advantage to one sex is less than the cost to the other. I study SA alleles in butterflies, moths and flies. In fruit flies (Drosophila melanogaster), a transposable element (TE) inserted into the detoxification gene (Cyp6g1) confers insecticide resistance and increases female fecundity, but can decrease male mating success and alter male aggression. TE insertions and Cyp6g1 duplications are associated with sex differences in resistance. I investigate the impact of multiple TE insertions on resistance evolution and their potential SA effects.

Multiply mating Drosophila pseudoobscura females promote sperm competition that undermine the transmission advantage of a sex-ratio distorting gene.

Some Australian populations of Eurema hecabe butterflies harbour feminising bacteria that affect the expression of male sexually selected signals.

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