WESTERN SYDNEY
UNIVERSITY

School of Science
Research Prospectus
2023

Congratulations on your success so far in your undergraduate studies!

This booklet lists research projects for 2023 in the School of Science. Please note that the projects listed may be on the Campbelltown, Hawkesbury, Parramatta, Penrith campus or at external facilities. Further, many of the projects listed are general in nature and may be suitable for more than one student.

If there are any further questions you need answered, please do not hesitate to contact SoSC-HDR@westernsydney.edu.au

Kind Regards,

Professor Janice Aldrich-Wright	A/Professor Liza Cubeddu
Associate Dean, HDR Research and Training	Associate Dean, Masters of Research

After you have browsed the booklet and you would like to find out more about a specific project, here is what you need to do next:

- **Please contact the supervisors** listed in the booklet with whom you might be interested to undertake your research project; make an appointment with those supervisors and ask them all you need to know about the project.

Students interested in undergraduate projects:

- Contact supervisors directly.

Students interested in MRes:

- **Applications are now open** for students commencing in 1H 2023. Applications close (domestic) on 20th January 2023. Students are encouraged to submit their applications as early as possible. To apply for entry into the Master of Research go to: https://www.westernsydney.edu.au/future/study/courses/research/master-of-research.html

Students interested in HDR projects:

- Contact supervisors directly

Read the information on the Graduate Research School website:
https://www.westernsydney.edu.au/future/study/courses/research/doctor-of-philosophy

Research Areas

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Astrophysics

Supervisor: Dr Shi Dai, Prof Miroslav Filipovic

Project Title: Searching for pulsating neutron stars with the world largest telescopes

Research Area: *Astronomy and Astrophysics*

Finding pulsating neutron stars (or pulsars) has always been an extremely rewarding challenge and has led to Nobel Prize winning science. Neutron stars are the most compact observable objects in the Universe and allow us to test Einstein's General Relativity and detect gravitational waves. We are now entering a new era of radio astronomy and have new game changers, sensitive, wide-field-of-view imaging telescopes and massive compute resources, to search for extreme pulsars. Such pulsars, including pulsar-blackhole systems and sub-millisecond pulsars, cannot be found with traditional pulsar surveys, but provide us unique laboratories to test gravity theories at ultra-strong gravitational fields and probe the state of matter at supra-nuclear densities. In this project we will be using images from the world largest radio telescope arryas, such the Australian Square Kilometre Array Pathfinder (ASKAP), to discover the most extreme pulsars in deep all-sky continuum surveys. We will investige and apply a range of statistical methods (such as Fourier Transform and Bayesian statistics) and carry out detailed studies of new pulsars.

Keywords: Astronomy, Astrophysics, Stars

Supervisor: Dr Shi Dai, Prof Miroslav Filipovic

Project Title: Revealing the nature of Fast Radio Burst with the Parkes telescope

Research Area: *Astronomy and Astrophysics*

Fast Radio Bursts (FRBs) are extremely short (~millisecond duration) and energetic radio flashes. It was first discovered in 2007 by the iconic Parkes telescope and has since become one of the most important targets in astronomy. Despite that a few hundred of FRBs have been detected so far, the nature and origin of FRBs are still unknown. Popular models of FRBs include blackholes and neutron stars with ultra-strong magnetic fields, both of which are the most extreme objects in the Universe. One of the biggest challenges in studies of FRBs is to obtain information of these radio flashes over a wide frequency range, which is crucial for us to come up with a full picture of these objects. Fortunately, we recently detected one FRB, 190520, with the Parkes telescope using the cutting-edge ultra-wideband low (UWL) receiver. This FRB turns out to be one of the most active FRB within our observing bands, and we detected more than 60 bursts within one hour. Currently, we are monitoring FRB 190520 with the Parkes telescope fortnightly and have already collected more than 120 bursts. This project will be focusing on investigating the wideband properties of FRB 190520, as well as detecting more bursts, based on the Parkes dataset. The outcome of this project will shed new light on the origin and natrue of FRBs.

Keywords: Astronomy, Astrophysics, Stars

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Biochemistry & Genetics

Supervisor: Dr Nathan Absalom

Project Title: Investigating Genetic Variants Associated with Childhood Epilepsy

Research Area: *Genetics, Neuroscience*

Genetic childhood epilepsies are profound disorders. For the most severe forms, seizures begin in the first year of life with patients often suffering multiple seizures each day. There are a host of associated comorbidities including hypotonia (floppy baby syndrome), severe intellectual and developmental delay, microcephaly, behavioural disorders and reduced life expectancy. Treatment options are limited, whereby in approximately 30% of cases the seizures are resistant to current medications, and in some cases medication will exacerbate the seizures or cause severe adverse effects.

Recent advances in whole-genome sequencing have revolutionized our understanding of these epilepsies. Patients with spontaneous changes in DNA (de novo variants) that cause epilepsies can now get a specific molecular diagnoses for their epilepsy syndrome. Amongst the many new genes identified are those that encode for the gamma aminobutyric acid type A (GABAA receptors), the major inhibitory receptor in the brain. These receptors allow chloride ions to flow into neurons, inhibiting neuronal activity, and several anti-epileptic drugs such as clobazam, vigabatrin, phenobarbital and cannabidiol either directly or indirectly target these receptors.
Surprisingly, these drugs don't always work for these patients, and sometimes even exacerbate the disorder (Absalom et al, 2021). Our research recently discovered that the genetic diagnosis is insufficient, instead the patients form two distinctive cohorts of gain and loss-of-function variants (Absalom et al, 2022, Ahring et al, 2022). This finding overturned a dominant paradigm that enhanced GABAergic activity is protective against seizures.

This project will evaluate the controversial role of the effect of GABAA receptor variants on cell surface expression and how this relates to patient phenotypes. The skills you will develop will include state-of-the-art molecular biology techniques, flow cytometry, two-electrode voltage clamp electrophysiology and analysis of clinical databases.

Keywords: Epilepsy, Genetics, Pharmacogenomics, Receptors, Molecular Biology

References:

Absalom NL, Liao VWY, Johannesen KMH, Gardella E, Jacobs J, Lesca G, Gokce-Samar Z, Arzimanoglou A, Zeidler S, Striano P, Meyer P, Benkel-Herrenbrueck I, Mero IL, Rummel J, Chebib M, Møller RS, Ahring PK. Gain-of-function and loss-of-function GABRB3 variants lead to distinct clinical phenotypes in patients with developmental and epileptic encephalopathies. Nature Communications. 2022 Apr 5;13(1):1822. doi: 10.1038/s41467-022-29280-x.

Absalom NL, Liao VWY, Kothur K, Indurthi DC, Bennetts B, Troedson C, Mohammad SS, Gupta S, McGregor IS, Bowen MT, Lederer D, Mary S, De Waele L, Jansen K, Gill D, Kurian MA, McTague A, Møller RS, Ahring PK, Dale RC, Chebib M. Gain-of-function GABRB3 variants identified in vigabatrin-hypersensitive epileptic encephalopathies. Brain Communications. 2020 Oct 1;2(2):fcaa162.

Ahring PK, Liao VWY, Lin S, Absalom NL, Chebib M, Møller RS. The de novo GABRA4 p.Thr300Ile variant found in a patient with early-onset intractable epilepsy and neurodevelopmental abnormalities displays gain-of-function traits. Epilepsia. 2022 Sep;63(9):2439-2441. doi: 10.1111/epi.17358. Epub 2022 Jul 20.

Supervisor: A/Prof Liza Cubeddu, Dr Roland Gamsjaeger

Project Title: Understanding the Mechanistic Role of New Human DNA Repair Proteins - Novel Avenues to Treat Cancer

Research Area: Biochemistry

Humans have evolved multiple mechanisms to ensure the integrity of their genetic information, which is carried by DNA. Each cell suffers more than 100 000 insults a day to its DNA; therefore, an effective DNA damage response is crucial for the maintenance of genetic integrity and for survival. One of the main outcomes of not upholding our genetic integrity is mutation; some mutations predispose individuals to developing cancers. The development of novel therapeutic agents for cancer treatment has been hindered because the molecular details of most human DNA repair pathways are not fully resolved. We have discovered two new human proteins, from the oligonucleotide binding domain family, that have critical roles in the DNA damage response. We are working toward a molecular understanding of the roles of these proteins using a combination of biochemical, functional and structural techniques to develop innovative therapeutics to selectively kill cancer cells.

Keywords: Cancer, DNA Repair, Protein Biochemistry, Structural Biology, NMR

Supervisor: Dr Roland Gamsjager, A/Prof Liza Cubeddu

Project Title: Characterisation of viral proteins to manage future pandemics

Research Area: Biochemistry

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a novel highly infectious RNA virus that belongs to the coronavirus family. The World Health Organization has declared the ongoing outbreak to be a global public health emergency. Replication of the viral genome is a fundamental step in the virus life cycle and the protein, Non-structural protein 9 (Nsp9), was found to be essential for virus replication through its ability to bind RNA. Homologs of the Nsp9 protein have been identified in numerous coronaviruses including SARS-CoV-1 (Nsp9SARS), human coronavirus 229E (Nsp9HcoV), avian infectious bronchitis virus (Nsp9IBV), and porcine epidemic diarrhoea virus (Nsp9PEDV). Three-dimensional structures of Nsp9 proteins from these viruses have been determined, revealing similarities to single-stranded DNA binding proteins from humans. Interestingly, despite the major role that Nsp9 plays in viral replication, its binding to RNA is very weak.

In this project, we are working towards determining the molecular details of Nsp9 involvement in viral replication in multiple viruses with the long-term aim of developing drugs that specifically inhibit Nsp9 and thus combat diseases caused by viruses such as SARS-CoV-2. To achieve this, we use a combination of biophysical and structural methods such as Biolayer Interferometry (BLI) and Nuclear Magnetic Resonance (NMR) spectroscopy.

Keywords: Covid-19, Coronavirus, Protein Biochemistry, Structural Biology, NMR

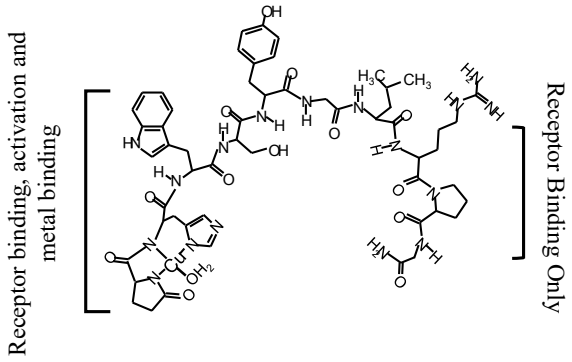
Supervisor: Dr Christopher Jones

Project Title: Neuropeptides: structure, function and the role of metal ions.

Research Area: *Biochemistry; Bioinorganic Chemistry*

Neuropeptides are important molecules for signalling in the nervous system. As small peptides (10-20 amino acids) they are traditionally considered to be unstructured, but recent evidence is suggesting that their ability to fold and adopt structure is important for their function. The structure they form can be dependent on how they interact with cellular components, such as membranes; other peptides and proteins, including cell surface receptors; and whether or not they can bind elements such as metal ions. Metals, including copper, iron and zinc are important for normal functioning of the nervous system and disruption to levels of metals in the brain is a feature of diseases such as Alzheimer's. We aim to determine how neuropeptides are structured and how environmental conditions can lead to changes in structure and function.

Projects in this area will use spectroscopic methods to investigate peptide structure, including CD, NMR and EPR and electronic spectroscopy (e.g. fluorescence). There is the potential to link biophysical experiments with cell based assays in order to investigate peptide function at the cellular level.



References:

Peacey et al, (2020) Roles of copper in neurokinin B and gonadotropin-releasing hormone structure and function and the endocrinology of reporduction. Gen. Comp. Endocrin. 287, 113342.

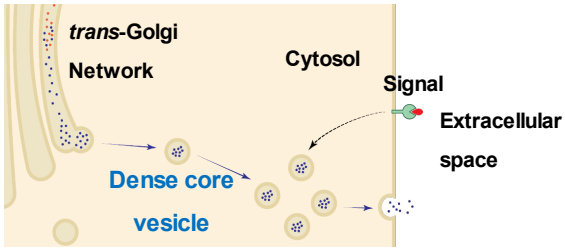
Supervisor: Dr Christopher Jones, Dr Mark Jones, Bhawantha Jayawardena (HDR student).

Project Title: Development and trafficking of dense core vesicles.

Research Area: *Biochemistry, Cell Biology*

A major component of cellular function is the trafficking of small molecules and proteins. This cellular trafficking can occur either from the cell to the extracellular environment and vice-versa. Some cells have specialised trafficking pathways for the movement of hormones and other small molecules, including neuropeptides, from where they are generated (in the endomembrane network) to where they are released from the cell (see figure). Because of the biological importance of molecules such as hormones, disruption to cellular secretory pathways has significant physiological consequences. In many cases the transported molecules, i.e. the 'cargoes', are stored in specialised vesicles known as dense core vesicles, which are so named because the cargo contained in the vesicle is so highly compacted and dense that electrons cannot pass through when imaged via an electron microscope. A lot of the biochemical mechanisms surrounding the formation and movement of dense core vesicles still ellude us, especially where and how the cargo is compacted to form the core of the granule.

This project will investigate mechanisms of dense core vesicle formation and the specific trafficking pathway it is a part of. This is a multidisciplinary project that will use techniques in cell biology (e.g. cultures of neuronal and astrocyte cell lines transfected with proteins of interest) and biophysical techniques such as confocal microscopy and fluorescence- and absorbance-based assays to understand how cells package and traffic peptides and hormones.



Keywords: Cell Biology, Cellular Signalling And Trafficking, Cell Culture, Transfection, Confocal And Fluorescence Microscopy

Supervisor: Dr Graham Jones

Project Title: The distribution and function of intragenic regulatory elements

Research Area: *Genetics, genomics, immunology*

Since the completion of the human draft genome in 2000, the study of genetics and our undertstanding of the genetic basis of health and disease has been revolutionised. We are now in the era of genomics and big data, and as researchers our work requires a good understanding of how to analyse large data sets and to then apply this analysis to functional work in the laboratory. An important finding from genome-wide analysis of the genetic basis of comon diseases is the realisation that the the number of DNA sequences that control the expression of the 20-25,000 genes in the human genome is estimated to be between 800,000 and 1,000,000. These DNA regulatory elements are responsible for the immense complexity of the tissue- and context-specific expression of our genome. We are interested in understanding the origin and function of regulatory elements that are within genes – so-called intragenic regulatory DNA sequences. Evidence supports multiple functional models for these intragenic elements: they may can increase or decrease transcription, and may act as internal promoters or enhancers. In this project, you will learn how to undertake genome-wide analysis of large datasets using R- and Python-based software packages to identify intragenic regulatory sequences and to then test the outcomes of these bioinformatic analyses by functional assays in the laboratory through using cell cuture models, real-time PCR, DNA methylation assays and flow cytometry.

Supervisor: A/Prof Michelle Moffitt, Dr Oliver Morton and Dr Colin Stack

Project Title: Microbial Interactions

Research Area: *Microbiology, however students with other backgrounds including medical science, food and nutrition, biology, agriculture, and chemistry are also welcome*

Microbes are everywhere, due to this they form a variety of interactions with other organisms. They must interact with other microbes or with their hosts for successful establishment in environments including humans, animals or plant hosts or in the production of fermented foods.

These cross-species interactions are important in defining the microbe in a mutualistic, symbiotic, pathogenic or parasitic relationship. These relationships can be manipulated by the microbe through the production of small molecules such as bioactive secondary metabolites or quorum sensing molecules and can elicit a response that can be measured in the host using proteomics, transcriptomics, metabolomics, quantitative techniques such as qPCR, or imaging techniques available in the School of Science (light microscopy, electron microscopy, or MRI).

These studies can lead to the identification of new antibiotic drugs or drug targets for human health, biocontrol agents for plant diseases, fermented foods, among others.

Some of the microbial interaction projects that are being conducted in our laboratory include, but are not limited to:

- Polymicrobial (fungi and bacteria) biofilms including investigation of quorum sensing inhibitors
- Cyanobacterial-plant interactions for the investigation of cyanobacteria as biofertilisers and biocontrol agents
- Interactions between rust disease and its host plant and using hyperparasitic fungi as biocontrol agents
- Characterisation of multispecies food fermentation products such as kombucha
- Mammalian host and parasitic protozoa
- Development of non-mammalian models to study microbial infections, includes protozoa and insect larvae as substitutes for animals or human immune cells.

The Microbial Interactions team will discuss projects in these or related areas of microbiology with interested students. We also aim to create an environment where students can develop project ideas in collaboration with the staff; the team can advise on feasibility, availability of resources, and assist in the progression of the student to become an independent researcher.

Keywords: Microbial Interactios, Myrtle Rust, Aspergillosis, Trichomonas infection, Pathogenesis

References:

Weiland-Bräuer, N. Friends or Foes—Microbial Interactions in Nature. Biology 2021, 10, 496. https://doi.org/10.3390/biology10060496

Wilson, A., Cuddy, W.S., Park, R.F. Harm G.F.S., Priest, M., Bailey, J. and Moffitt M.C.. Investigating hyperparasites as potential biological control agents of rust pathogens on cereal crops. Australasian Plant Pathol. 49, 231–238 (2020). https://doi.org/10.1007/s13313-020-00695-8

Morton CO, Wurster S, Fliesser M, Ebel F, Page L, Hünniger K, Kurzai O, Schmitt AL, Michel D, Springer J, Einsele H, Loeffler J. Validation of a simplified in vitro Transwell® model of the alveolar surface to assess host immunity induced by different morphotypes of Aspergillus fumigatus. Int J Med Microbiol. 2018 Dec;308(8):1009-1017. doi: 10.1016/j.ijmm.2018.09.001. https://www.sciencedirect.com/science/article/pii/S143842211830300X?via%3Dihub

Morton CO, Chau M, Stack C. In vitro combination therapy using low dose clotrimazole and photodynamic therapy leads to enhanced killing of the dermatophyte Trichophyton rubrum. BMC Microbiol. 2014 Oct 15;14:261. doi: 10.1186/s12866-014-0261-z. https://bmcmicrobiol.biomedcentral.com/articles/10.1186/s12866-014-0261-z

El-Khoury M, Ligot R, Mahoney S, Stack CM, Perrone GG, Morton CO. The in vitro effects of interferon-gamma, alone or in combination with amphotericin B, tested against the pathogenic fungi Candida albicans and Aspergillus fumigatus. BMC Res Notes. 2017 Aug 1;10(1):364. doi: 10.1186/s13104-017-2696-4. https://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-017-2696-4

Supervisor: Dr Sabine Piller, and various co-supervisors possible depending on project including Dr Jonathan Plett (HIE), Dr Michelle Moffitt, Dr Ben Perry, Dr Kayte Jenkin, Dr Chris Gordon, Dr Peter Shortland, Dr Nathan Absalom, Dr David Mahns (SoM) and others

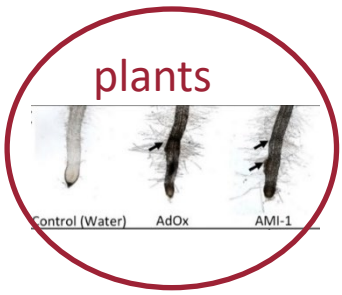
Project Title: The role of protein arginine methylation of cellular, non-histone proteins in health and disease

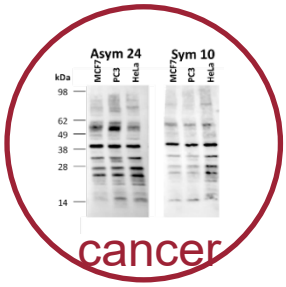
Research Area: *Postr-Translational Modification, Proetin Arginine Methylation, Cellular Biology, Neuoscience, Cancer Biology, Ion Channels, Plant Biology*

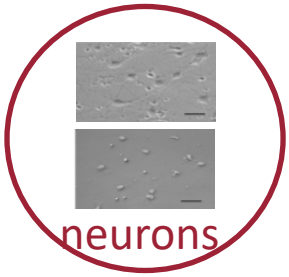
Protein arginine methylation is a post-translational modification that has been known since the early 1960ies. Recently, protein arginine methylation has become one of the hot topics of research in a variety of fields including virology, immunology, cell biology, molecular mechanisms of disease, potential drug target development, cancer biology, as well as in plants and microrrhizal fungi (1) Protein arginine methylation is a likely key modulator of cellular processes such as transcription, cell signalling, nuclear transport, ageing and cellular stress which has implications for a wide range of diseases in humans including cancer, cardiovascular diseases, viral infections, lung disease, and neuronal diseases and is considered as a potential drug target (2). However, protein arginine methylation is also important in plants, algae, fungi and yeast and more research is required to better understand the importance of this post-translational modification in these organisms.

The Piller lab is interested in determining the molecular mechanisms of the effects of protein arginine methylation in normal cell function in a variety of systems including plants (3) and plant diseases like rust in collaboration with Dr Jonathan Plett at the Hawkesbury institute of the Environment (HIE) and Dr Michelle Moffitt, as well as in a range of human diseases including various cancers, viruses and neuronal diseases with the ultimate aim of identifying potential future drug targets. Collaborative projects are possible with a variety of co-supervisors depending on the project including Dr Ben Perry (muscle physiology); Dr Kayte Jenkin (cannabinoid receptor biology), Dr Chris Gordon (screening potential PRMT5 inhibitors, chemistry background beneficial); Dr Peter Shortland, Dr Nathan Absalom and Dr David Mahns (SoM) for neuroscience and ion channel projects.

The main techniques you will learn include cell and tissue culture, immunoprecipitation, SDS-PAGE, Western blotting, cloning, PCR, protein expression, mass spectrometry, ELISA, flow cytometry and others depending on the chosen project.







Keywords: Protein Arginine Methylation, Protein Arginne Methyltransferases, Cell Biology, Molecular Biology,

References:

Ernesto, Guccione., Stéphane, Richard. The regulation, functions and clinical relevance of arginine methylation.. Nature Reviews Molecular Cell Biology, (2019).;20(10):642-657.

Wu Q, Schapira M, Arrowsmith CH, Barsyte-Lovejoy D. Protein arginine methylation: from enigmatic functions to therapeutic targeting. Nat Rev Drug Discov. 2021 Jul;20(7):509-530.

Willemsen NM, Hitchen EM, Bodetti TJ, Apolloni A, Warrilow D, Piller SC, Harrich D. Protein methylation is required to maintain optimal HIV-1 infectivity. Retrovirology. 2006 Dec 15;3:92.

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Plett KL, Raposo AE, Anderson IC, Piller SC, Plett JM. Protein Arginine Methyltransferase Expression Affects Ectomycorrhizal Symbiosis and the Regulation of Hormone Signaling Pathways. Mol Plant Microbe Interact. 2019 Oct;32(10):1291-1302.

Raposo AE, Piller SC. Protein arginine methylation: an emerging regulator of the cell cycle. Cell Div. 2018 Mar 20;13:3.

Supervisor: Dr Ming Wu

Project Title: Unravelling the molecular network of zinc homeostasis in breast and prostate cancer cells

Research Area: *Biochemistry, Molecular Biology, Cancers*

Zinc ion (Zn^{2+}) is essential to life. It functions in the cell as a cofactor for well over 300 enzymes and as a structural component for approximately 10% of the human proteome (~3000 proteins). Consequently, the cell has developed an elaborate molecular network over the extensive evolutionary timeline to maintain zinc homeostasis. Any disruption of such a network will lead to zinc dyshomeostasis, resulting in health problems such as cancers.

Zinc dyshomeostasis is an intriguing phenomenon in breast and prostate cancers, with breast cancer cells exhibiting higher intracellular Zn^{2+} levels compared to their corresponding normal epithelial cells, in contrast to the low Zn^{2+} levels in prostate cancer cells compared to the normal prostate counterpart.

In the past ten years, our lab has been focussing on zinc-related gene and protein profiling in breast and prostate cancer cells in order to understand the underlying molecular network of zinc homeostasis.

In this research project, the candidate will continue the current pursuit of understanding the molecular network in zinc homeostasis of breast and prostate cancer cells by a systematic approach of gene profiling, proteomic analysis and immunofluorescence confocal microscopy using a panel of cell lines which include two breast cancer cell lines, two prostate cancer cell lines, along with normal breast and prostate epithelial cell lines. It is expected that the outcomes of this project should shed more light on the molecular intricacy of zinc homeostasis in both breast and prostate cancer cells.

Keywords: Zinc Homeostasis, Breast Cancer, Prostate Cancer, Gene Profiling, Proteomics, Immunofluorescence Confocal Microscopy

References:

Barman, S., Zaman, M., Veljanoski, F., Malladi, C., Mahns, D. and Wu, M. (2022), 'Expression profiles of the genes associated with zinc homeostasis in normal and cancerous breast and prostate cells', Metallomics, vol 14, no 8. DOI: 10.1093/mtomcs/mfac038

Zaman, M., Barman, S., Corley, S., Wilkins, M., Malladi, C. and Wu, M. (2021), 'Transcriptomic insights into the zinc homeostasis of MCF-7 breast cancer cells via next-generation RNA sequencing', Metallomics, vol 13, no 6. DOI: 10.1093/mtomcs/mfab026

Photo by Hans Reniers on Unsplash

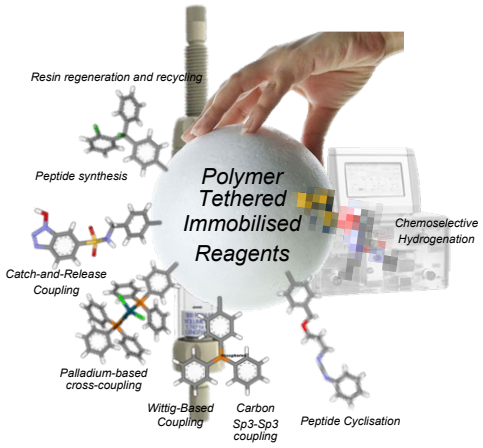
Chemistry

Supervisor: Dr Christopher Gordon

Project Title: Immobilised Reagent Assisted Flow Chemistry

Research Area: *Flow and Organic Chemistry*

In contrast to the majority of scientific disciplines, the technologies and methodologies employed to perform synthetic chemistry have fundamentally remained unchanged for over a century. Making the transition from inefficient and waste intensive processes requires a significant change in both approach and available technologies. In this respect, flow reactors and polymer tethered immobilised reagents are potentially viable alternatives to wasteful conventional synthetic processing. Briefly, flow reactors are tubular or chip-based systems in which reagent streams are continuously pumped through reaction chambers and/or columns containing solid-supported reagents and chemical scavengers. Compared to traditional batch chemistry processing, the advantages of flow chemistry are numerous and include faster reactions, cleaner products, safer reactions, quick reaction optimisation, easy scale-up, and the integration of typically separate processes such as work-up and analysis. Thus the all-encompassing aim of this project is to devise immobilised reagent assisted flow-synthesis methodologies to access molecules with biological activities.



Supervisor: Dr Feng Li

Project Title: Metallo-supramolecular Materials (including Nano Materials): Molecular Recognition, Catalysis, Optical and/or Magnetic Properties

Research Area: *Metallo-Supramolecular Chemistry*

The application of nanotechnology in nanomaterials for supramolecular systems has been a vigorous, fast-growing and fascinating area of current research with inorganic, organic, and biological processes and in environment. It is a highly interdisciplinary field with wide-ranging collaborations between chemists, physicists, biochemists, biologists, environmental scientists, engineers, theoreticians, mathematicians and others. Because the structure and properties of nanomaterials differ significantly from those of atoms and molecules as well as those of bulk materials, the synthesis of functional nanomaterials and new assembled nanostructures has been characterized by explosive growth derived in part from their use as models for metal-proteins in a substantial number of metalloproteins, their use as synthetic ionophores, the study of their associated magnetic exchange phenomena, their use as therapeutic reagents in chelation therapy, their application as antibiotics that owe their antibiotic action to specific metal coordination and, more generally, as hosts for specific guests.

This project is focused on three significant issues in the area of nanomaterials in supramolecular systems:

1) The use of designed metal-ion directed assembly for constructing new nanometer-scale supramolecular entities and the investigation of host-guest inclusion behaviour in metallo-supramolecular systems;
2) The construction of organic metal hosts for gas or/and solvent absorption in metallo-supramolecular systems;
3) The exploration of optical and dielectric properties of spin-crossover (SCO) materials and the development of memory effects and switching in SCO systems.

The objectives of the project are as follows:

- To employ metal-directed assembly procedures to generate a range of metallo-supramolecular derivatives in which perturbations of topologies are induced by variation of guest species;
- To probe relationships between structure and function by variation of the steric nature of ligand type, the associated metal ions and guests.
- To observe and study the host-guest association in metallo-supramolecular materials and develop devices for sensing molecular and ionic species, leading to molecular recognition, gas absorption and catalysis in practical applications.
- To construct metallo-supramolecular materials by the linking of SCO centres and to investigate their optical and dielectric properties, leading to nano-chemical switches and memory devices in practical application.

Keywords: Nano Materials, Chemosensor, Molecular Magnet, Nano-Switches and Memory Devices

Supervisor: Dr Feng Li

Project Title: Metallo-supramolecular Materials in Biological Applications: DNA Binding, Drug Delivery and MRI Contrast Agent

Research Area: *Metallo-Supramolecular Chemistry*

The aim of this proposal is to design and synthesise several new classes of discrete spin transition metallo-supramolecular nanomaterials for applications in biology and medicine including DNA binding, magnetic resonance imaging (MRI) and drug delivery. There is wide opportunity to explore, for the first time, DNA binding for cellular targeting using spin-crossover (SCO) assemblies and to develop an innovative approach for probing DNA binding using such metallo-supramolecular materials that undergo motional or mechanical changes triggered by fine tuning the spin state of the switching sites. At the applied level, spin transition metallo-supramolecular assemblies are expected to spur the development of a new class of tumour-selective drugs and spin-activated MRI contrast agents that involve switching between paramagnetic and diamagnetic states. In addition, metallo-supramolecular assemblies exhibiting three-dimensional cage-like architectures with mesoporosity will be designed as drug carriers to deliver a drug to a desired location and then release it by mechanically opening the door of the carrier in a spin-controlled manner.

The specific Objectives are as follows:

1. Nanoscale discrete spin-switch metallo-supramolecular assemblies
    - To employ directed assembly procedures, hierarchical or stepwise syntheses and template controls for constructing innovative finite nanometre-scale spin-switch assemblies that include three categories: (1) mononuclar, dinuclear and trinuclear coordination complexes with rigid planar aromatic ligands; (2) cones, single stranded complexes, double stranded helicates, triple stranded cylinders and rigid polynuclear complexes; (3) homonuclear coordination cage and capsule systems as well as heteronuclear/mixed-valence supramolecular polyhedra using both functional organic ligands and tripodal metalloligands;
    - To observe and study spin-switching behaviours by variation of both the steric nature of the ligand type employed and the applied external stimulus (e.g., temperature and light) as well as to explore the structural and electronic features that impart electronic communication in such SCO systems;
    - To integrate such materials that show an abrupt spin transition near the body temperature (between 36-40°C) into practical applications involving DNA interaction, MRI and drug delivery.
2. DNA interaction
    1. To investigate DNA recognition by variation of both the steric nature of the ligand type and the external stimulus (e.g., temperature and light);
    2. To determine how the selectivity of DNA binding can be fine-tuned using geometric modification of the metallo-intercalators associated with the spin transition process;
    3. To develop new SCO-based DNA probes as therapeutic agents which can recognize and cleave DNA, in particular metal-based DNA-binding drugs which target abnormal cells (e.g., cancerous cells) in the presence of normal cells, and investigate DNA-mediators of electronic communication.
3. Spin-activated MRI contrast agents
    - To develop new spin-activated chemical exchange saturation transfer (CEST) agents that can switch between paramagnetic and diamagnetic states by variation of an external stimulus (e.g., temperature and light) and to integrate traditional Gd3+-based MRI contrast agents into SCO assemblies to produce multifunctional contrast agents;
    - To explore the variation of the image intensity achieved by both spin-activated MRI contrast agents and multifunctional contrast agents under the same conditions by just tuning the external stimulus and observing the relationship between Gd3+-based and spin-activated sites of multifunctional contrast agents;
    - To exploit iron(II)-based CEST contrast agents using MRI techniques in living specimens and achieve new classes of MRI contrast agents for eventual use in clinical applications.
4. Drug delivery
    - To explore the potential of new delivery systems based on spin transition coordination cages which incorporate readily variable functional groups (e.g., unsaturated metal sites to increase loading capacity) and tuneable pores sizes.
    - To investigate drug release processes involving motional changes triggered by tuning of the spin state of the switching sites leading to control release mechanisms.
    - To develop new classes of optimal drug-delivery materials involving multifunctional components.
    - In summary, while the focus of this project is on the design of metallo-supramolecular materials and evaluation of their molecular recognition properties and molecular imaging involving spin transition behaviour, as outlined above it is anticipated that the materials produced will have potential applications in DNA binding, drug delivery and MRI contrast agents.

Keywords: Spin-Switch Materials, DNA Binding, MRI Contrast Agents, Drug Delivery System

Supervisor: Dr Christopher Jones, Dr Leon Burgess-Dean (Industry partner), Dr Mariam Darestani (SoE)

Project Title: Analysing novel ceramic composites

Research Area: *Inorganic, Physical Chemistry*

CalAlSil™ is a material technology company committed to the development of sustainable materials for the building and construction industry. Their work resulted in the invention of a world first alkali-alumino-silicate resin system. These resins and their composites are applicable replacements for concrete, fired clay and organic polymer fibre composites and offer a new benchmark for sustainable materials. This project aims to use analytical and imaging techniques to provide a comparison of material and mechanical properties for CalAlSil®'s Alkali-Alumino-Silicate-organic hybrid resin and composites across a broad range of compositions. The project will produce a detailed evaluation of CalAlSil®'s chemical and structural character and fire properties compared with mechanical strength, fracture toughness and density. The results will provide a summary of the composite polymer's material properties so they can be compared with current fire-retardant polymers and polymer concretes. This is an opportunity for a student to gain experience and knowledge in a broad range of advanced characterization techniques, including infrared spectroscopy, electron microscopy (see figure on right), calorimetry, sample formulation and mix design and mechanical testing. This multidisciplinary project will allow the student to work with industry and across the schools of Science and Engineering.

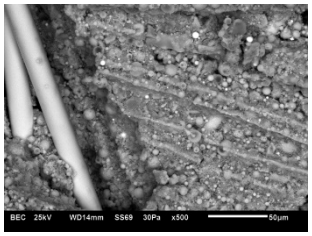


Photo by Jan Kopřiva on Unsplash

Conservation & Ecology

Supervisor: Dr Christa Beckmann

Project Title: Avian Ecology and Conservation

Research Area: *Animal Behaviour, Human-Wildlife Conflict, Predator-Prey Relationships, Breeding Ecology, Invasive Species, Conservation Biology*

The research team studies animal behaviour and ecology, with a focus on birds. Research topics include conservation, predator-prey relationships, breeding ecology, vocal communication, predator-prey dynamics, and human-wildlife conflict. Most projects will involve field work, some can be lab-based. I encourage students to contact me to chat about project ideas and interests; a few ideas are listed below however we can discuss variations based on your interests:

1. Why do birds sing on the nest? Vocalizing on the nest can attract predators – this study will assess the costs and benefits of vocalizing on the nest.
2. Noisy Neighbours: Do native birds sing less when invasive birds are singing? Biological invasions are one of the greatest threats to biodiversity. The calls of invasive species are an important source of novel noise, yet their effects on native species are poorly understood. This project will examine the effects of invasive songbirds on the vocal activity of native Australian birds.
3. Human-Wildlife Conflict. The world is rapidly urbanizing, and it is predicted that by 2050, 66% of the global human population will be living in urban areas. Urban expansion is detrimental to many bird species, yet a few have adapted to urban life. This inevitably creates conflict between humans and wildlife. This study will investigate how birds such as parrots choose roost sites in cities, and bird activity and behaviour at the roosts.

Students are based at the Hawkesbury Campus

Keywords: Animal Behaviour, Human-Wildlife Conflict, Predator-Prey Relationships, Breeding Ecology, Invasive Species, Birds, Bioacoustics, Field Work

References:

Beckmann, C., & Martin, K. (2016). Testing hypotheses about the function of repeated nest abandonment as a life history strategy in a passerine bird. Ibis, 158(2), 335-342

Beckmann, C., & McDonald, P. G. (2016). Placement of re-nests following predation: are birds managing risk? Emu-Austral Ornithology, 116(1), 9-13

Flegeltaub, M., Biro, P. A., & Beckmann, C. (2017). Avian nest abandonment prior to laying—a strategy to minimize predation risk? Journal of ornithology, 158(4), 1091-1098

Bleach, I. T., Beckmann, C., Both, C., Brown, G. P., & Shine, R. (2015). Noisy neighbours at the frog pond: effects of invasive cane toads on the calling behaviour of native Australian frogs. Behavioral Ecology and Sociobiology, 69(4), 675-683

Supervisor: Dr Amy-Marie Gilpin, Dr Kate Umbers

Project Title: Understanding interactions between the introduced honeybee Apis mellifera and native bees on a communal floral resource

Research Area: *Behavioural Ecology*

Since their introduction 200 years ago, the European honeybee, Apis mellifera, has successfully invaded most ecosystems within Australia (Paton 2003; Prendergast et al., 2022). Their dominance within many plant-pollinator networks (Hermannssen et al., 2014; Gilpin et al., 2014), combined with their generalist foraging behaviour means that there is the potential for honeybees to compete with native bees for floral resources. Understanding the foraging behaviour of honeybees and native bees on shared floral resources is important in determining whether there is competitive displacement of polllinators which can lead to impacts on health and in addition on pollination services provided to the plant.

This project will provide the student with an understanding of the fundamentals of research – from hypothesis development to experimental design and data collection – providing a solid framework for future participation in HDR study in the area of plant- pollination ecology and behaviour. The student joining this project will have opportunity to learn how to collect data within a field setting, analyse experimental data using behavioural software programs and communicate their findings in a variety of ways.

Figure 1. A native Tetragonula carbonaria and introduce honeybee Apis mellifera forage on an apple flower.

Keywords: Introduced Pollinator; Behavioural Ecology; Interspecific Competition; Resource Overlap.

References:

Gilpin, A.M., Ayre, D.J. and Denham, A.J., 2014. Can the pollination biology and floral ontogeny of the threatened Acacia carneorum explain its lack of reproductive success?. Ecological research, 29(2), pp.225-235.

Hermansen, T.D., Britton, D.R., Ayre, D.J. and Minchinton, T.E., 2014. Identifying the real pollinators? Exotic honeybees are the dominant flower visitors and only effective pollinators of Avicennia marina in Australian temperate mangroves. Estuaries and Coasts, 37(3), pp.621-635.

Paini, D.R., 2004. Impact of the introduced honey bee (Apis mellifera)(Hymenoptera: Apidae) on native bees: a review. Austral ecology, 29(4), pp.399-407.

Paton, D.C., 1993. Honeybees in the Australian environment. Bioscience, 43(2), pp.95-103.

Prendergast, K.S., Dixon, K.W., Bateman, P.W. and Calver, M., 2022. The evidence for and against competition between the European honeybee and Australian native bees. Pacific Conservation Biology.

Supervisor: Dr Clarissa House, A/Prof Robert Spooner-Hart

Project Title: Investigating the invasiveness of an internationally important pest species, the small hive beetle

Research Area: *Entomology, Environmental Research, Zoology, Evolution*

Small hive beetle, Aethina tumida has been known as a parasite of honeybee, Apis mellifera, colonies native to sub-Saharan Africa. It has become an important invasive species and is now established worldwide (including eastern Australia). While it is a minor pest in Africa, it can cause significant damage to apiculture within its invasive ranges as well as infesting nests of other bee species. Its rapid range expansion and impacts requires a better understanding to mitigate these invasions.

Figure 1. Adult small hive beetle

Figure 2. Infestation of small hive beetle larvae in honeybee hive

This project provides opportunities for up to 3 MRes students:

To work as part of a new international project with researchers from 7 countries, including the Australian researchers, on the small hive beetle (SHB) - an important invasive insect pest of honeybees and other endemic bees.

- To explore fundamental evolutionary aspects of biological invasions, using SHB as a model system.
- To select aspects of the project that are of personal interest, e.g. mating systems (i.e. polyandry), trade-offs (i.e. fecundity and starvation/immunity), molecular studies (i.e. DNA paternity tests) etc.
- Provide opportunities to publish in high-impact journals.
- The project aims to investigate the biology of invasive SHB populations in Australia, and compare them with invasive populations in Italy, USA and Brazil, as well as endemic populations from South Africa and Kenya.

We aim to test the hypotheses:

A. Polyandry (multiple mating by females) is a preadaptation for invasion success.
B. Adaptive shifts in mating and in reproductive traits increase invasion impact.
C. Trade-offs between fecundity and starvation resistance/immunity to diseases foster adaptive shifts.
D. Heritability of certain traits differs between endemic and invasive range, reflecting distinct selection scenarios.

SHB populations occur on the Hawkesbury campus, as well as other parts of coastal NSW (i.e. they are easily accessible).

The WSU supervisors have experience in collecting and rearing SHB, and its biology.
There will also be opportunities for communication with international project team researchers.

Keywords: Entomology, Honeybee, Biological Invasions

References:

Neumann P, Pettis JS & Schäfer MO. 2016 Quo vadis Aethina tumida? Biology and control of small hive beetles. Apidologie 47, 427–466.

Neumann P, Spiewok S, Pettis J, Radloff S, Spooner-Hart R, Hepburn H 2018. Differences in absconding between African and European honey bee subspecies facilitate invasion success of small hive beetles. Apidologie. doi: 10.1007/s13592-018-0580-4.

Mustafa SG, Spooner-Hart R, Duncan M, Pettis JS, Steidle JLM, Rosenkranz P 2015. Age and aggregation trigger mating behaviour in the small hive beetle, Aethina tumida (Nitidulidae). Naturwissenschaften 102:49. doi: 10.1007/s00114-015-1300-9.

Spooner-Hart R, Annand N, Duncan M 2017. The small hive beetle in Australia. In The small hive beetle - a growing problem in the 21st century N.L. Carreck (ed). International Bee Research Association / Northern Bee Books; Congresbury, UK. ISBN: 978-0-86098-278-4 p. 59-74

Supervisor: Dr Thomas Jeffries

Project Title: Biogeography of Australia's Ocean Microbiome

Research Area: *Microbiology, Ecology*

Prokaryotes are dominant organisms in the world's oceans and coastal regions and are responsible for driving global nutrient cycles, measuring the response to climate change and indicating pollution levels. Only recently, due to advances in DNA sequencing and computational tools, has this vast pool of dynamic microbial diversity been accessible to microbiologists.

This project will utilize a continental scale survey of seven national reference stations which cover several distinct climatic regions and ocean currents (Fig 1) over several decades. The project will involve analyzing 16S and 18S rDNA sequences to profile how microbial diversity shifts over depth, and spatially as a response to changing environmental variables. Network metrics that profile the extent of microbial interaction, indicative of the ecological resilience of the microbiome to change, will be used within the context of increasing sea surface temperature and strengthening tropical currents driven by climate change. Details of the project can be tailored to suit the student's interest.

This project will suit a student with an interest in microbiology and ecology, with reasonably well developed computer and statistics skills or a willingness to learn these.

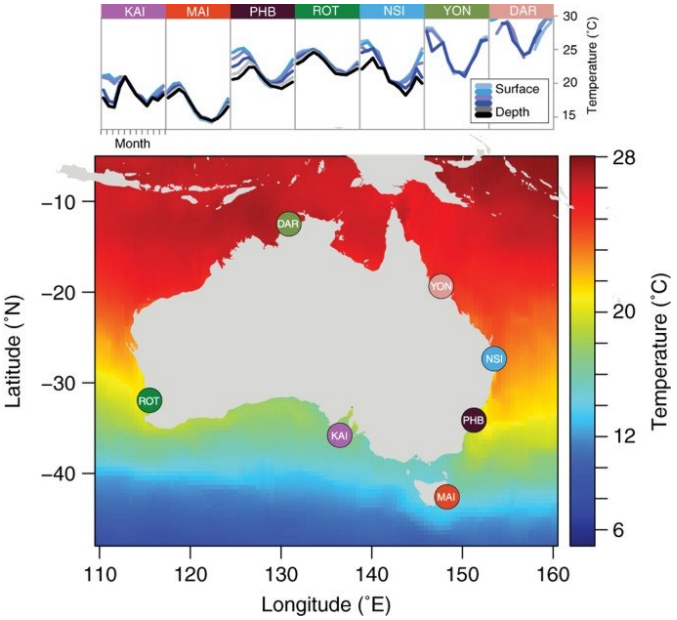


Fig 1, Australia's Ocean Microbiome reference sites and environmental gradients, Brown et al, 2018.

Keywords: Microbiome, Ocean, Biogeography, Network Analysis, Microbial Ecology

References:

Brown, M., van de Kamp, J., Ostrowski, M. et al. Systematic, continental scale temporal monitoring of marine pelagic microbiota by the Australian Marine Microbial Biodiversity Initiative. Sci Data 5, 180130 (2018). https://doi.org/10.1038/sdata.2018.130

Supervisor: Dr Thomas Jeffries, Dr Eleonora Egidi (HIE)

Project Title: Diversity Hotspots in Australia's Soil Microbiome

Research Area: *Microbiology, Ecology*

Prokaryotes and fungi are dominant organisms in soils and are responsible for driving global nutrient cycles, measuring the response to climate change and determining soil health. Only recently, due to advances in DNA sequencing and computational tools, has this vast pool of dynamic microbial diversity been accessible to microbiologists.

This project will utilize a continental scale survey of Australia's soils which cover several distinct climatic regions and land use types (Fig. 1) The project will involve analyzing 16S rDNA and ITS sequences to profile how microbial diversity shifts over spatially as a response to changing environmental variables. Network metrics that profile the extent of microbial interaction, indicative of the ecological resilience of the microbiome to change, will be used to find hotspots of microbial diversity and keystone species abundance allowing us to determine soils relevant to conservation and biosprospectying. Details of the project can be tailored to suit the student's interest.

This project will suit a student with an interest in microbiology and ecology, with reasonably well developed computer and statistics skills or a willingness to learn these.

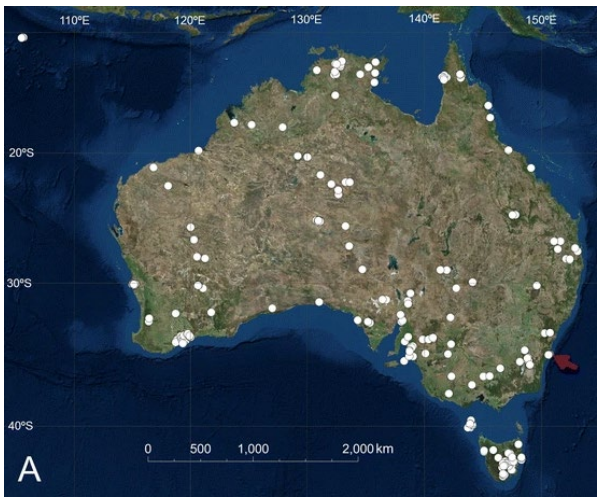


Fig 1, Australia's Soil Microbiome Sampling Sites, Bissett et al, 2016

Keywords: Soil, Biodiversity Biogeography, Network Analysis, Microbial Ecology

References:

Bissett, A., Fitzgerald, A., Meintjes, T. et al. Introducing BASE: the Biomes of Australian Soil Environments soil microbial diversity database. GigaSci 5, 21 (2016). https://doi.org/10.1186/s13742-016-0126-5

Supervisor: A/Prof Julie Old

Project Title: WomSAT

Research Area: *Citizen Science And Wombats*

WomSAT (Wombat Survey and Analysis Tool) is a citizen science project that collects data on wombats (Fig. 1), specifically information on sarcoptic mange incidence and roadkill in real-time. The data collected is being used to conserve wombats. To ensure citizens are continuing to collect data, and to educate the wider community about wombat, citizens must continue to engage in the project, hence this project will be involved in promotion of citizen science to the wider community. Data collected using WomSAT will be analysed to identify trends and educate the community about wombats.

Fig. 1 WomSAT logo

Keywords: Citizen Science, Wombat, Conservation, Roadkill, Sarctopic Mange

References:

Mayadunnage S., Stannard HJ, West P, Old JM (2022). Identification of hotspots and the factors affecting wombat vehicle collisions using the citizen science tool, WomSAT. Australian Mammalogy. Accepted DOI: 10.1071/AM22001

Thorley RK, Old JM (2020). Distribution, abundance and threats to bare-nosed wombats (Vombatus ursinus). Australian Mammalogy. 42, 249-256. DOI: 10.1071/AM19035

Skelton C, Cook A, West P, Spencer R-J, Old JM (2018). Building an army of wombat warriors: developing and sustaining a citizen science project. Australian Mammalogy. 41, 186-195. DOI: 10.1071/AM18018

Old JM, Sengupta C, Narayan E, Wolfenden J (2018). Sarcoptic mange in wombats – A review and future research directions. Transboundary and Emerging Diseases. 65, 399-407. DOI: 10.1111/tbed.12770.

Supervisor: A/Prof Julie Old

Project Title: Wombat care

Research Area: *Conservation And Wildilfe Care*

Wildlife carers spend large amounts of time and effort caring for wombats (Fig. 1). This project will survey wombat carers regarding how much time and money they spend caring for wombats, as well as investigating the reasons wombats come into care, how long they spend in care, and the outcomes of those wombats. The information obtained will provide information to management agencies on how best to support wombat carers.

Fig. 1 Baby wombat in care

Keywords: Wildlife Care, Wombat, Conservation, Roadkill, Sarcoptic Mange

References:

Old JM, Skelton CJA, Stannard HJ (2021). The use of Cydectin® by wildlife carers to treat sarcoptic mange in free-ranging bare-nosed wombats (Vombatus ursinus). Parasitology Research. 120, 1077-1090. DOI: 10.1007/s00436-020-07012-8

Fabian MC, Cook AS, Old JM (2020). Do Australians have the willingness to participate in wildlife conservation? Australian Zoologist. 40, 575-584. DOI: 10.7882/AZ.2019.010

Fabian MC, Cook AS, Old JM (2020). Attitudes towards wildlife conservation. Australian Zoologist. 40, 585-604. DOI: 10.7882/AZ.2019.017

Supervisor: A/Prof Julie Old

Project Title: Wombat immune system

Research Area: *Comparative Immunology*

Wombats are under significant threat from sarctopic mange, a disease initially caused by the mite, Sarcoptic scabiei. After a wombat has been infected, it leads to a slow and painful death for the wombat, with it ultimately dying as a result of secondary infections (Fig. 1). Despite this disease being well documented, we know relatively little about the immune system and response of wombats, or even their immune tissues. This project will describe and document the immune system of wombats to gain insights into its function. The project will incorporate publicly available genomic information and may also incorporate histological studies.

Fig. 1. A wombat suffering from sarcoptic mange

Keywords: Comparative Immunology, Marsupial, Wombat, Conservation, Sarcoptic Mange

References:

Schraven AL, Hansen VL, Morrissey KA, Stannard HJ, Ong OTW, Douek DC, Miller RD, Old JM (2021). Single-cell transcriptome analysis of the B-cell repertoire reveals the usage of immunoglobulins in the gray short-tailed opossum (Monodelphis domestica). Developmental and Comparative Immunology. 123, 104141. DOI:

Schraven AL, Stannard HJ, Ong OTW, Old JM (2020). Immunogenetics of marsupial B-cells. Molecular Immunology. 117, 1-11. DOI: 10.1016/j.molimm.2019.10.024

Old JM, Hermsen E, Young LJ (2019). Major Histocompatibility Complex Class II in the bare-nosed wombat (Vombatus ursinus). Australian Mammalogy. 42,135-143. DOI: 10.1071/AM19015

Borthwick CR, Young LJ, Old JM (2019). An examination of the development and localisation of key immune cells in developing pouch young of the red-tailed phascogale (Phascogale calura). The Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology. 302, 1985-2002. DOI: 10.1002/ar.24176

Old JM, Sengupta C, Narayan E, Wolfenden J (2018). Sarcoptic mange in wombats – A review and future research directions. Transboundary and Emerging Diseases. 65, 399-407. DOI: 10.1111/tbed.12770.

Ong O, Young LJ, Old JM (2016). Preliminary genomic survey and sequence analysis of the complement system in non-eutherian mammals. Australian Mammalogy. 38, 80-90. DOI: 10.1071/AM15036

Borthwick CR, Old JM (2016) Histological development of the immune tissues of a marsupial, the red-tailed phascogale (Phascogale calura). Anatomical Record. 299, 207-219. DOI: 10.1002/ar.23297

Borthwick CR, Young LJ, Old JM (2014). The development of the immune tissues and in marsupial pouch young. Journal of Morphology. 275, 822-839. DOI: 10.1111/vcp.12094.

Belov K, Miller RD, Old JM, Young LJ (2013). Marsupial immunology bounding ahead. Australian Journal of Zoology. 61, 24-40. DOI: 10.1071/ZO12111

Old JM, Deane EM (2000). Development of the immune system and immunological protection in marsupial pouch young. Developmental and Comparative Immunology. 24(5), 445-454. DOI: 10.1016/S0145-305X(00)00008-2

Supervisor: Dr Jason Reynolds, Prof Jeff Powell

Project Title: Circular economies and soil health

Research Area: *Soil Science, Soil Ecology*

The School of Science and The Hawkesbury Institute for the Environment are part of a new ARC Research Hub on Nutrients in a Circular Economy (NiCE). The NiCE Hub brings together researchers from multidisciplinary fields at several leading Australian universities and is partnered with industry, working towards building a circular economy for nutrients to grow our food and to manage our greenspaces. With climate modelling indicating a warmer and drier western Sydney region, the recovery of resources from waste and their use on land areas may be of benefit to blue and green landscape management, agriculture, and horticulture.

The aim of our work here is to support the repair of degraded soils. Through the addition of recovered resources it may be possible to reverse poorly performing soil and transform them into productive and healthy ecosystems. To achieve this, a combination of field and lab-based investigations soils and their interactions with these recycled materials are required. This will ensure future land management is appropriate for maximising nutrient capture in soil and minimising losses due to leaching, runoff and greenhouse gas emission. It will also ensure that these recycled materials are safe, fit-for-purpose and as easy to use as conventional fertilisers.

Come talk with us to discuss any similar ideas. Our work provides an attractive opportunity for potential research students who have an interest in plant-soil ecology, soil geochemistry, pedologic processes and sustainable land management and who are looking for training in a variety of lab-, field- and data-based analytical techniques that will be useful in many workplaces. Our work also offers engagement with industrial partners responsible for managing water and waste, as well as identifying new markets for recovered resources, providing that all-important foot-in-the-door for those interested in working with or in industry during their career.

Keywords: Sustainability, Soil Fertility, Carbon Farming, Resource Recovery, Waste Diversion

References:

Breure, A. M., J. P. A. Lijzen, and L. Maring. 2018. “Soil and Land Management in a Circular Economy.” Science of The Total Environment 624 (May): 1125–30. https://doi.org/10.1016/j.scitotenv.2017.12.137 .

Wald, Chelsea. 2022. “The Urine Revolution: How Recycling Pee Could Help to Save the World.” Nature 602 (7896): 202–6. https://doi.org/10.1038/d41586-022-00338-6 .

Supervisor: Dr Jason Reynolds, Dr Richard Wuhrer (AMCF), Dr Daniel Fanna (AMCF)

Project Title: Looking for old dirt and older meteorites

Research Area: *Earth Sscience.*

Only a few years ago (about ~259 million years give or take) a large extinction period occurred. So severe were the several events in this period that almost everything on Earth became extinct. We tend to think these sorts of events impacted other locations around the world whilst we think of Australia as being rather dull and flat. However, we can find evidence of catastrophic events in the Sydney-basin and around several other tourist destinations within the Australian continent. One potential project will investigate some of the ancient soils that existed prior to these catastrophic events to try and understand what existed before it stopped existing. A second potential project will look at collecting meteorites and providing a chemical and physical characterisation of these materials to understand their origin within the universe.

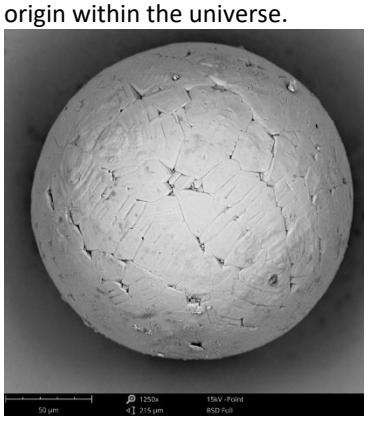


Figure 1. Tiny micrometeorite particle under Scanning Electron Microscopy

The Advanced Materials Characterisation Facility (AMCF) at WSU is home to a suite of state-of-the-art instruments for characterisation of materials. During the course of this investigation, the student candidate will be gain experience in the use of several advanced tools for materials characterisation these include:

1. Scanning Electron Microscopy and Microanalysis
2. X-Ray Diffraction
3. X-ray mapping

The candidate will become a competent operator of many advanced characterisation techniques. The candidate will also develop the associated sample preparation skills for these methods, and experience with the use of typical characterisation. Potential students are welcome to reach out and discuss project ideas of a similar nature.

Keywords: Meteorite, paleosol, earth science.

Supervisor: A/Prof Ricky Spencer, Dr Michelle Ryan, Dr Jenna Condiw (SoSS) and a team from UNE, La Trobe, University of Sydney, and Australian Reptile Park

Project Title: 1 Million Turtles Citizen Science and Conservation Project

Research Area: *Ecology, Conservation, Citizen Science*

We are creating Australia's largest, community-empowered, conservation program. Local communities will lead "expansionary conservation", where we aim to release more than 1 million extra turtles throughout Australia each year.

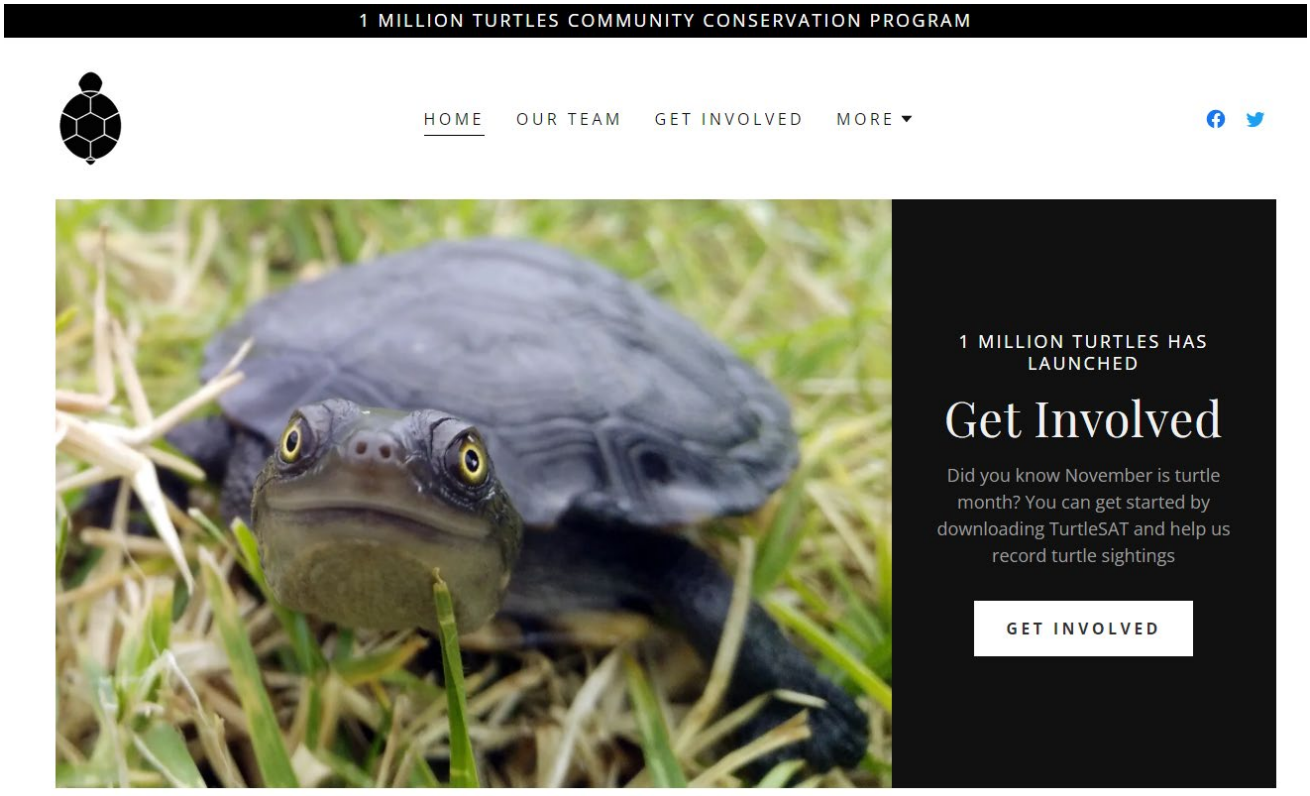
Through Citizen Science, the 1 Million Turtles Community Conservation Program will support turtle conservation initiatives, such as "Turtles in the Schools" or the creation of protected islands and nesting grounds around local wetlands, urban parks, and even golf courses.

There are up to 10 research projects associated with this project including:

1) Emerging technologies and mitigation strategies to manage fox predation (up 3 projects)
2) Population genetics, disease risk and survival of critically endangered species (through the Australian Reptile Park) (2-3 projects)
3) Turtles in the schools program (2 projects)
4) Floating Island technology and Ecology (2 porjects)

These projects will see you working in various parts of the country and with a ranges of stakeholders, such as the Australian Reptile Park, Aussie Ark, Foundation for National Parks and Wildlife (Charity of the Year), as well as community group and and governmenet agencies.

These projects will ensure that our freshwater turtle populations persist into the future, as well as set a new standard in Citizen Science and Community Conservation



Keywords: Conservation, Wildlife, Turtle, Ecology, Citizen Science

References:

See 1MillionTurtles.com

Supervisor: Dr Christopher Turbill

Project Title: Thermal physiology, behavioural ecology and energetics of Australian birds

Research Area: *Animal Physiological Ecology*

Birds and mammals are endotherms, which means they have high rates of metabolism even while resting, and for smaller species their resting energy costs increase greatly in cold conditions. The high energy cost for maintenance of small birds and mammals can be difficult to sustain in the face of natural variation in food supply and environmental conditions (e.g. during winter, or extreme weather events). A solution to the problem of avoiding starvation used by some birds and mammals is to temporarily reduce their body temperature 'set-point' and allow themselves to cool below normal levels This controlled physiological state of hypothermia is called torpor. Like turning down the thermostat in your central heating system, using torpor provides a large energy saving for small mammals and birds.

There is a gap in our knowlegde about the whether and how birds in Australia use torpor (whereas we know torpor is used extensively among our native small mammals). This information is important because an ability to use torpor, and hence save a lot of energy and reduce the chance of starvation, has wide-ranging and fundamental implications for understanding the behaviour and ecology (e.g. how they forage, where they live, how their populations change over time) of Australia's native bird fauna.

A range of rewarding and achievable research projects for MRes or PhD students are possible under my supervision in this area. These projects would record the thermoregulatory physiology of Australian birds and relate thermal and energetic physiological responses to measurements of behavioural ecology. Projects would involve methods including 'biologging' of body temperature in wild birds, radio-tracking to record behvaiour, and lab-based studies using respirometry methods to quantify metabolic energy expenditure.

Keywords: Animal, Behaviour, Ecology, Environment, Physiology, Temperature, Zoology

References:

Romano, Hunt Welbergen, and Turbill (2019) Nocturnal torpor by superb fairy-wrens : a key mechanism for reducing winter daily energy expenidture. Biology Letters 15: 20190211. https://royalsocietypublishing.org/doi/10.1098/rsbl.2019.0211
Geiser (2006) Torpor in Australian Birds. Acta Zoologica Sinica 52: 405-408.
https://www.une.edu.au/__data/assets/pdf_file/0009/35748/TorporOzBirdsZoolSin06.pdf

Supervisor: Dr Christopher Turbill, A/Prof. Justin Welbergen

Project Title: Vulnerability of Australian bats to White-nose Syndrome – a catastrophic Fungal Disease

Research Area: *Conservation Physiology; Behavioural Ecology*

This project addresses the serious risk posed by a new fungal disease called white-nose syndrome to Australia's cave-roosting insectivorous bats. White-nose syndrome has decimated bat populations across North America, and this fungus is predicted to be accidently introduced into Australia within the next 10 years.
In this project we aim to gather the missing information we need about the winter biology of Australian insectivorous bats to assess the threat posed by white-nose syndrome of their survival. These data will be used to produce models of vulnerability to white-nose syndrome that can direct actions to prevent, detect and mitigate the impacts of this potentially catastrophic wildlife disease. In addition, it will provide the first detailed information about the winter ecology and hibernation biology of Australian cave-roosting bats.

This project is funded by an ARC 'Linkage Project' grant led by Dr Turbill and involving investigators from the Hawkesbury Institute for the Environment (A/Prof. Welbergen) and other organisations, including Taronga Conservation Society and government conservation departments.

There are a range of opportunities for MRes students to develop their own important research projects within the overall scope of funded research program. The MRes student would join a team of other MRes and PhD students, and a Postdoctoral Research Fellow working towards a common goal on this project.

Potential MRes research projects could address any of the following research areas:

- Temperature and humidity within winter cave roosts of bats and habitat suitability for fungal growth
- Thermal and metabolic physiological traits of bats
- Roosting behaviour and winter activity of bats during winter
- Theromregulatory behaviour and energetics of bats during winter
- Mapping of vulnerability using mechanism-based models
- Population monitoring to establish a baseline for regional bat populations

For more information about this project and other bat research at Western, see: https://www.batslab.org

Keywords: Animals, Bats, Conservation, Disease, Metabolism, Physiology, Thermoregulation, Threatened Species, Wildlife

References:

Turbill C. and Welbergen JA. 2020. Anticipating white-nose syndrome in the southern hemisphere: widespread conditions favourable to Psuedogymnoascus destructans pose a serious risk to Australia's bat fauna. Austral Ecology, 45(1): 89-96.

Supervisor: A/Prof Justin Welbergen; Dr Jessica Meade; A/Prof Matthias Boer; Dr Christopher Turbill; Dr John Martin

Project Title: Improving conservation management outcomes for flying-foxes (Pteropus spp.)

Research Area: *Conservation Biology; Wildlife Management*

Flying-foxes are charismatic bats found across the Old World and Australia. They are among the most mobile mammals on earth by most measures, and their extreme mobility makes them key long-distance pollen and seed dispersers in Australia's fragmented forest ecosystems. However, their extreme mobility also has important implications for the zoonotic dynamics of flying-fox populations and for current management practices in flying-fox conservation and human-wildlife conflict mitigation.

Sound conservation management of flying-foxes is predicated on a better understanding of flying-fox movements, population status, and threats. To this end, the Lab of Animal Ecology at the Hawkesbury Institute for the Environment has funding, equipment and logistical support available for five distinct projects aimed at improving conservation management outcomes for these ecologically important species:

1) Heat stress: Determine of the vulnerability of flying-foxes to extreme heat events, and provide a much-needed evidence base for management and conservation. (Welbergen, Meade, Turbill, Martin)
2) Population monitoring: Capitalise on new methodologies (radar and drones) developed by the research team to monitor flying-foxes at nationally important camps. (Welbergen, Meade, Boer, Martin)
3) Foraging resource mapping: Develop remotely sensed landscape-scale nectar availability maps to highlight spatially explicit targets for flying-fox habitat conservation and restoration. (Welbergen, Meade, Boer, Cook, Martin)
4) Urbanisation: determine what supports flying-foxes in human-modified landscapes, to help managers make informed decisions regarding the conservation management of flying-foxes in urban environments (Welbergen, Martin, Meade)
5) Rehabilitation: Assess the survival of flying-foxes following rehabilitation, to help inform current rehabilitation practices (Welbergen, Martin, Meade)

The work will supervised by members of the Lab of Animal Ecology (www.animalecologylab.org) and affiliates at the Hawkesbury Institute for the Environment in collaboration with the Taronga Conservation Society. Primary supervisor Welbergen, with co-supervisors, has a history of successful MRes student completions with all students having managed to generate published outcomes from their theses.

Keywords: Animals, Animal Tracking, Bats, Climate Change, Conservation, Drones, Field Work, Radar, Wildlife Monitoring, Wildlife Urbanisation

References:

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Supervisor: A/Prof Justin Welbergen; Dr Anastasia Dalziell

Project Title: The acoustic ecology and conservation of the endangered rufous scrub-bird

Research Area: *Behavioural Ecology; Conservation Biology*

The rufous scrub-bird (Atrichornis rufescens) is a cryptic near-flightless passerine with a powerful song. It is one of only two extant species of the Atrichornithidae - the sister family to the lyrebirds (Menuridae). The rufous scrub-bird is classified as Endangered under the Commonwealth EPBC Act, and is restricted to five isolated sub-populations in high altitude habitat "islands" in NSW and Queensland, including an area south-east of Gloucester (the Gloucester Tops). Monitoring this listed species is a key to their conservation but the habitat in which the birds are found is challenging and remote. This study will involve development and application of acoustic monitoring techniques and other appropriate means of remote monitoring, aimed at increasing knowledge about the biology and behaviour of this intriguing but little-known species.

The work will supervised by members of the Lab of Animal Ecology (www.animalecologylab.org) and Lyrebird Lab (www.lyrebirdlab.org) at the Hawkesbury Institute for the Environment in collaboration with the Hunter Bird Observers Club.

Keywords: Animals, Birds, Bioaccoustics, Conservation, Field Work, Rufous Scrub-Bird

References:

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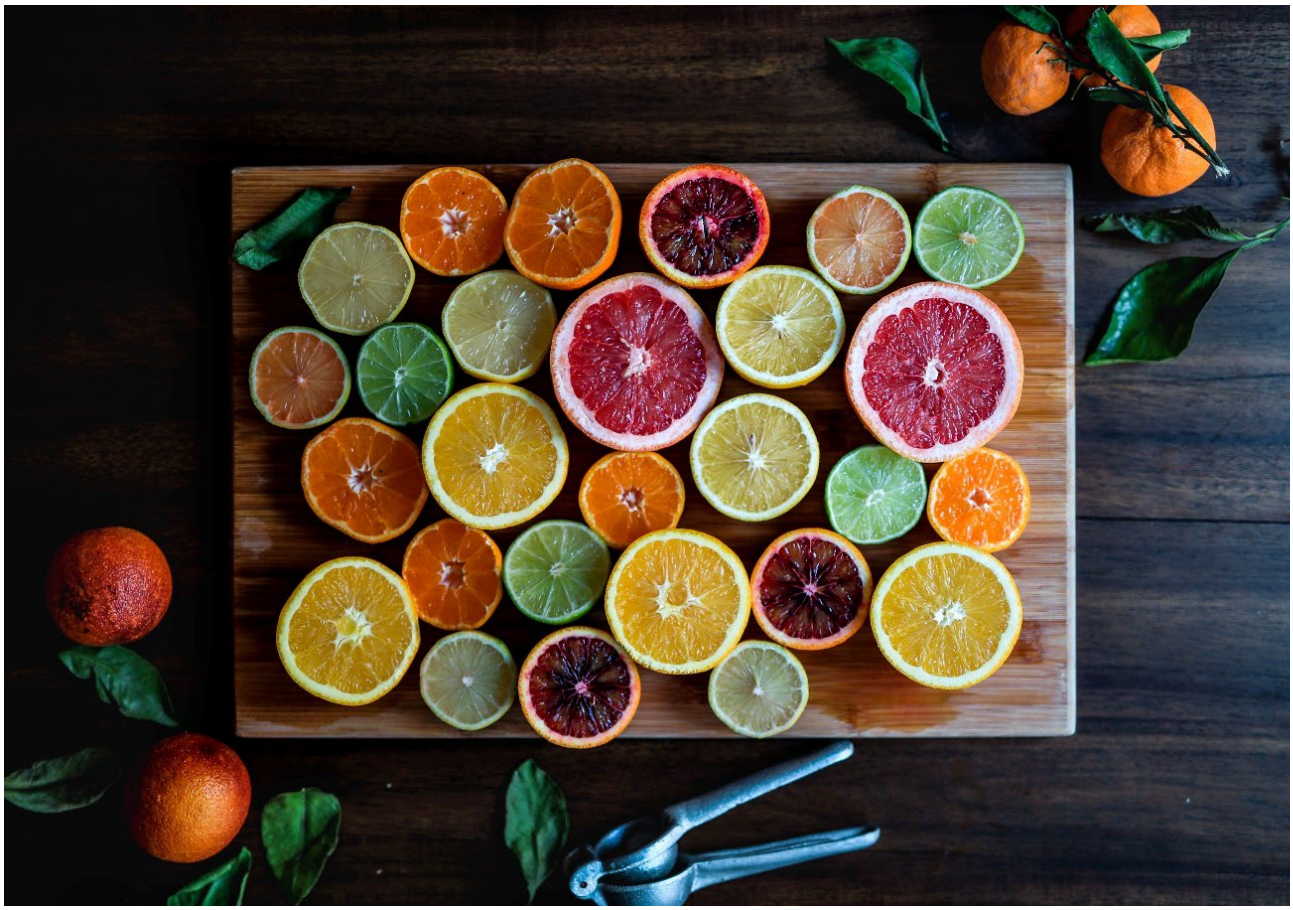

Photo by Edgar Castrejon on Unsplash

Food Science

Supervisor: Dr Li Li, Dr Sunil Panchal

Project Title: An independent audit of food and beverage items containing probiotics and/or prebiotics in major Australian supermarkets

Research Area: *Nutrition, Food Science, Health*

Food and beverage containing probiotics and/or prebiotics have flourished in local and global markets in recent years. This trend is largely due to increased provision and promotion of such products, accompanying rapidly expanding understanding of gut microbiome, probiotic microorganisms and prebiotic food components. This has attracted much public attention and nutrition practitioners commonly receive questions about which products to choose and how to select them among a myriad of products marketed based on potential health benefits associated with one or more probiotic and/or prebiotic ingredients. Recommenations and guidelines to guide practices on such topics are not widely available. The complexity and rapid expansion of knowledge and skills in this field increases burden for practitioners to embrace evidence-based and personalised recommendations of such products. This creates another barrier for consumers to identify and purchase a product suitable for their health management. This project thus aims to audit foods and beverages available in major Austalian supermarkets for probiotics and prebiotic ingredients. It will involve online and physical visits to supermarket outlets to identify and verify items containing probiotic and/or prebiotics ingredients. Documentation and recording of basic food product information including the ingredient list, nutrition information panel, and nutrition and health claims will be required. A preliminary database containg such information will be compiled. An audit of such ingrediants and claims based on relevant regulation locally and in major markets is also expected. This database can be further developed and distributed for clinical and public health uses, as well as adapted for consumer education. Promotion of products potentially beneficial for consumers can also help promote relevant food industry.

Keywords: Protiocs, Prebiotics, Food Products, Gut Microbiome

References:

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Supervisor: Dr Li Li, Dr Sunil Panchal

Project Title: Quality evaluation of anthocyanin rich foods and recipes

Research Area: *Food Science, Nutrition*

Accumulating evidence highlights the multiple health benefits of anthocyanins, a class of phytochemical compounds rich in most blue, purple and red fruits and vegetables. National nutrition surveys show stably low consumption of fruits and vegetables, including those rich in anthocyanins for the past couple of decades. Factors influencing consumer purchase and consumption of foods include but not limited to nutritional and sensory quality of foods. Information about nutritional content of anthocyanins recipes has been recognised by consumers as a strategy to promote anthocyanin-rich recipes. There is a lack of anthocyanin content in existing Australian food composition databases. The project thus aims to evaluate the nutritional content of common anthocyanin-rich foods and recipes previously compiled to provide good quantities of anthocyanins. Sensory evaluation of those foods and recipes can also be incorporated to highlight the sensory characteristics appreciated by the consumers.

The energy content can be analysed using bomb calorimetry, protein content using Dumas or Kjehldal method, fat content using Ankom or Soxhlet method, carbohydrate and dietary fibre using relevant AOAC approved methods, and sugar content using UPLC. The anthocyanin content can also be measured using HPLC or UPLC.

Sensory analysis will require human ethics approval, after which analysis with a trained panel or consumer groups can be carried out in the state-of-art sensory laboratory on Hawkesbury campus.

Information of the nutritional content and disirable sensory characteristics of such foods and recipes can assist the promotion and marketing of them. Such information can also inform the development of commercial food products such as ready-to-eat or packaged meals or snacks rich in anthocyanins.

Keywords: Anthocyanin, Fruits And Vegetables, Food Quality, Nutrition, Sensory

References:

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Photo by Tanya Kukarkina on Unsplash

Forensic Anthropology

Supervisor: Dr Hayley Green

Project Title: Forensic Anthropology - determining environmental influence on human decomposition

Research Area: *Forensic Anthropology and Taphonomy, Forensic Science*

Forensic Anthropology is traditionally the study of human skeletal remains to estimate factors such as sex, age, ancestry of an individual. Recently, forensic anthropologists have been tasked with answering questions such as whether a bone is human, what was the cause of death and how long has the person been deceased (alos know as the postmortem interval or PMI). All of these questions and analyses are important, as they contribute to the evidence that investigators use to determine identity of the individual and/or the circumstances before, during and after death.

Forensic taphonomy is the study of how the environment influences the human body after death during the decomposition process. Methods of assessing this impact include visual approaches, such as measuring decomposition using changes to soft tissue and correlating changes to time and climate data, to more multidiciplinary approaches that bring together forensic anthropology and taphonomy with disciplines such as chemistry, forensic biology, microbiology and soil science.

Examples of multidisciplinary projects currently being conducted by WSU students include:

- Use of alternative light sources to detect skeletal remains in outdoor crime scene scenarios
- Can field portable equipment (eg. Raman, FTIR and XRF) aid in the identification of:
    - Fragmentary human vs non-human bone?
    - Human from human in commingled/mass grave scenarios?
    - Estimation of PMI from skeletal remains?
- Microbiology and anthropology: an innovative scientific approach for estimating time since death
- Taphonomic changes and decomposition rates of remains after exposure to cold environments; a porcine model
- Estimation of time since death of remains found in the Hawkesbury/Western Sydney region: a porcine model

Future multidiciplinary projects include (but are not limited to):

- Relationships between soil composition and decomposition in the Western Sydney region
- Determination of time since death from fully skeletonised remains using multidiciplinary approaches
- Applications of field portable equipment to forensic investigations of human skeletal remains
- Proteomics in forensic analysis of human postmortem samples

With thes eprojects being co-led and supervised by expert academic staff in the School of Science.
Student designed projects and projects in collaboration with industry will also be considered.

Keywords: Forensic, Anthropology, Decomposition, Taphonomy, Multidisciplinary, Soil, Biology, Microbiology

References:

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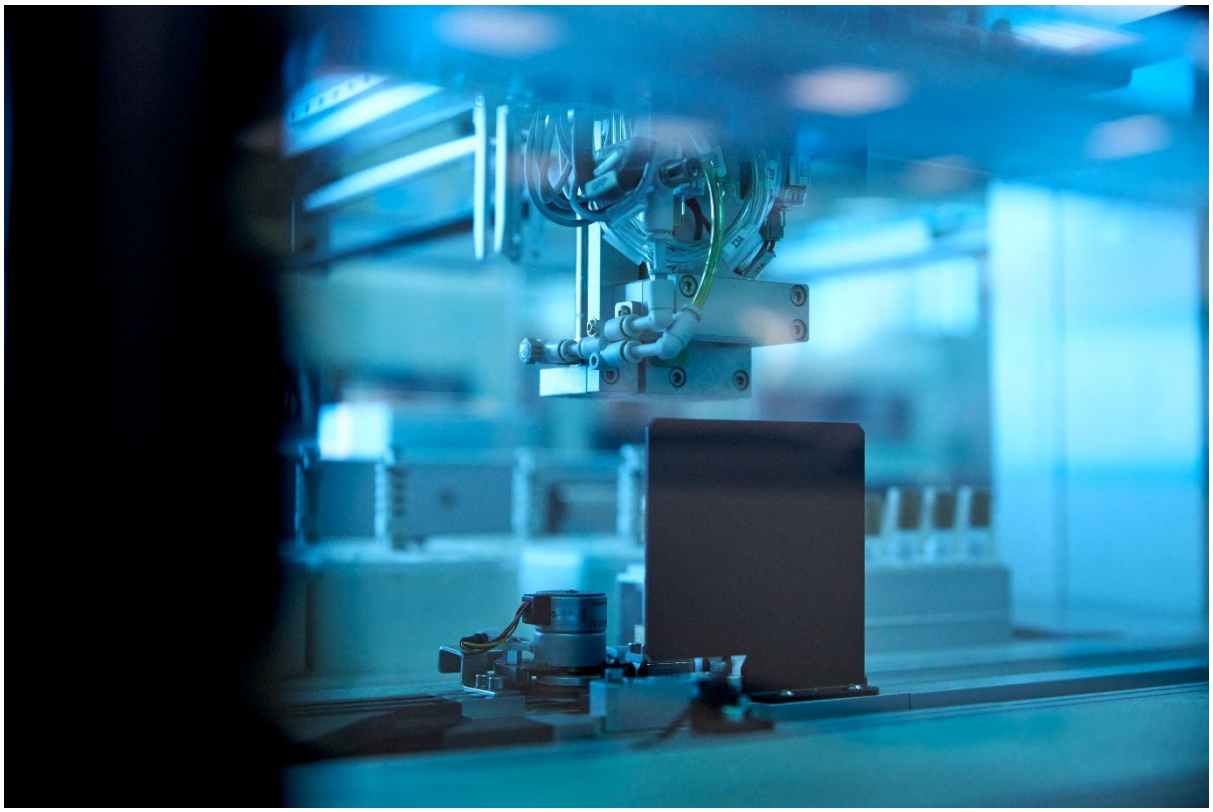


Photo by Testalize.me on Unsplash

Medical Science

Supervisor: Dr David Harman, Dr Aiden O'Loughlin, A/Prof Anand Hardikar

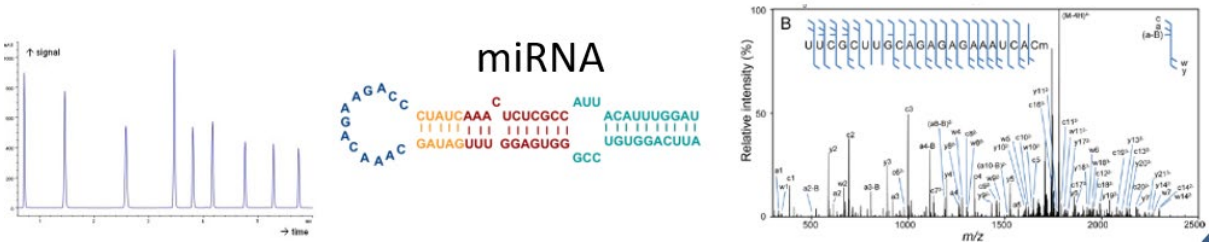
Project Title: Development of a mass spectrometry-based method for the early detection of atherosclerosis

Research Area: *Analytical Chemistry And Medical Diagnostics*

Atherosclerosis, the obstruction of arteries caused by the accumulation of fatty plaque deposits, is the single largest cause of human death worldwide. Despite the serious disease burden presented by this condition, medicine still lacks a simple, cheap, non-invasive test permitting its detection well before symptoms are observed. At present, diagnosis often relies upon angiography, a technique which is expensive, time consuming and imparts a significant radioactivity load to the patient.

Furthermore, existing technologies only enable detection of the disease in its more advanced stages. In contrast, the development of a new and more sensitive test would enable atherosclerosis to be detected in its early stages, thus providing an opportunity for prevention of acute coronary events, including heart attack. A class of biomarkers which potentially exhibit high specificity for only atherosclerosis have been identified. Micro ribonucleic acids (miRNAs) are short, non-coding RNA molecules containing approximately 20 nucleotides, their function thought to be mainly gene regulation.

A liquid chromatography/mass spectrometry method to detect and quantify miRNAs has recently been developed, and this method will be applied to this project. The junior researcher undertaking this MRes project will aim to achieve several things: 1) transform raw LC-MS/MS data into a format which allows database searching of miRNA identities; 2) extract spiked miRNAs from human blood and confirm identities via database searching; 3) analyse blood samples from human subjects with atherosclerosis using the methods developed; and 4) investigate pathways analysis and machine learning methods to enable the discovery of reliable miRNA biomarkers of atherosclerosis. During the project the junior researcher will be trained to use state of the art analytical instrumentation, work with bioinformatics software, and develop lab skills in the extraction of miRNAs from blood samples.



Keywords: Atherosclerosis, miRNA, LC-MS/MS, Diagnostic Test

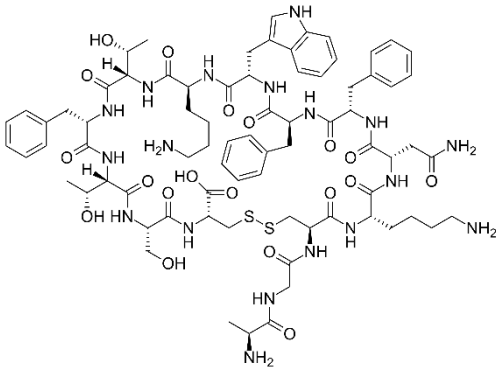
Supervisor: Dr David Harman, Dr David Mahns

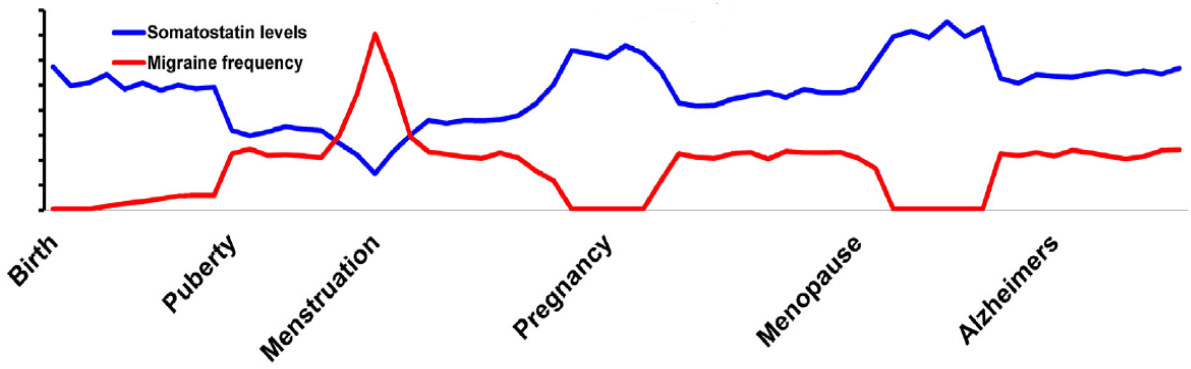
Project Title: Does a low somatostatin level trigger migraine?

Research Area: *Medical Science Research*

It has been hypothesised in 2018 that somatostatin is the compound responsible for the genesis of migraine. Somatostatin is a cyclic peptide containing 14 amino acids and is produced by the brain and the digestive system. It has several biological roles, including the inhibition of human growth hormone. We suspect that a low concentration of somatostatin is responsible for amplification of sensory signals to the brain, creating neural "noise" and making ordinary stimuli be perceived as painful.

We are the first group in the world to develop a UPLC-MS/MS method to accurately measure somatostatin concentration in blood. We would like to apply this method to experiments which are designed to establish whether there is a link between systemic somatostatin concentration and migraine incidence. Have we found the missing link?





Keywords: Migraine, Somatostatin, UPLC-MS/MS

References:

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Supervisor: Dr Kayte Jenkin

Project Title: Cannabinoid signalling in the kidney

Research Area: *Medical Science*

In Australia, up to 1 in 10 adults show signs or symptoms of Chronic Kidney Disease (CKD). Kidney Health Australia has recently identified that the region of Western Sydney and South-Western Sydney as a hotspots for increased prevalence of CKD. It has been reported that 9- 12% of the local adult population of these two hotspots having biomedical signs of renal impairment. The endocannabinoid system and adiponectin have separately been identified as potential therapeutic targets for the treatment of CKD. However, our current understanding of how the endocannabinoid system and adiponectin may interact, and the mechanistic pathways responsible for improvements observed in models of CKD has yet to be elucidated, particularly within proximal tubule cells of the kidney.

This project will use cultured cells and a range of biochemical techniques to investigate the signaling pathways in renal cells. The aim of this project is to investigate the effects of inhibiting the CB1 receptor using the CB1 inhibitors and co-treatment with adiponectin treatment in cell culture models of CKD. This project will evaluate the interaction between endocannabinoid and adiponectin signalling, and downstream mechanistic pathways in renal proximal tubule cells.

Keywords: Kidney, Renal, Proximal Tubule Cells, Cannabinoid, CB1 Receptor, Obesity, Adiponectin, Chronic Kidney Disease (CKD), Physiology, Cell Culture

References:

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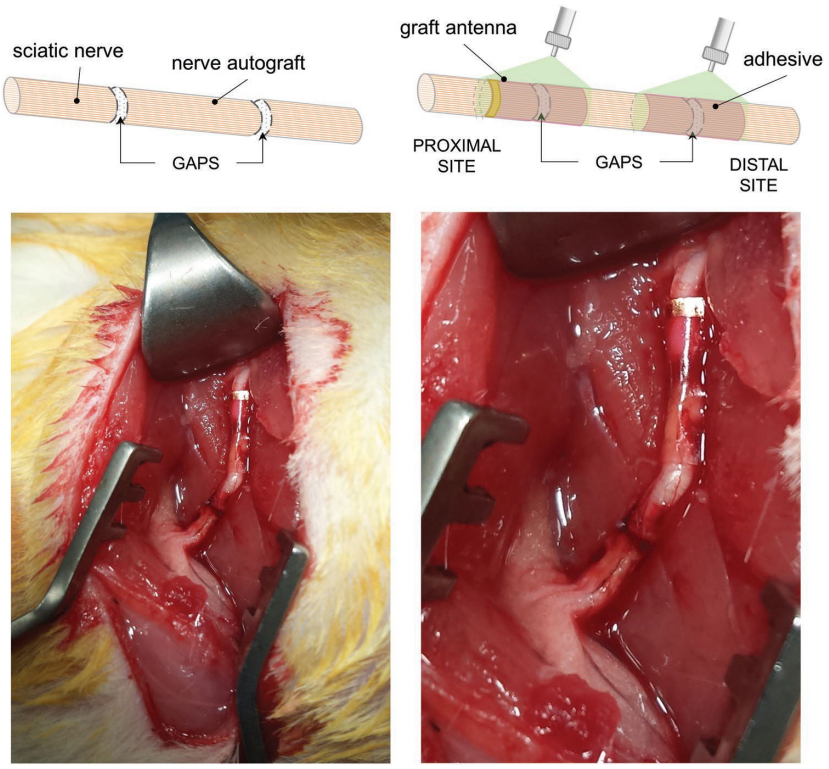
Supervisor: Dr Antonio Lauto

Project Title: Graft-Antenna for Nerve Stimulation and Regeneration

Research Area: *Biomedical Science, Neuroscience, Applied Physics*

Peripheral nerve injury is a significant medical problem; over one million people in the United States and Europe alone suffer from syndromes directly related to nerve injury every year, of whom~600,000 have surgery but only 50% regain some function. In Australia, neuropathic pain resulting from nerve injuries occur in 75% of patients [1]. Consequently, there is a significant loss of productivity for society and a high cost burden on the healthcare system, with average hospital stays of 28 days each year. Current surgical techniques in repairing and stimulating peripheral nerves are limited or unsuccessful in their ability to restore neuronal function [2].

Our group aims to address this need with a recently pioneered wireless device that innovatively combines the function of a nerve stimulator and a nerve graft (Figure below). Our device, which we named the graft-antenna, is based on a biocompatible metal loop (diameter ~1 mm) that is powered by an external transcutaneous magnetic stimulator (TMS). The loop is integrated into a biocompatible chitosan scaffold that functions as a graft when applied onto transected nerves. Our recent publications [3-5] demonstrated that when the graft-antenna was photochemically bonded to rat sciatic nerves via laser irradiation, i.e. without sutures, it was able to trigger steady compound muscle action potentials for 12 weeks (CMAP). When applied on transected nerves, our device facilitated axon regeneration following 1 hour/week TMS-stimulation (brief electrical stimulation) in rats.



This project aims to improve the design and application of the graft-antenna technology to peripheral nerves (sciatic nerves) and spinal cord in a rat model. The candidate will test the funcionality of the graft-antenna device and test the triggering capacity on nervous tissue, measuring basic electrophisiology parameters. This project is done in collaboration with the University of Adelaide and an industrial partner.

Keywords: Tissue Stimulation, Wireless devices, Neuroscience

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Bioadhesive Graft-Antenna for Stimulation and Repair of Peripheral Nerves. Ashour Sliow, Zhi Ma, Gaetano Gargiulo, David Mahns, Damia Mawad, Paul Breen, Marcus Stoodley, Jessica Houang, Rhiannon Kuchel, Giuseppe Tettamanzi, Richard D Tilley, Samuel J Frost, John Morley, Leonardo Longo and Antonio Lauto. Adv Sci. 2019, 3;6(11):1801212.

Stimulation and repair of peripheral nerves using a bioadhesive graft-antenna. Antonio Lauto, Ashour Sliow, Zhi Ma, Gaetano D Gargiulo, David Mahns, Damia Mawad, Paul Breen, Marcus Stoodley, Jessica Houang, Giuseppe Tettamanzi, John W Morley, Leonardo Longo, Rhiannon Kuchel. International Society for Optics and Photonics, Clinical and Translational Neurophotonics, volume 10864, page 1086405 (2019).

Supervisor: Dr Antonio Lauto

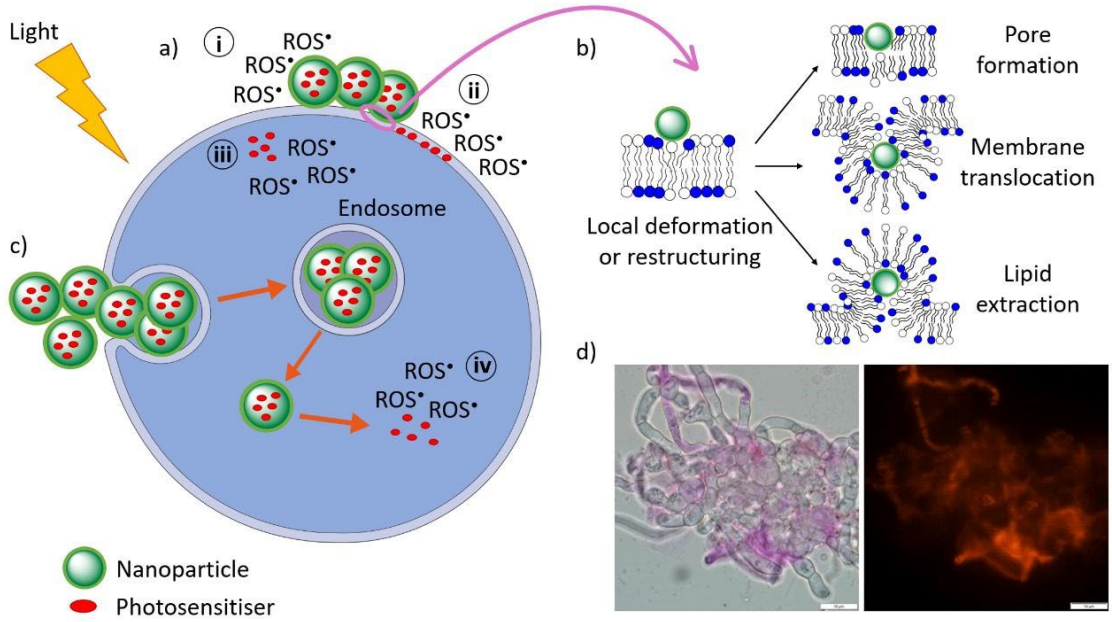
Project Title: Photodynamic Treatment of Fungal Nail Infections

Research Area: *Medical Science, Microbiology, Photochemistry, Nanotechnology*

Dr Lauto's group pioneered the use of rose bengal (RB) with a low power laser to kill very effectively Trichophyton rubrum spores in a pilot clinical study [1,2 ,3]. However, there is a potential problem: RB has limited penetration of the nail that may compromise its ability to kill fungus spores. The photodynamic mechanism of action of RB on spore fungi is also unclear and more studies are necessary to fully elucidate it.

Nanoparticles are well known to penetrate effectively tissue barriers and function as carrier for RB delivery under the nail. The first objective of this project is the development of polymeric nanoparticles loaded with RB or having RB bound to their surface (Figure). Biocompatible and biodegradable polymers are required for the nanoparticle matrixes where rose bangal is loaded, such as liposomes, polylacticglycolic acid, modified chitosan analogues, and cyclodextrins. Rose bengal can also be attached to the surface of nanoparticles such as quantum dots, Au nanoparticles and carbon nanotubes. Loading or attaching rose bengal are possible modalities with high photochemical efficiency, high tendency of accumulating in abnormal tissues and negligible toxicity [4].

The second objective is the investigation of mechanistic pathways through which rose bengal induces spore death. There are two types of photosensitization reactions; Type I (the activated PS reacts directly with the cell membrane resulting in the formation of free radicals) and Type II (the activated PS transfers energy directly to oxygen forming singlet oxygen). Distinguishing Type I from Type II reaction mechanisms may be challenging, particularly in biological systems. Single oxygen and other ROS production will be monitored using a number of techniques, including specific probes combined with spectrophotometry and flow cytometry and time-resolved absorption spectrum of singlet oxygen using transmission microscopy. This project is done in collaboration with Westmead Hospital and an industrial partner.



Keywords: Fungi, Nanoparticles, Photodynamic Therapy

References:

Genetic Tolerance to Rose Bengal Photodynamic Therapy and Antifungal Clinical Application for Onychomycosis. J. Houang, G. Perrone, C. Pedrinazzi, L. Longo, D. Mawad, P. C. Boughton, A. J. Ruys and A. Lauto. Advanced Therapeutics. https://doi.org/10.1002/adtp.201800105, 2018.

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Supervisor: Dr Antonio Lauto

Project Title: Mechanobiology of stimulated cells using the atomic force microscope

Research Area: *Biomedical science, cell biology, biomedical engineering, biomedical physics*

Mechanobiology is a rapidly emerging field that studies the impact of physical forces on cell differentiation, physiology and disease.

Mechano-biological forces are studied at the scale of the whole micro organism, where physiological development related to the progression of a disease can be examined. The Atomic Force Microscope (AFM) is available to perform such measuremets allowing to quantify forces in the pico Newton range (10-12). From a cellular perspective, the AFM cantilever permits the evaluation of cell stiffness (elastic modulus) or adhesion forces that occur between cells and their surrounding matrix, as well as between neighbouring cells [1].

Neuroblastoma cells are commonly used in neurological cell models to study Alzheimer's, Parkinson's Diseases, and Hereditary Sensory Neuropathy Type 1A (HSN-1A) [2]. The latter is a neurodegenerative disease affecting the peripheral sensory neurons. This project aims to quantify the elastic modulus of neuroblastomas, used as a model for HSN-1A, under different biological and physical conditions. In our previous research [3], we showed that electrical stimulation of non-transfected cells enhanced significantly their elastic modulus when compared to non-stimulated cells. The stiffness of stimulated neuroblastomas was 5 times and twice higher than non-stimulated cells plated on a plastic substrate and gold substrate, respectively (Figure 1). More studies are needed to confirm the latter results and translate the therapeutic effect of electrical stimulation to clinical practice. The Candidate will measure the elastic modulus of neuroblastoma cells using the atomic force microscope and assess the effect of brief electrical stumulation on cell membrane when cells are conditioned with growth factors and grown on conductive and non-conductive substrates.

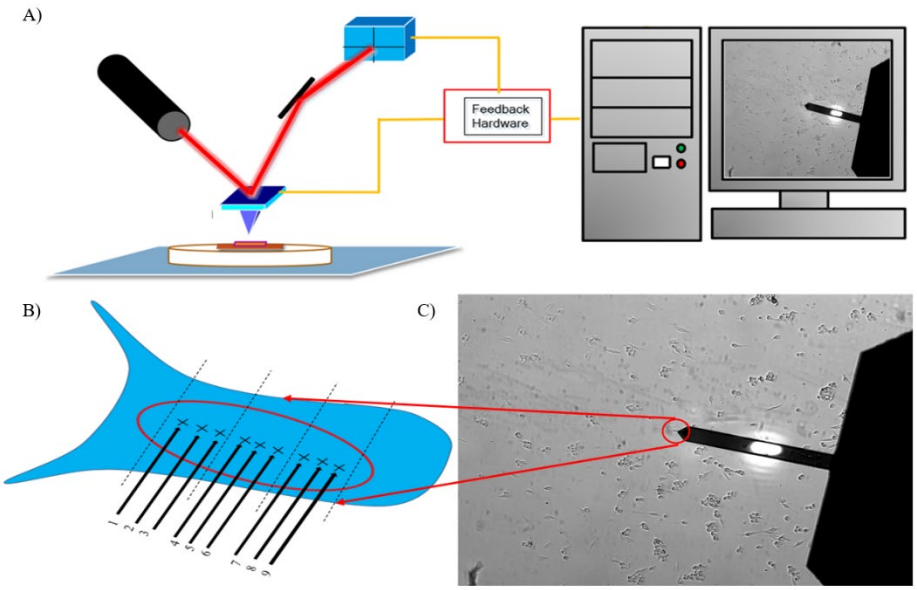

Figure 1. A) Cells are analysed by the AFM , data are then recorded and sent towards the computer. (B) Force indents are indicated along the cell axis. (C) The AFM cantiliver on an isolated cell.

Keywords: Neuroblastoma Cells, Mechanobiology, Atomic Force Microscope

References:

A new strategy to measure intercellular adhesion forces in mature cell-cell contacts.Sancho A, Vandersmissen I, Craps S, Luttun A, Groll J. Sci Rep. 2017 Apr 10;7:46152. doi: 10.1038/srep46152.

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Bioadhesive Graft-Antenna for Stimulation and Repair of Peripheral Nerves. Ashour Sliow, Zhi Ma, Gaetano Gargiulo, David Mahns, Damia Mawad, Paul Breen, Marcus Stoodley, Jessica Houang, Rhiannon Kuchel, Giuseppe Tettamanzi, Richard D Tilley, Samuel J Frost, John Morley, Leonardo Longo and Antonio Lauto. Adv Sci. 2019, 3;6(11):1801212.

Supervisor: Dr Valentina Naumovski

Project Title: Medicinal cannabis policies in health care facilities

Research Area: *Medical Sciences*

Cannabis is seen as the panacea for many chronic illnesses and symptoms, and there is a worldwide public movement for its legalisation and access, especially for advanced cancer patients. However, the clinical evidence remains inconclusive and clinical trials are not keeping up with cannabis demand and usage. Many hospitals are incorporating guidelines for patients to use cannabis on premises, especially for chronic conditions where mainstream medicine has not been successful. It is important to find out whether there are any processes are in place and what guidelines are being implemented. This could be used to inform government policy regarding cannabis use in hospitals.

The student can pick ONE or a combination of projects from the following:

1. Scoping review
2. Survey hospitals around Australia
3. Survey hospital pharmacists internationally
4. Analyse local health district policy documents in Aust and NZ. HREC approved.

Please note: if students are interested in medicinal cannabis and have other ideas, please feel free to discuss with me. The sky is the limit!!

Keywords: Cannabis, Policy, Health Care Facilities

References:

Ashton, C. H. (2001). Pharmacology and effects of cannabis: a brief review. The British Journal of Psychiatry, 178(2), 101-106.
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Zlas, J., Stark, H., Seligman, J., Levy, R., Werker, E., Breuer, A., & Mechoulam, R. (1993). Early medical use of cannabis. Nature, 363(6426), 215-215.

Supervisor: Dr Valentina Naumovski, Dr Leah Stroud, Prof. Dennis Chang

Project Title: Student's experiences and expectations in Clinical Pharmacology (NATS 2008) at WSU

Research Area: Education

As delivery of tertiary education changes over the years, so do students' experiences and their expectations. Although pharmacology seems relevant to many medical degrees, it appears less so to allied health. Currently, Clinical Pharmacology (NATS 2008) is offered as a mantatory subject in the Spring session (S2) at WSU and consists of 250 students from paramedicine, podiatry, physiotherapy and traditional Chinese medicine disciplines. Although we have experienced online delivery, course content has not significantly changed over the years. Also, we have no real input from students as to what they want and expect.

The aim of the research is to find out the student's experiences in NATS 2008 and whether the unit has satisfied learning and expectations for the student.

The main objectives are to (depending on the student's interest):

1. Perfom a scoping/systemmatic review of the literature regarding how clinical pharmacology is taught OR experiences of the student.
2. Examine the subject outline in other tertiary institutions
3. Evaluate SFU in the last few years.
4. Survey the students regarding their experiences with online learning (ethics approval required).

The outcomes for the student include:

1. Learning how to collect and critically analyse the literature
2. Survey development including RedCap design of the survey
3. Ethics application process

Keywords: Education, Tertiary, Clinical Pharmacology, Allied Health, Experiences.

Supervisor: Dr Valentina Naumovski; Dr Vanessa Vaughan

Project Title: Oncology/supportive care services in the public versus private health care sectors

Research Area: *Clinical Research*

As people with cancer are surviving a lot longer, they are also facing increased risk of poor quality of life (1). There are many gaps to their treatment, particularly access to supportive care services. However, the differences between the public versus private health system has not been well evaluated. More specific questions about the services provided and the unmet service gaps are needed.

The aim of the research is to find out the differences between the private versus public sector when it comes to oncology and/or supportive care services.

The main objectives are to :

1. Perfom a scoping/systematic review of the literature regarding the differences between the private vs public sector
2. Collect data on billing. Health services will have information on whether patients are public or private, and what was billed to which.

The outcomes for the student include:

1. Learning how to collect and critically analyse the literature
2. Review of data and its analysis
3. Ethics application process

Keywords: Oncology, Supportive Care, Palliative Care, Private, Public, Health

References:

Hunter, J., Smith, C., Delaney, G. P., Templeman, K., Grant, S., & Ussher, J. M. (2019). Coverage of cancer services in Australia and providers' views on service gaps: findings from a national cross-sectional survey. BMC cancer, 19(1), 1-11.

Supervisor: Dr. Ben Perry

Project Title: Treatment of inflammation-induced muscle loss

Research Area: *Biomedical Science*

The loss of skeletal muscle mass (muscle atrophy) is an increasingly common and ultimately debilitative outcome of aging, inactivity and disease. The substantial loss of muscle mass and strength is associated with reduced quality of life and increased mortality. One factor that can contribute to muscle atrophy is the negative physiological effects of prolonged and heightened inflammation, this is especially prevalent in cancer cachexia where hyper-inflammation drastically reduces muscle mass and quality of life for sufferers, and in genetic conditions such as Duchenne muscular dystrophy. Greater understanding of the molecular mechanisms which cause inflammation-induced atrophy, and treatments to reduce muscle atrophy are urgently required. DHA (docosahexaenoic acid), which is commonly found in fish oil, is emerging as a promising potential treatment to alleviate muscle atrophy in many circumstances. However, how DHA can reduce muscle atrophy remains poorly understood, and discovery of its mechanisms could lead to more targeted future treatments.

This research will explore the mechanisms of how inflammatory signalling contributes to muscle atrophy and investigate whether DHA can alleviate such atrophic effects. This research will not only investigate the cellular efficacy of DHA, but explore what parts of its cellular effects are beneficial for preventing muscle atrophy.

This project will allow the candidate to gain an in-depth understanding of cell culture methodologies and skeletal muscle, and the role of muscle atrophy in health and disease. This will give the candidate a broad and transferable range of skills for a future in biomedical science.

Keywords: Muscle Atrophy, Cell Physiology, Skeletal Muscle, Health, Disease

Supervisor: Dr Phoebe Zhou, Professor Gerald Muench

Project Title: Replacement of fish oil iby sustainably farmed algal oils in complementary medicine supplements

Research Area: *Natural Products Chemistry, Cell Biology*

Master of Research: Sustainable Development Goals

An MRes opportunity exists for students commencing study in the Master of Research program in 2023 to undertake research linked to the United Nations' Sustainable Development Goals (SDGs) at the NICM Health Research Insitute under the supervision of Dr. Phoebe Zhou and Professor Gerald Munch. This project will have an exclusive focus on UN Sustain Development Goal SDG 14: Life below water (to conserve and sustainably use the oceans, sea, and marine resources for sustainable development). The project will investigate the replacement of fish oil in complementary medicine supplements by sustainably farmed algal oils in collaboration with an industry partner.

Fish oils are beneficial for patients with cardiovascular risk factors, reducing blood pressure and normalizing high triglycerides and cholesterol. Fish oils are also beneficial in rheumatoid arthritis, reduce pain, improve morning stiffness and relieve joint tenderness. Algal-oil supplements are a viable alternative to fish-oil supplements, as a plant-based source of EPA and DHA, two omega-3 fatty acids that are essential for the therapeutic effect. It provides the same benefits as fish oil but is a better choice for vegetarians and vegans. Fish are essential to our society. But we're running out of them and overfishing leads to a depletion of fish stocks, including anchovies, sardines, and mackerel. salmon, and tuna.

In semester 1 of year 1, the candidate will undertake extensive literature research about the properties of omega-3 fatty acids, and the difference in EPA and DHA in different fish and algal oil sources. In semester 2, they will familiarize themselves with cell culture assays testing targets of omega-3 fatty acids in pro-inflammatory signal transduction pathways, and also measure these compounds via GC-MS. In year 2, they will formulate and compare different anti-inflammatory products containing algal oils for their anti-inflammatory effects in cell culture and search for the most potent and synergistically active combination. The final aim is the create a potent product which is sustainably harvested.

Keywords: Inflammation, Cell culture, Integrative medicine, Natural Health, Sustainability

References:

Therapeutic Opportunities for Food Supplements in Neurodegenerative Disease and Depression. Businaro R, Vauzour D, Sarris J, Münch G, Gyengesi E, Brogelli L, Zuzarte P. Front Nutr. 2021 May 14;8:669846. doi: 10.3389/fnut.2021.669846. eCollection 2021. PMID: 34055858 Free PMC article. Review.

Algal Oil Rich in Docosahexaenoic Acid Alleviates Intestinal Inflammation Induced by Antibiotics Associated with the Modulation of the Gut Microbiome and Metabolome. Yang C, Qiao Z, Xu Z, Wang X, Deng Q, Chen W, Huang F. J Agric Food Chem. 2021 Aug 18;69(32):9124-9136. doi: 10.1021/acs.jafc.0c07323. Epub 2021 Apr 26. PMID: 33900083

Protective activities of distinct omega-3 enriched oils are linked to their ability to upregulate specialized pro-resolving mediators. Sobrino A, Walker ME, Colas RA, Dalli J. PLoS One. 2020 Dec 16;15(12):e0242543. doi: 10.1371/journal.pone.0242543. eCollection 2020.

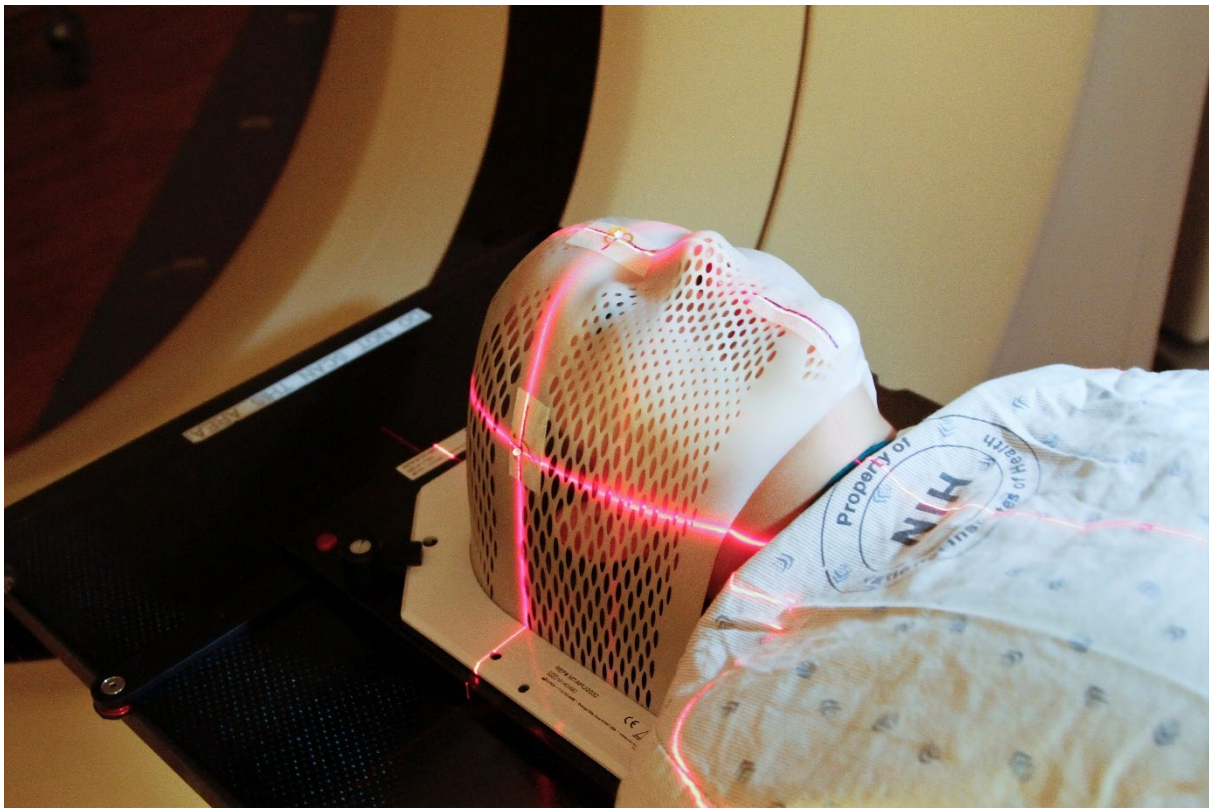


Photo by National Cancer Institute on Unsplash

MRI

Supervisor: Prof. William Price, Dr Abhishek Gupta

Project Title: Design and development of molecular 'switches' for the targeted and 'on-demand' delivery of drugs and MRI contrast agents

Research Area: *Synthetic and Nanochemistry, and Physics*

Modern medicine has utilised self-assembled lipid-based nanoparticles as drug delivery vehicles to a great success. Most recent examples include several mRNA-based Covid vaccines, including Moderna and Pfizer. In addition to drug delivery, such lipidic nanoparticles offer several unique properties that have been exploited to significantly improve the diagnostic potential of magnetic resonance imaging (MRI). This project looks to take these drug delivery vehicles to the next level by designing, developing and characterising those lipidic nanoparticles which only release cargo in response to either a molecular stimulus such as pH, temperature or pO_2 levels, or an external stimulus such as light, ultrasound, magnetic field, or radiation. Such molecularly responsive nanoparticles will ensure the safe and targeted 'on-demand' delivery of drugs (therapeutics) or MRI contrast agents (diagnostics) or both (theranostics), thus significantly improving the clinical prognosis of a variety of diseases.

Working on this project, the research candidate will become a part of the Nanoscale Group and the Translational Health and Research Institute. Depending on the selected application focus (diagnostic/therapeutics/theranostics), they will also have the opportunity to collaborate with industry and/or the clinicians and radiographers at the Liverpool Hospital to understand and address unmet clinical needs and requirements through their research. The research candidate will have access to the state-of-the-art MRI facility through Biomedical Magnetic Resonance Facility, and the chemistry laboratories at the Campbelltown Campus.

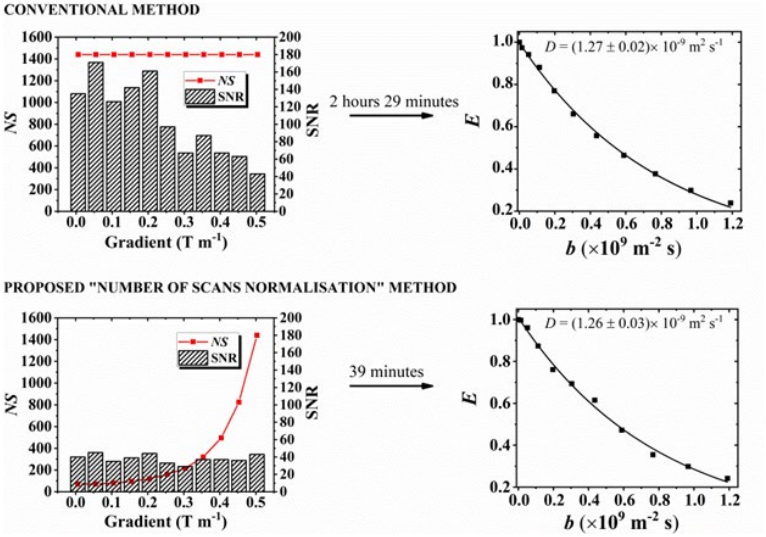
Keywords: Nanoparticles, Drug Delivery, MRI, Diagnosis, Theranostics

Supervisor: Prof. William Price, Dr Tim Stait-Gardner, Dr Abhishek Gupta, Dr Allan Torres, other members of the Nanoscale Group

Project Title: Fast MRI

Research Area: *Medical Physics, Condensed Matter Physics, Biochemistry, Chemistry*

Most magnetic resonance measurements (e.g., MRI and multidimensional NMR) suffer from poor signal-to-noise ratios (SNR). The normal 'solution' is to keep repeating the measurement and co-adding the results – but this leads to long measurement times. This is undesirable in the clinical setting (i.e., patients do not like/cannot be in the MRI for very long) as well as making many experiments impracticable. Consequently, there is enormous interest in designing new more efficient pulse sequences (i.e., the code that controls/defines the particular MRI experiment – an analogy is a musical score for an orchestra) that provide increased SNR for the same experimental time. Such fast MRI sequences open up new possibilities both in the clinical setting, but also in other areas (e.g., using NMR to follow the progress of a bio/chemical reaction like polymerisation). The Nanoscale Group are world-leaders at developing new pulse sequences and accompanying analysis (see figures below from Masuda et al 2018). This project involves both theoretical and experimental development of fast MRI sequences and their applications.



Working on this project, the research candidate will become a part of the Nanoscale group, and will also have the opportunity to collaborate with Ingham Institute for Applied Medical Research and/or leading international researchers. They will have access to the state-of-the-art research grade MRI spectrometers at the Biomedical Magnetic Resonance Facility at the Campbelltown Campus, and (through existing collaboration) clinical MRI scanners at Liverpool Hospital.

Multiple research projects focussing on different strategies for Fast MRI biomarker discovery are available as part of this important project. The exact supervisory panel will be discussed with the candidate depending on the selected sub-project. Nevertheless, the listed supervisors are all theoretical and experimental experts in the field of MRI and applications. They also have established collaborations with clinicians and radiographers at the Liverpool Hospital as well as researchers in industrial settings.

Keywords: MRI, NMR, Fast Measurements, Clinical Diagnosis, Chemical Reactions

References:

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Günther, J.-P., L. L. Fillbrook, T. S. C. MacDonald, G. Majer, W. S. Price, P. Fischer and J. E. Beves (2021). "Comment on "Boosted molecular mobility during common chemical reactions"." Science 371(6526): eabe8322.
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Supervisor: Prof. William Price, Dr Tim Stait-Gardner, Dr Abhishek Gupta

Project Title: Investigation and analysis of MRI biomarkers to improve clinical diagnosis

Research Area: *Medical Physics*

Imaging biomarkers refer to the biological features (or biochemical processes) which are detectable in an image. Identification and analysis of effective imaging biomarkers is vital for the diagnosis and personalised treatment planning of a variety of diseases, including cancer. Magnetic resonance imaging (MRI), in particular, offers numerous biomarkers that help identify the type and extent of a disease. Although, some MRI biomarkers are now routinely used in clinics, many are still underexplored. This project aims to investigate and identify novel MRI biomarkers to aid in the diagnosis and treatment planning of diseases.

Working on this project, the research candidate will become a part of the Nanoscale group, and will also have the opportunity to collaborate with Ingham Institute for Applied Medical Research. They will have access to the state-of-the-art research grade MRI spectrometers at the Biomedical Magnetic Resonance Facility at the Campbelltown Campus, and (through existing collaboration) clinical MRI scanners at Liverpool Hospital.

Multiple research projects focussing on different strategies for MRI biomarker discovery are available as part of this major project. The exact supervisory panel will be discussed with the candidate depending on the selected sub-project. Nevertheless, the listed supervisors are all theoretical and experimental experts in the field of MRI and biomarkers investigation. They also have established collaborations with clinicians and radiographers at the Liverpool Hospital.

Keywords: MRI, Imaging Biomarkers, Cancer, Diagnosis, Medical Physics

Supervisor: Dr Gang Zheng, Dr Tim Stait-Gardner, Dr Nirbhay Yadav (Johns Hopkins), Prof. William Price

Project Title: Proton exchange based molecular imaging by MRI

Research Area: *Physical Chemistry, Nuclear Magnetic Resonance Imaging, Data Science*

In general chemistry, we've learned that acidic protons are constantly hopping between solute molecules and water molecules. The efficiency of this hopping process is affected by many factors and one of these factors, pH, is directly linked to the disease state of biological tissues (e.g., metastasis of cancer), which means we can achieve medical diagnosis by measuring the micro-environmental acidity in diseased tissues.

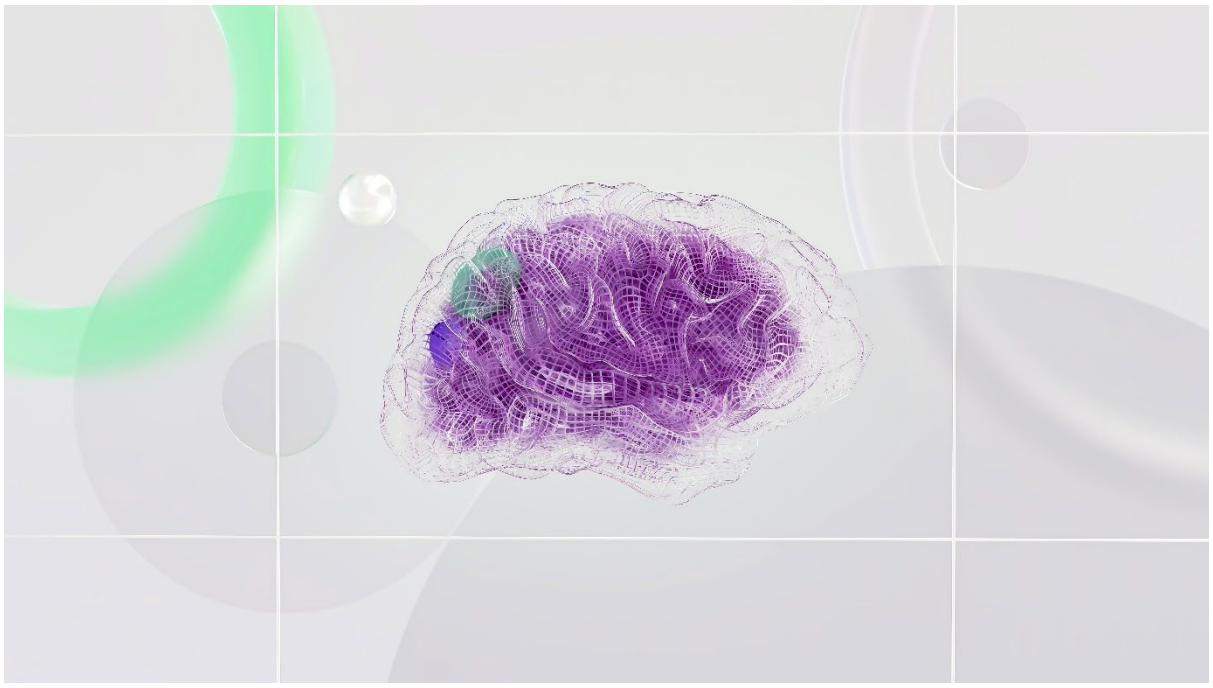
In this project, the student will study the basics of chemical kinetics, nuclear magnetic resonance (NMR), and experimental magnetic resonance imaging (MRI). From this background, the student will then develop novel chemical exchange saturation transfer (CEST) techniques for the study of proton exchange in solutions and tissues, focusing on the observation and quantification of the CEST peaks close to the water signal of diagnostically important metabolites such as myo-inositol and glucose in the NMR spectrum. If the newly developed techniques afford the distinction between metabolite and water signals in the water-proximate region in the experiments on phantom samples, they will be applied in animal experiments in the School of Medicine, Johns Hopkins University.

Keywords: Chemical Kinetics, MRI Contrast, Proton Exchange

References:

van Zijl PC, Yadav NN. Chemical exchange saturation transfer (CEST): what is in a name and what isn't? Magn Reson Med. 2011 Apr;65(4):927-48. doi: 10.1002/mrm.22761.

Chen J, Yadav NN, Stait-Gardner T, Gupta A, Price WS, Zheng G. Thiol-water proton exchange of glutathione, cysteine, and N-acetylcysteine: Implications for CEST MRI. NMR Biomed. 2020 Jan;33(1):e4188. doi: 10.1002/nbm.4188.



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Neuroscience

Supervisor: Dr Erika Gyengesi, Dr Garry Neidermayer, Prof Gerald Muench

Project Title: The role of chronic neuroinflammation in ageing and neurodegenerative diseases

Research Area: Neuroscience

Chronic neuroinflammation in Alzheimer's disease. Alzheimer's disease (AD) is recognized as a disease with significant chronic neuroinflammation, and is the single greatest cause of disability in older Australians, affecting >300,000 people1. The term 'neuroinflammation' is generally applied to chronic, central nervous system (CNS) specific, inflammation-like glial responses that causes neurodegeneration. Chronic microglial activation (T-cell independent neuroinflammation) has been described in many neurodegenerative diseases including AD. Accumulating evidence points at neuroinflammation as an emerging treatment target in AD. Consequently, targeting chronic neuroinflammation has been suggested as a disease-modifying treatment for many neurodegenerative diseases including AD.

Cytokine suppressive anti-inflammatory drugs (CSAIDs) against dementia. To combat chronic neuroinflammation, drugs with a broader range of anti-inflammatory effects, other than non-steroidal anti-inflammatory drugs, may be more effective. Cytokine suppressive anti-inflammatory drugs (CSAIDs) such as curcumin target the pro-inflammatory nuclear factor-κB signalling pathways and inhibit the expression of many pro-inflammatory cytokines, such as IL1, IL6, TNF-α2–5. Curcumin not only exerts a broad range of CNS specific anti-inflammatory effects, but penetrates into the CNS and is safe in humans and rodents6–8. Highly bioavailable curcumin formulations (encapsulated in liposomes or micelles) such as Meriva (Indena) can achieve μM concentrations in the brain9,10. Human clinical trial data indicate that Meriva curcumin exerts effects on muscular pain, osteoarthritis, psoriasis and cancer, but evidence for its anti- inflammatory effect in the CNS is still limited11–13.

Hypothesis and aims: Chronic neuroinflammation leads to progressive neurodegeneration, and a decline in motor skills and cognitive function in the GFAP-IL6 mouse model, which can be ameliorated by CSAIDs, such as curcumin.

- Aim 1. To determine effects of Meriva curcumin on the motor and cognitive function of the GFAP- IL6 mice.
- Aim 2. To determine effects of Meriva curcumin on the neuroanatomical features of the brain, including microglia and neuronal numbers, morphology, and synaptic degeneration.

Keywords: Neuroinflammation, Ageing, Neurodegeneration, Microglia, Astrocytes, Inflammaging, Dementias

References:

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Guo, X. et al. Regulation of the severity of neuroinflammation and demyelination by TLR-ASK1- p38 pathway. EMBO Mol. Med. 2, 504–515 (2010).
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Panahi, Y. et al. Efficacy and Safety of Phytosomal Curcumin in Non-Alcoholic Fatty Liver Disease: A Randomized Controlled Trial. Drug Res. (Stuttg). (2017). doi:10.1055/s-0043-100019
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Belcaro, G. et al. A controlled study of a lecithinized delivery system of curcumin (meriva®) to alleviate the adverse effects of cancer treatment. Phyther. Res. (2014). doi:10.1002/ptr.5014

Supervisor: Dr Garry Neidermayer, Dr Erika Gyengesi, Prof Gerald Muench

Project Title: Modifying neuroinflammation and the glial response

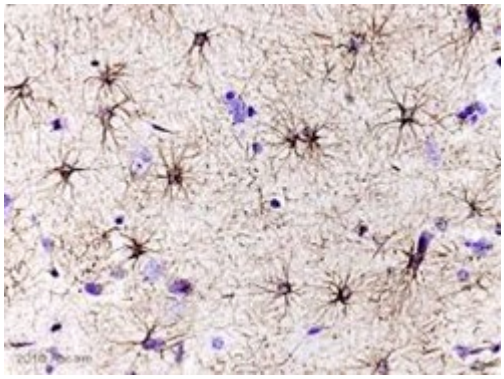
Research Area: Dementia, Inflammation, Glia, Brain, Treatment

Chronic microglial activation is a prominent feature of many chronic neurodegenerative diseases, including Parkinson's and Alzheimer's disease. Neuroinflammation appears to be a major contributor to these diseases, and therefore anti-inflammatory drugs including cytokine suppressive anti-inflammatory drugs (CSAIDs) might be promising therapeutic options to limit neuroinflammation, neurodegeneration and improve the clinical outcome.

Curcumin is a potent CSAID, but has low solubility and bioavailability in vivo. In order to increase its bioavailability, a variety of curcumin preparations have been designed, which lead to increased bioavailability, with the goal to achieve therapeutic concentrations in the brain. We work with a number of compounds that have recently been discovered to possess anti-inflammatory effects.

To investigate the effects of bioavailable forms of curcumin (and other compounds) on chronic microglial activation, transgenic GFAP-IL6 mice were fed with bioavailable curcumin formulations, naïve curcumin and no curcumin. These mice were then evaluated for motor function and inflammatory markers in the brain. Administration of bioavailable curcumin led to a dose-dependent reduction in neuroinflammatory markers and motor function improvement compared to controls.

We will investigate the effects of these bioavailable compounds on glial, neuronal and astrocytic populations and morphology.

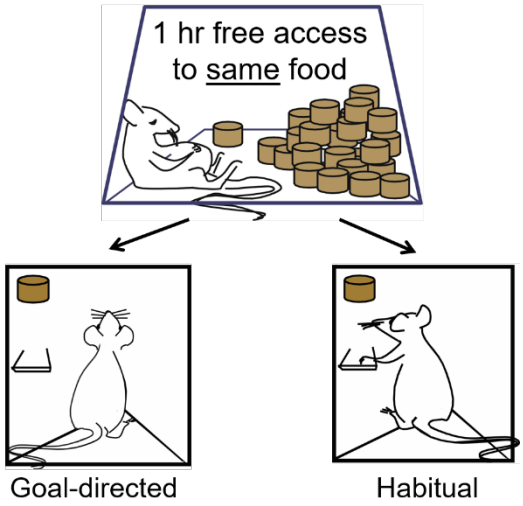


Supervisor: Dr Sam Merlin, Teri Furlong (UNSW)

Project Title: Neural Circuits of Habitual Behaviour

Research Area: *Neuroscience, Behavioural Neuroscience*

This project involves investigating the neural circuits that underlie the formation of habitual behaviours. These behaviours are implicated in drug addiction, as well as several neurological conditions, such as Parkinson's disease, autism, ADHD, and tourette syndrome. Habitual behaviours are inflexible, context-driven actions that usually occur with extended training, such as driving a manual car. However, alterations to the neurocircuits that underlie these actions can lead to the formation of inappropriate habits, or alternatively, the inability to establish habits[1]. Unlike goal-directed actions, that are flexible and depend on the value of the outcome of the action, habitual actions are inflexible and not dependent on the action outcome. Habits are known to be mediated by a brain region called the dorsolateral striatum (while goal-directed behaviour is mediated by the dorsomedial striatum), however, little is known about which other brain areas modulate this region[1,2]. One candidate is the perifornical region of the hypothalamus, that connects with several regions involved in these complex habit and goal-directed circuits[3]. This project will involve using various tools, such as viral expression constructs, chemical lesion models, and pharmacological blockade to determine the role the lateral hypothalamus plays in controlling these behaviours, using a rat behavioural model. Rats will be placed in chambers and taught to associate a lever press with a reward, establishing goal-directed responses. Habits will occur with over-training, and interventions will be assessed on whether they accelarate or inhibit habit acquisition. Behavioural changes will be comprehensively correlated with neuroanatomical changes, through histological and microscopic quantification.



Keywords: Habits, Goal-Directed, Hypothalamus, Behaviour, Neural Circuits, Cognition

References:

Balleine, B. W. and J. P. O'Doherty (2010). "Human and rodent homologies in action control: corticostriatal determinants of goal-directed and habitual action." Neuropsychopharmacology 35(1): 48-69.

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Sharpe, M. J., N. J. Marchant, L. R. Whitaker, C. T. Richie, Y. J. Zhang, E. J. Campbell, P. P. Koivula, J. C. Necarsulmer, C. Mejias-Aponte, M. Morales, J. Pickel, J. C. Smith, Y. Niv, Y. Shaham, B. K. Harvey and G. Schoenbaum (2017). "Lateral Hypothalamic GABAergic Neurons Encode Reward Predictions that Are Relayed to the Ventral Tegmental Area to Regulate Learning." Curr Biol 27(14): 2089-2100

Supervisor: A/Prof Peter Shortland, Prof Janice Aldrich-Wright, Dr Chris Gordon

Project Title: In vitro investigations into mechanisms of chemotherapy induced neuropathic pain

Research Area: *Medical Sciences, Cancer Cell Biology*

Patient treatment with platinum (Pt^{II}) based anticancer drugs such as oxaliplatin often results in peripheral neuropathy that starts after the first cycle and gets progressively worse. This limits patient compliance to the point of cessation of treatment. Better platinum-based drug are needed. One potential complex is Pt^{IV}56MESS. This has been shown to have potent anti-tumour effects in vitro on tumor cell lines resistant to oxaliplatin. Additionally, it is 10-fold more potent than oxaliplatin. Using preclinical animal models, it has been shown that oxaliplatin may stimulate glial cells such as macrophages, microglia and astrocytes that contribute to the pathogenesis of pain. Our preliminary data suggests that Pt^{IV}56MESS evokes a weaker behavioural hypersensitivity response in rodents and a weaker activation of glial cell lines, making it a potentially attractive complex for future clinical trials. However, whether Pt^{IV}56MESS has direct effects on nervous system tissue is unknown. Moreover, there are newer variants of this complex where other ligands, such as non-steroidal anti-inflammatory drugs, are attached, that may be even more potent without causing neuropathy. Using neuronal and glial cell lines, this project will investigate the effects of Pt^{IV}-based complexes on cell survival and activation using cell culture survival assays and biochemical assays such as ELISA to analyse cytokine releas e in response to stimulation.

This project offers students the chance to learn in depth methodologies and skills relevant to biomedical and medicinal chemistry research.

Keywords: Cancer, Cell Culture, Cell Lines, Cell Death

References:

Gebremedhn EG, et al. (2018). The incidence of acute oxaliplatin-induced neuropathy and its impact on treatment in the first cycle: a systematic review.. BMC cancer;18:410 https://doi.org/10.1186/s12885-018-4185-0.

Macias FJ, et al. (2015). Synthesis and analysis of the structure, diffusion and cytotoxicity of heterocyclic platinum(IV) complexes. Chemistry 21(47):16990-7001.

Starobova H, Vetter I (2017). Pathophysiology of chemotherapy-induced peripheral neuropathy. Frontiers in Molecular Neuroscience https://doi: 10.3389/fnmol.2017.00174

Supervisor: A/Prof Peter Shortland, Dr Kayte Jenkin

Project Title: Does spinal root avulsion injury alter cannanbinoid receptors and signalling in the rodent CNS?

Research Area: *Medical Sciences, Neuroscience, Pain*

Tearing (avulsion) of nerve roots in adult humans often occurs due to road traffic accidents (RTA) involving motorbike riders. These injuries primarily affect the nerves of brachial plexus, but also affect those to the legs and genitalia. They damage the junction of the nerves with the spinal cord producing a very discrete form of spinal cord injury. In Australia in 2021, motorbike riders were involved in 51% of multi-vehicle accidents with 80% of survivors having some form of serious injury. Avulsion injuries result in muscle paralysis and paradoxically, extreme, intractable pain in the insensate limb. Pain management for these patients appears refractory to most drug treatments, largely due to poor understanding of the mechanisms involved and intolerable side effects. Anecdotally, suffers report that the use of cannabis is effective in alleviating the pain.

Using animal models of avulsion injury we have shown that root avulsion results in degeneration of spinal cord neurons, motoneurons and increased glial cell staining, suggesting that multiple mechanisms may underlie the pain genesis. Some of these mechanisms may be more important than others, and may be amenable to pharmacological manipulation. In particular, the role of glia in the production of pro-inflammatory pain mediators appear to be important. Surprisingly, ventral root injury only produces changes that affect the dorsal horn suggestive of transneuronal retrograde changes. The physiological consequences of this aspect have not been explored. This project will investigate the hypothesis that avulsion induces increased expression of endocannabinoid receptors in the spinal cord, spinal ganglia, brain and glia therby providing a rationale for the use of cannabinoid analgesic drugs as novel way to alleviate avulsion-induce pain.

This projects offer students the chance to learn in depth research methodologies associated with tissue specimen preparation, immunohistochemistry, western blot, microscopy thereby providing a range of transferrable skills for biomedical research.

Keywords: Neurodegeneration, Immunohistology, Glia, Pain

References:

Rahn, E.J., & Hohmann, H.G. (2009) Cannabinoids as Pharmacotherapies for Neuropathic Pain: From the Bench to the Bedside Exp Neurotherapeutics 6:713-737.

Bergerot A. et al. (2004) Co-treatment with riluzole and GDNF are necessary for functional recovery after ventral root avulsion injury. Exp. Neurol. 187: 359-366.

Berman J. et al (2003) Efficacy of two cannabis-related medicinal extracts for relief of central neuropathic pain from brachial plexus avulsion: results from a randomized control trial. Anaes. 58:936

Chew DJ et al. (2014) The effects of minocycline or riluzole treatment on spinal root avulsion–induced pain in adult rats. J. Pain 15:664-675.

Supervisor: A/Prof Peter Shortland Dr Gary Niedermeyer, Dr Erica Gyengesi

Project Title: Investigating the effects of chronic IL6 expression on microglial and astrocytes in the spinal cord in health and disease.

Research Area: *Medical Sciences, Neuroscience, Neurodegenerative Diseases*

Chronic neuroinflammation is a major contributory factor to the pathogenesis of neurodegenerative diseases like Alzheimer's disease (AD), Multiple Sclerosis and to chronic neuropathic pain conditions following nerve injury. Using a transgenic mouse model where interleukin-6 (IL-6) is over-expressed under the glial fibrillary acidic protein (GFAP) promoter only in the astrocytes in the brain it has been shown that GFAP-IL6 mice exhibit progressive loss of motor and cognitive function as a result of chronic neuroinflammation from 3-6 months of age. However, no studies have assessed whether this mouse model has altered behavioral sensitivity to peripheral stimuli or whether overexpression affects glial function in the spinal cord. Several different studies are available: 1) To investigate the potential behavioural and anatomical changes in the GFAP-IL6 transgenic mice, compared to their wild type littermates in the spinal cord and dorsal root ganglia 2) to investigate the effects of continous overexpression of the ligand on its receptos IL6R and gp130 in neuronal tissues 3) to examine the effects of nerve injury on IL6 expression and glial expression in the nervous system and 4) to investigate the effects of novel anti-inflammatory treatments, such as curcumin treatment, on the gliobiology in the spinal cord and dorsal root ganglia.

These projects offer students the chance to learn in depth research methodologies associated with tissue specimen preparation, immunohistochemistry, western blot, microscopy and animal behaviour and provide a good range of transferrable skills for biomedical research.

Keywords: Neurodegeneration, Chronic Inflammation, Immunohistology, Glia

References:

Ullah, F., Liang, H., Niedermayer, G., Muench, G. and Gyengesi, E. (2020), Evaluation of phytosomal curcumin as an anti-inflammatory agent for chronic glial activation in the GFAP-IL6 mouse model', Frontiers in Neuroscience, vol 14. https://doi.org/10.3389/fnins.2020.00170

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Plant & Crop Science

Supervisor: Dr Jay Bose, Dr Ryan McQuinn, Prof Zhonghua Chen

Project Title: Targetting chloroplasts to improve salt tolerance in wheat

Research Area: *Agriculture, Plant Biology, Molecular biology*

Cereals account for approximately 70% of the world's food supply. Soil salinity reduces crop growth and causes severe yield penalties. The agricultural area under salinity expected to treble in Australia (5.7 to 17 M ha) by 2050. The most widely grown cereal crops, rice and bread wheat, are salt-sensitive (glycophytic plants) and are generally poorly equipped to grow and produce food in salty soils.This jeopardises the increase in food production required to supply 9.3 billion people by 2050. To reverse this trend, a major breakthrough in crop breeding for salt tolerance is required to grow crops on increasingly saline soils.

High salt concentrations (> 40 mM NaCl or EC > 4 dS cm^{-2}) in soils severely inhibit photosynthesis, growth and yield in the majority of crop plants (e.g. rice, wheat). On the other hand, naturally salt-loving plants (e.g. halophytic rice, Oryza coarctata, and Quinoa) can maintain or show enhanced photosynthesis, growth and yield at similar salt concentrations. Emerging data suggests that a key to the increased salt tolerance of halophytes lies in their chloroplasts, the organelles in which photosynthesis occurs. In this project, you will identify key genes that underpin chloroplast function during salt stress in wheat.

This MRes – research project forms part of a four-year Future Fellowship project funded by the Australian Research Council (ARC) to Dr Jay Bose, can lead onto to a PhD based on interests and performance. In this project, you will grow wheat landraces in a range of salt concentrations over six to eight weeks, and will measure changes in photosynthetic parameters, leaf-sap osmolarity using a cryo-osmometer, chloroplast volume changes using live-cell imaging, and expression of candidate genes using quantitative reverse transcription (qRT)-PCR on RNA isolated from leaf tissues.

You will acquire skills in:

1. Growing and phenotyping wheat landraces in state-of-the-art glasshouse facilities.
2. Photosynthetic measurements.
3. Imaging and image analysis techniques.
4. Scientific research: developing hypothesis, planning, and conducting experiments, data collection and analysis, review and report writing.

Keywords: Salinity, Chloroplasts, Ion Transport, Tissue Tolerance

References:

Bose J, Munns R, Shabala S, Gilliham M, Pogson B, Tyerman SD. 2017. Chloroplast function and ion regulation in plants growing on saline soils: lessons from halophytes. Journal of Experimental Botany 68, 3129-3143.

Borjigin C, Schilling RK, Bose J, Hrmova M, Qiu J, Wege S, Situmorang A, Byrt C, Brien C, Berger B, Gilliham M, Pearson AS, Roy SJ. 2020. A single nucleotide substitution in TaHKT1;5-D controls shoot Na^+ accumulation in bread wheat. Plant, Cell & Environment 43, 2158–2171.

Supervisor: Dr Jay Bose, Dr Ryan McQuinn, Prof Zhonghua Chen

Project Title: Improving salt tolerance by optimising solute balance within chloroplasts

Research Area: *Agriculture, Plant Biology, Molecular Biology*

Salt stress severely inhibits photosynthesis in salt-sensitive crops (glycophytes), and thus their fitness, growth, and yield. Some naturally salt-loving plants (halophytes) can tolerate elevated soil salt concentrations. Emerging data suggests that a key to the increased salt tolerance of salt-loving plants lies in their chloroplasts. The overall objective of this project is to discover and characterise solute (water and ion) transport mechanisms operating in chloroplast membranes that underpin salt tolerance in naturally salt-loving plants (halophytes). These advances in understanding will create targeted opportunities to introduce salt-tolerance genes into salt-sensitive crops (e.g. canola, cotton, wheat, barley and rice), creating rapid, and step-change improvements in crop productivity in saline soils.

This MRes – research project forms part of a four-year Future Fellowship project funded by the Australian Research Council (ARC) to Dr Jay Bose, can lead onto to a PhD based on interests and performance. The MSc student will be responsible for gene cloning and their functional characterisation of water and ion transporter genes relevant to chloroplast volume regulation in crops. The MSc student will conduct laboratory and greenhouse experiments to test salinity tolerance of model plants as well as selected transgenic plants.

You will acquire skills in

1. Growing and phenotyping model plants in state-of-the-art glasshouse facilities.
2. Photosynthetic measurements.
3. Imaging and image analysis techniques.
4. Scientific research: developing hypothesis, planning and conducting experiments, data collection and analysis, review and report writing.

Keywords: Salinity, Chloroplasts, Ion Transport, Tissue Tolerance

References:

Bose J, Munns R, Shabala S, Gilliham M, Pogson B, Tyerman SD. 2017. Chloroplast function and ion regulation in plants growing on saline soils: lessons from halophytes. Journal of Experimental Botany 68, 3129-3143.

Borjigin C, Schilling RK, Bose J, Hrmova M, Qiu J, Wege S, Situmorang A, Byrt C, Brien C, Berger B, Gilliham M, Pearson AS, Roy SJ. 2020. A single nucleotide substitution in TaHKT1;5-D controls shoot Na^+ accumulation in bread wheat. Plant, Cell & Environment 43, 2158–2171.

Supervisor: Dr Jay Bose, Dr Ryan McQuinn, Prof Zhonghua Chen

Project Title: Deciphering trichome function in tomato

Research Area: *Agriculture, Plant Biology, Molecular biology*

The tomato (Solanum lycopersicum) plants canopy is covered by the tiny hair-like structures called trichomes. The main function of trichomes is suggested to protect plants against herbivorous insect invasion. But some pieces of evidence suggest these trichomes may have a role in low temperature, drought, and salt tolerance. As an MSc Research student, you will use tomato plants with altered trichome density and structure to investigate the roles of trichomes during low temperature, drought and salt stress. You will assess growth and use the scanning electron microscope (SEM) and/or transmission electron microscopy (TEM) to reveal changes in glandular and non-glandular trichome distribution and metabolites under a given stress.

Project Aims

1. Assess the growth and development of tomato trichome mutants under low temperature, drought, and salt stress.
2. Quantify changes in trichome density and morphology under low temperature, drought, and salt stress.
3. Assess metabolomic changes during stresses.

You will acquire skills in:

1. Growing and phenotyping tomato plants in state-of-the-art glasshouse facilities.
2. Photosynthetic measurements.
3. Imaging and image analysis techniques.
4. Metabolomic analysis,
5. Scientific research: developing hypothesis, planning, and conducting experiments, data collection and analysis, review and report writing.

Keywords: Salinity, Chloroplasts, Ion Transport, Tissue Tolerance

References:

Kortbeek RW, Xu J, Ramirez A, Spyropoulou E, Diergaarde P, Otten-Bruggeman I, de Both M, Nagel R, Schmidt A, Schuurink RC, Bleeker PM. 2016. Engineering of tomato glandular trichomes for the production of specialized metabolites. Methods Enzymology 576:305-331.

Shabala S, Bose J, Hedrich R. 2014. Salt bladders: do they matter? Trends in Plant Science 19, 687-691.

Supervisor: A/Prof Nijat Imin

Project Title: Let's talk about nitrogen – a serious environmental crisis you haven't heard of yet

Research Area: *Environmental And Agricultural Sciences*

Humans have disrupted the nitrogen cycle. Nitrogen pollution – the disturbance of ecosystems, human health and economies by massively altering of the global nitrogen cycle is one of the upmost challenges humans are facing. A recent UN Environment Frontiers Report highlighted the importance of fixing the broken nitrogen cycle. Nitrogen is essential for life, and an extremely abundant element in the Earth's atmosphere. In the form of the N_2 molecule, nitrogen is harmless, making up 78% of every breath we take. Growing demand on the livestock and agriculture has led to a sharp growth of the levels of reactive nitrogen such as ammonia, nitrate and nitrous oxide in our ecosystems. Nitrogen released into water bodies can cause eutrophication, posing a risk to aquatic organisms. The excess nitrogen pollution has tremendous consequences on humans and the environment. In the form of nitrous oxide, for example, it is 300 times more powerful than carbon dioxide as a greenhouse gas. Humans are producing a cocktail of reactive nitrogen that threatens health, climate and ecosystems, making nitrogen one of the most important pollution issues facing humanity. However, the scale of the problem remains largely unknown and unacknowledged outside scientific circles.

The student can pick one or a combination of projects from the following:

1. Scoping review;
2. Survey n-pollution around australia;
3. Survey nitrogen pollution globally;
4. Analyse relevant policy documents in Aust and NZ.

Students are also encouraged to suggest ideas regarding global and national nitrogen issues and proposal a alternative project.

Keywords: Nitrogen Polution, Policy

References:

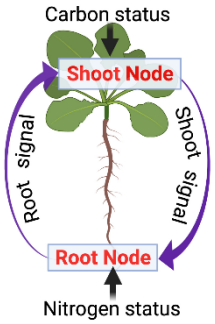
UN environmental programme: https://www.unep.org/

Supervisor: A/Prof Nijat Imin

Project Title: Small but Mighty – Investigating the role of peptide hormones that control the growth and yield of crops

Research Area: *Intensive Food Production, Agriculture, Horticulture, Plant Biology And Crop Science*

Nitrogen (N) is a key determinant of crop productivity. We have discovered a molecular process involving a peptide hormone (CEP, C-TERMINALLY ENCODED PEPTIDE - a hunger for N signal that is induced by N limitation in the root. The peptide travels to the shoot node through the xylem to activate its receptor and incorporates plant's carbon status , then generates rootward systemic signals to regulate N uptake and root proliferation (including root nodule formation and symbiotic N-fixation in legumes). Contrarily, CLE (CLAVATA 3/ESR-related) peptides inhibit cell proliferation and nodulation in a receptor dependent manner. This project investigates how long-distance signalling involved in the modulation of root, nodule, shoot and seed development in response to nutrient availability and identified downstream targets and underlying molecular mechanisms. Overall, the student will be involved in defining and confirming how signalling peptides are important positive and negative regulators of plant development and symbiotic N-fixation, linking N-demand signalling to developmental programs.



Keywords: Plant Growth, Crop Yield, Nutrient Uptake, Symbiotic Nitrogen Fixation, Long-Distance Signalling

References:

Taleski M, Chapman K, Imin N, Djordjevic MA and M Groszmann (2020) The peptide hormone receptor CEPR1 functions in the reproductive tissue to control seed size and yield. Plant Physiology. 183 (2), 620-636.

Chapman K, Taleski M, Ogilvie HA, Imin N and Djordjevic MA (2019) CEP-CEPR1 signalling inhibits the sucrose-dependent enhancement of lateral root growth. Journal of Experimental Botany. 70 (15), 3955-3967.

Delay C, Chapman K, Taleski M, Wang Y, Tyagi S, Xiong Y, Imin N and Djordjevic MA (2019) CEP3 levels affect starvation-related growth responses of the primary root. Journal of Experimental Botany. 70 (18), 4763-4774.

Imin N, Patel N, Corcilius L, Payne RJ, Djordjevic MA (2018) CLE peptide tri-arabinosylation and peptide domain sequence composition are essential for SUNN-dependent autoregulation of nodulation in Medicago truncatula. New Phytologist. 218 (1), 73-80.

Supervisor: Dr Michelle Mak

Project Title: Might verses mite: investigating Australian ladybird beetles as biocontrol agents

Research Area: *Crop Production & Entomology*

A variety of ladybird bettles have been commercialised as biocontrol agents for arthrod pests as a means of reducing the need for applications of synthetic pesticides (Rondoni et al. 2021). Modern biosecurity efforts globably now shun the introduction of exotic biocontrol agents into non-indigenous environments preferring to look to native, coevolved species for new potential stocks of preditors and paracitoids (De Groot & Haelewaters 2022). However, developing the protocols to rare new species to significant numbers for commercialisation relies on answering multiple questions from basic biology to potential diets to preditor-prey interactions (Ricupero et al. 2020).

In this study we will investigate non-commercialised, Australian species of ladybird beetles to assess their efficacy against key horticultural and floriculture pests. Investigations can be understaken to explore biology and rearing, tolerance to current pesticides, efficacy of semiochemical lures and banker plantings.

References:

De Groot, M & Haelewaters, D 2022, 'Double infections of the invasive ladybird Harmonia axyridis', Frontiers in Ecology and Evolution, vol. 10.

Ricupero, M, Dai, C, Siscaro, G, Russo, A, Biondi, A & Zappalà, L 2020, 'Potential diet regimens for laboratory rearing of the harlequin ladybird', Biocontrol, vol. 65, no. 5, pp. 583-92.

Rondoni, G, Borges, I, Collatz, J, Conti, E, Costamagna, AC, Dumont, F et al. 2021, 'Exotic ladybirds for biological control of herbivorous insects–a review', Entomologia Experimentalis et Applicata, vol. 169, no. 1, pp. 6-27.

Supervisor: Dr Ryan McQuinn, Dr Jay Bose, Dr Michelle Mak

Project Title: Exploring the impacts of prolonged drought on flower quality in crops and Australian native flowering plants.

Research Area: *Intensive Food Production and Agriculture*

Despite advancements made in drought resilient canola varieties and precision agriculture strategies, canola oilseed quality and yield remain vulnerable to severe drought. According to the Australian Oilseed Federation Crop Report (November 2019) the severe drought in 2019, with the lowest rainfall on record in some areas (i.e. NSW), resulted in approximately 50% reduction in canola yield. Previously, it has been demonstrated the drought stress during the reproductive phase poses a more severe threat to oil seed yield compared to droughts during the vegetative growth phase (Champolivier & Merrien, 1996; Hashem et al., 1998; Din et al., 2011; Sinaki et al., 2007; Ahmadi & Bahrani, 2009). In this case, it is interesting to consider how prolonged drought stress during reproductive growth may impact flower development and floral nectar and aroma volatile quality and quantity as these characteristics are detrimental to successful pollination.

By comparing changes in volatile organic compound profiles from flowers of multiple canola cultivars, including the more drought tolerant wild relative Brassica juncea, in response to drought stress we can explore how drought during the reproductive development impacts oilseed yield. In turn, this may enable the development of innovative breeding strategies to improve flower quality during drought conditions to safeguard canola oilseed yield. Alternatively, one could examine how a newly identified plant-derived chemical which triggers drought escapism may maintain flower quality despite drought conditions (D'Allessandro et al. 2019). Lastly, investigating how Australian native flowering plants respond to drought conditions with respect to their floral volatile profile may result in the development of new strategies to enhance canola flower quality during drought conditions.

Keywords: Drought Tolerance, Flower Development, Pollination, Aroma Volatiles, Floral Nectar

References:

Ahmadi M, Bahrani MJ. 2009. Yield and yield components of rapeseed as influenced by water stress at different growth stages and nitrogen levels. American-Eurasian Journal of Agricultural and Environmental Sciences 5: 755–761.

Champolivier L, Merrien A. 1996. Effects of water stress applied at different growth stages to Brassica napus L. var. oleifera on yield, yield components and seed quality. European Journal of Agronomy 5: 153–160.

D'Alessandro SD., Mizokami Y., Legeret B., Havaux M. 2019. The apocarotenoid b-cyclocitric acid elicits drought tolerance in plants. iScience 19: 461-473.

Din J, Khan SU, Ali I, Gurmani AR. 2011. Physiological and agronomic response of canola varieties to drought stress. Journal of Animal and Plant Sciences 21: 78–82.

Hashem A, Amin Majumdar MN, Hamid A, Hossain MM. 1998. Drought stress effects on seed yield, yield attributes, growth, cell membrane stability and gas exchange of synthesized Brassica napus L. Journal of Agronomy and Crop Science 180: 129–136.

Sinaki JM, Heravan EM, Rad AHS, Noormohammadi G, Zarei G. 2007. The effects of water deficit during growth stages of canola (Brassica napus L.). Journal of Agriculture and Environmental Sciences 2: 417–422.

Supervisor: Prof Sally Power, Mr Manjunatha Chandregowda

Project Title: Climate-resilient pastures for the future

Research Area: *Agricultural Sustainability and Climate Change*

Pasture grasslands underpin the >$30 billion livestock and dairy industries in Australia. The nutritional quality and amount of pasture available for grazing is therefore crucial for agricultural productivity. Here, in SE Australia, climate models predict that we'll experience warmer growing seasons and more severe heatwaves, along with drier winter/spring periods and more extreme rainfall patterns. Understanding pasture performance (productivity, nutrition and persistence) in response to future, more extreme climates is essential for managing future climate risk. Furthermore, given that livestock makes a major contribution to national greenhouse gas emissions, identifying productive pasture species that are associated with lower livestock methane emissions is crucial in reducing the industry's carbon footprint.

Incorporating legumes in pasture systems has been shown to reduce soil-based greenhouse gas emissions by reducing the nitrogen fertilizer requirement for forage production. Several legume species also show promise in terms of both their drought-tolerance and their capacity to directly reduce ruminant methane emissions (cow burps!). Understanding how pasture species respond to droughts and heatwaves is an essential step towards developing climate-resilient pasture systems. The Pastures and Climate Extremes (PACE) project at the Hawkesbury Campus examines the responses of pasture grasses, herbs and legumes, grown under polytunnel shelters (pictured above), to predicted changes in temperature and rainfall, using a factorial field manipulation experiment. This project will provide an opportunity to join a team of researchers working to understand species' sensitivity (resistance) and recovery (resilience) under simulated future warmer, drier climates. The project provides an opportunity to learn a range of ecological field and laboratory skills, along with data processing and management. Furthermore, by joining an established research project you will gain hands-on research experience, working alongside a team of student and postdoctoral scientists within the wider PACE project.

Keywords: Climate Extremes, Resistance And Recovery, Climate-Manipulation Experiment, Carbon Footprint

References:

Churchill AC, Zhang H, Fuller KJ, Amiji B, Anderson IC, Barton CVM, Carrillo Y, Catunda KLM, Chandregowda MH, Igwenagu C, Jacob V, Kim GW, Macdonald CA, Medlyn BE, Moore BD, Pendall E, Plett JM, Post AK, Powell JR, … Power SA, (2022) 'Pastures and Climate Extremes: Impacts of Cool Season Warming and Drought on the Productivity of Key Pasture Species in a Field Experiment', Frontiers in Plant Science, 13. https://www.frontiersin.org/article/10.3389/fpls.2022.836968

Chandregowda MH, Tjoelker MG, Pendall E, Zhang H, Churchill AC, Power SA, (2022) 'Root trait shifts towards an avoidance strategy promote productivity and recovery in C3 and C4 pasture grasses under drought', Functional Ecology, vol.36, no.7, pp 1754–1771 https://doi.org/10.1111/1365-2435.14085

Catunda KLM, Churchill AC, Zhang H, Power SA, Moore BD, (2021) 'Short-term drought is a stronger driver of plant morphology and nutritional composition than warming in two common pasture species', Journal of Agronomy and Crop Science, https://doi.org/10.1111/jac.12531