WESTERN SYDNEY
UNIVERSITY

# School of Science
# Master of Research Projects
# 2022

Congratulations on your success so far in your undergraduate studies!

You are receiving this email and the attached Master of Research Project Booklet as you may qualify to commence the Master of Research degree in 2022.

This booklet lists research projects for 2022 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, some 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
Associate Dean HDR Research and Training

A/Professor Lisa Cubeddu
Associate Dean Masters of Research

After you have browsed through the booklet and you would like to find out more about the Master of Research, here is what you need to do next:

1. **Attend one of the Master of Research information sessions**. At this session you will receive more information about the Master of Research and the application process. The information sessions are also an opportunity to meet supervisors and current research students.
2. **Please contact the supervisors** listed in the booklet with whom you might be interested to undertake your Master of Research studies (note that it is a good idea to keep your options open and have at least 3-4 choices as depending on demand not every student may get their first choice of projects); make an appointment with those supervisors and ask them all you need to know about the project.
3. **Applications are now open** for students commencing in 1H 2022. To ensure your applications are processed well before January 2022, 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
4. **Entry Requirements:** You will need to have completed a Bachelor's degree or be about to complete it. You will need to have achieved a threshold Admission Average Mark (AAM) equal to or above the minimum of 65.
5. The School of Science is asking that all students **contact supervisors prior to applying online** https://www.westernsydney.edu.au/staff_profiles

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**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 ($GABA_A$ 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. Our research group has recently identified that patients with variants reduce $GABA_A$ receptor activity respond well to vigabatrin and become seizure free. Patients with variants that increase GABAergic activity instead have a severe adverse effect to vigabatrin, becoming non-responsive to stimuli and lose muscle tone (Absalom et al, 2021).

This project will take a broader view of $GABA_A$ receptor variants. By combining information from an international cohort of patient data with molecular biology, mouse phenotyping, electrophysiological and cell surface expression assays, this project will investigate how genetic variants cause these epilepsy syndromes, and help to guide patients toward the best possible treatments.

**Keywords:** Epilepsy, genetics, pharmacogenomics, receptors, molecular biology

**References:**
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 Commun. 2020 Oct 1;2(2):fcaa162.

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**Supervisor:** Dr Christa Beckmann

**Project Title: Avian Ecology and Conservation**

**Research Area:** Animal behaviour, human-wildlife conflict, predator-prey relationships, breeding ecology, invasive species

The research team studies animal behaviour and ecology, with a focus on birds. Research topics include 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. Students can be based at the Hawkesbury Campus.

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.

Noisy Neighbors: 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.
Avian nest construction. Nest structures are essential for successful reproduction in most bird species. Using an experimental approach, this study will examine the effects of nest characteristics (i.e. camouflage) on nest predation rates.
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. This study will investigate human attitudes to birds roosting in urban areas.

**Keywords:** Birds, Animal behaviour, human-wildlife conflict, wildlife conservation, preator-prey relationships, breeding ecology, invasive species

**References:**

1. Beckmann, C., Major, R. E., Frankham, G. J., Thomas, S., Biro, P. A., Ujvari, B., & Neaves, L. (2021). Genetic structure and gene flow in the Flame Robin (Petroica phoenicea). *Emu-Austral Ornithology*, 1-6.
2. 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.
3. Beckmann, C., & McDonald, P. G. (2016). Placement of re-nests following predation: are birds managing risk? *Emu-Austral Ornithology*, *116*(1), 9-13.
4. 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.
5. 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

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**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.

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**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:**
1. **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.
2. 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.

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**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:**


1. 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 Enzymol*ogy **576:**305-331.
2. Shabala S, **Bose J**, Hedrich R. 2014. Salt bladders: do they matter? *Trends in Plant Science* **19**, 687-691.


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**Supervisor:** Liza Cubeddu, 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

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**Supervisor:** Roland Gamsjager, 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

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**Supervisor:** Shi Dai, 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

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**Supervisor:** Shi Dai, 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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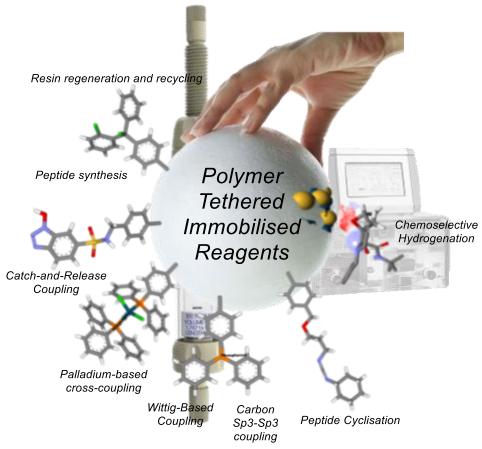
**Supervisor:** Christopher Gordon

**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.

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**Supervisor:** Dr Hayley Green

**Project Title: Detection of skeletal remains using Alternate Light Sources (ALS)**

**Research Area:** Forensic Anthropology/Forensic Science

Alternate light sources (ALS) are commonly used in forensic casework to detect items such as biological fluids, foreign fibres and fingerprints [1]. This method of detection is non-destructive and non-invasive and is based on the fluorescent properties of the item in question when exposed to specific wavelengths of light [1].

Recently, the usefulness of ALS technology in the detection of bone and teeth has been explored. However, there has been no consensus as to which specific wavelength (450nm-490nm) or filter (orange or red) is best for bone and tooth detection. A limiting factor is that few studies to date have been conducted, with no consistency in the experimental environment and their associated taphonomic effects.

A pilot study conducted in 2018 [2] found that the portable ALS provided the highest intensity bone and tooth fluorescence compared to the laboratory-based light source at the same wavelength and distance from sample, suggesting it is the more appropriate tool for bone fragment detection. The 450nm Poliflare® with orange filter provides the best discrimination of bone/tooth versus non-bone (figure 1), with a maximum distance of 100cm from the sample. These parameters however were not optimal for temperature treated bone, which has implications for detecting skeletal remains in bushfire scenarios.

The aim of this study is expanding on the previous laboratory- controlled pilot study above to investigate the optimum parameters of ALS for the detection of bone and teeth fragments in a crime scene setting.

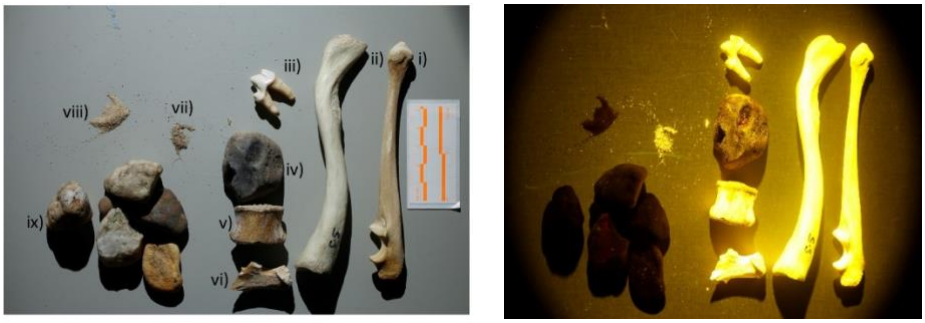


*Figure 1: Bone and non-bone objects visualised with A) white light and B) Polilight flare® 450nm with an Orange filter. Bone objects: i) dog ulna, ii) human clavicle, iii) dog tooth, iv) soiled pig epiphysis, v) frozen pig, vi) pig (untreated), vii) bone dust (pig). Non-bone objects: viii) sand, ix) rock.*

**Keywords:** Bone, fluorescence, alternate light source, forensic anthropology, taphonomy

**References:**

1. Miranda GE, Melani RFH, Francisquini Júnior L, et al. Use of an Alternate Light Source to Detect Tooth and Bone. Braz Dent J. 2017;28(1).
2. Green, H., Jabez, J., & Nelson, J. Optimizing parameters for the use of alternate light sources in detecting fragmentary bones: a pilot study. Aust J for Sci. 2019; 51(sup1), S201-S204.

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**Supervisor:** Dr Hayley Green

**Project Title: Characterisation of skeletal remins using field portable analytical methods**

**Research Area:** Forensic Anthropology/Forensic Science

This study will contribute to furthering scientific knowledge regarding physical and chemical changes to human bone over time in a controlled environment. As the methods used are semi-quantitative, the combination of field portable equipment and changes to bone during decomposition may be of use in determining the post-mortem interval (PMI) in casework contexts, providing vital information to investigators with regards to times since death windows and better direct investigations. It may also be of use in rapid discrimination of forensic versus historical skeletal remains and human vs non-human skeletal remains. It is hoped that the outcomes of this project will complement visual anthropological methods assessing PMI. Analytical equipment to be used includes (but is not limited to) Raman spectroscopy, FTIR and XRF.

**Keywords:** Bone, postmortem interval, commingled, forensic anthropology, XRF, Raman, FTIR

**References:**
1. Christensen, A. M., Smith, M. A., & Thomas, R. M. (2012). Validation of x-ray fluorescence spectrometry for determining osseous or dental origin of unknown material. *Journal of forensic sciences*, *57*(1), 47-51.
2. Creagh, D., & Cameron, A. (2017). Estimating the Post-Mortem Interval of skeletonized remains: The use of Infrared spectroscopy and Raman spectro-microscopy. *Radiation Physics and Chemistry*, *137*, 225-229.
3. Wang, Q., Zhang, Y., Lin, H., Zha, S., Fang, R., Wei, X., ... & Wang, Z. (2017). Estimation of the late postmortem interval using FTIR spectroscopy and chemometrics in human skeletal remains. *Forensic science international*, *281*, 113-120.

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**Supervisor:** Dr Abhishek Gupta and Prof. William S. Price

**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

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**Supervisor:** Dr David Harman (primary supervisor), Dr Aiden O'Loughlin, Assoc Prof Anand Hardikar

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

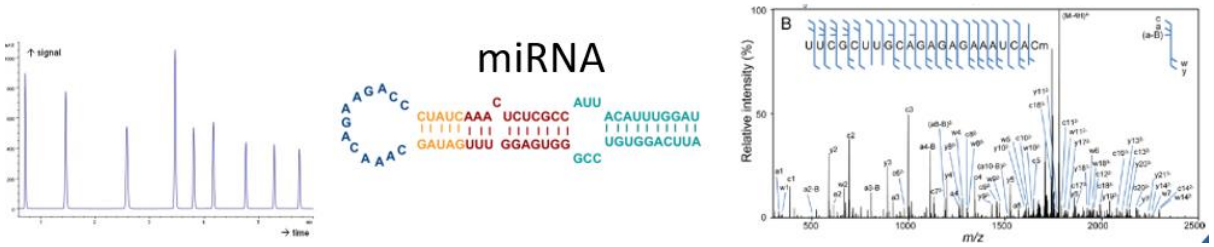
**Research Area:** Analytical chemistry and medical diagnostics

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

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**Supervisor:** Dr Clarissa House, Associate Professor 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

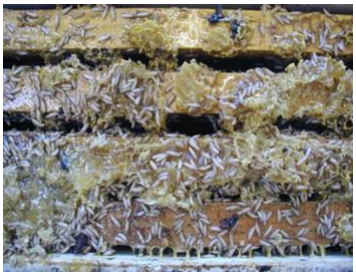

Figure 2. Infestation of small hive beetle larvae in honeybee hive

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:**


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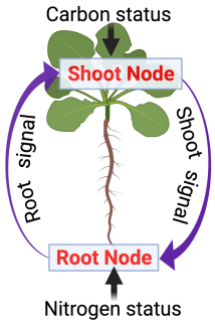
**Supervisor:** Nijat Imin

**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:**

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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 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.

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**Supervisor:** Antonio Lauto

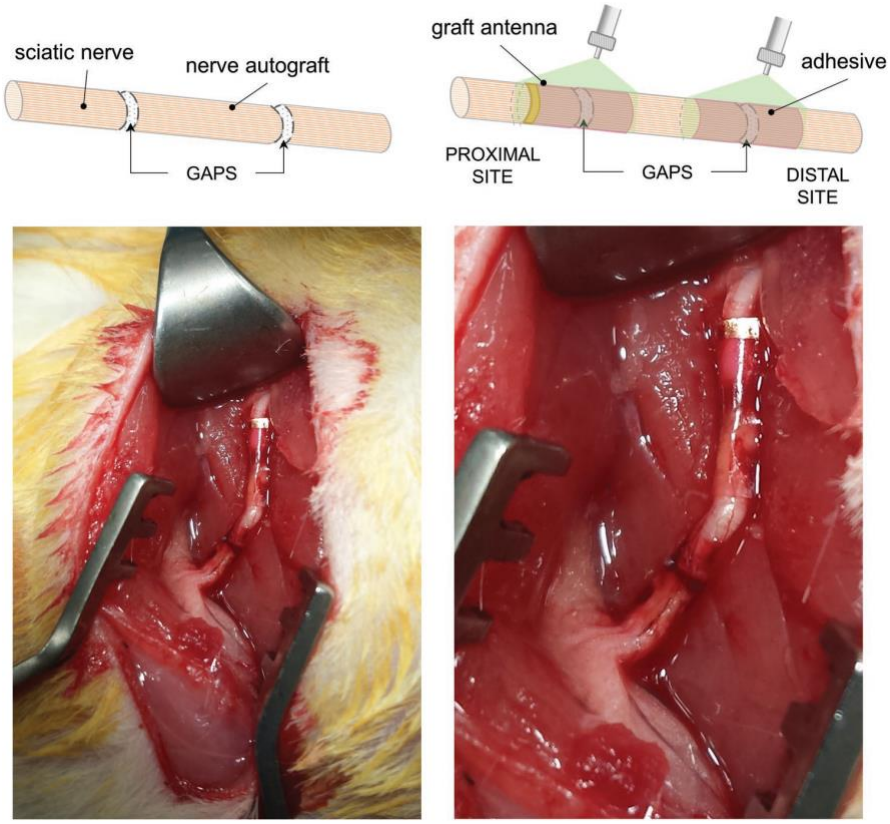
**Project Title: An Innovative Wireless Device for Nerve Stimulation and Regeneration**

**Research Area:** Medical Science, Electrophysiology, Biomedical Engineering

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:** Electrical Stimulation, Wireless Device, Nerve Rigeneration

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**Supervisor:** Antonio Lauto

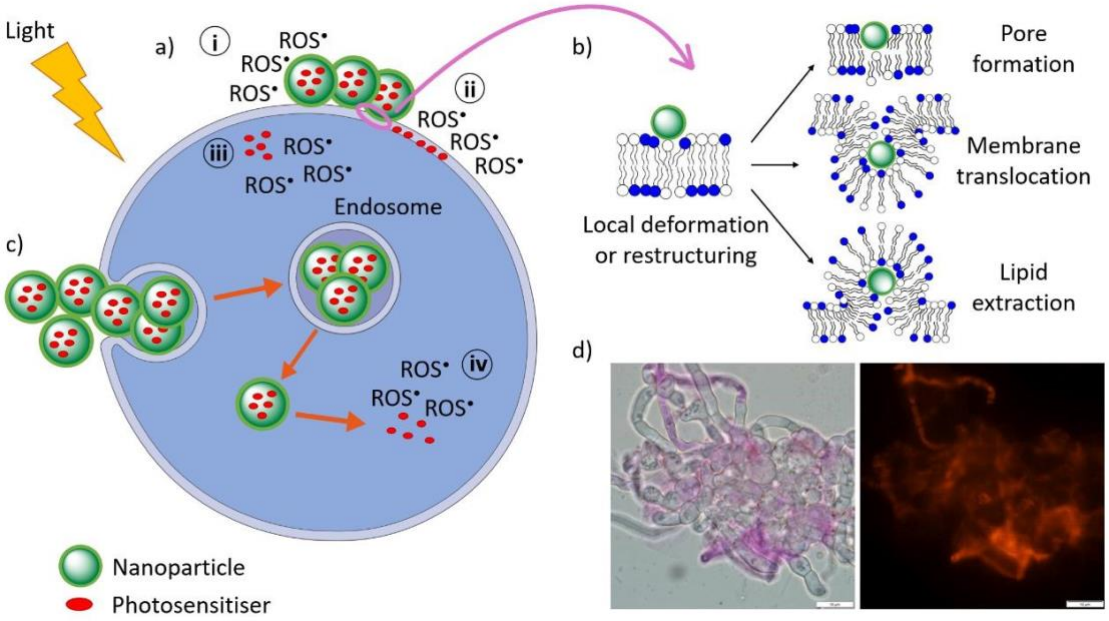
**Project Title: Photodynamic Treatment of Fungal Nail Infections with Nanoparticles**

**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:**

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**Supervisor:** Antonio Lauto

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

**Research Area:** Medical 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.

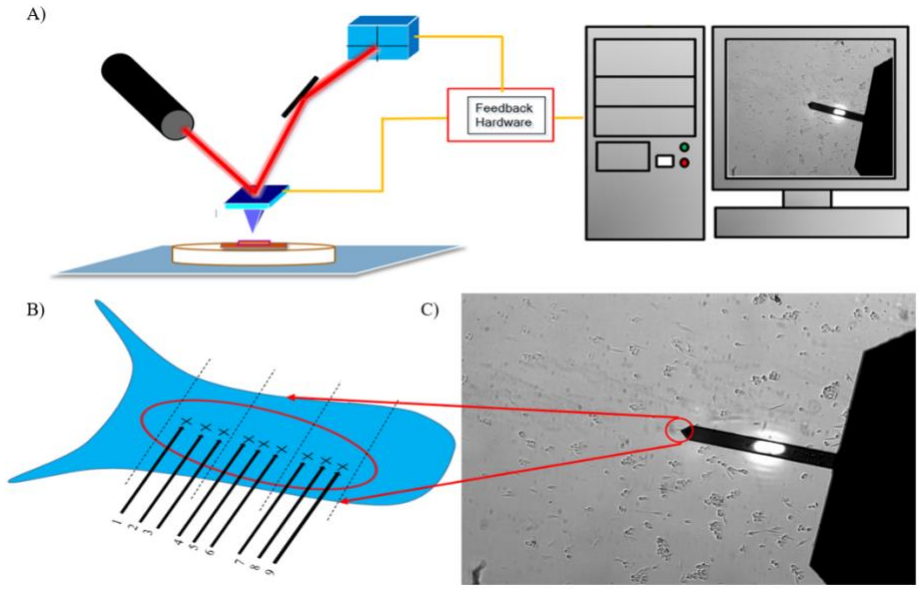


Figure 1. A) Cells are analysed by the AFM , data are then recorded and sent towards the computer. (B) Force indents are indicated along the cell axis. (C) The AFM cantiliver on an isolated cell.

**Keywords:** Neuroblastoma Cells, Mechanobiology, Atomic Force Microscope

**References:**


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3. 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.


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**Supervisor:** Dr. Antonio Lauto and Dr Anai Gonzalez Cordero

**Project Title: Elucidating the effects of light stimulation in stem cell-derived retinal organoids**

**Research Area:** Photonics, Stem Cell Biology, Ophthalmology

Organoids are mini organs in the dish generated from induced pluripotent stem cells (iPSCs). These have revolutionized research as they provide human models in the dish enhancing the understand of diseases. Our group is interested in understanding the pathophysiology of genetic eye diseases affecting the retina. We have generated several control and diseased iPSC lines that can generate retinal organoids. These retinal organoids mimic eye lamination and contain all major retinal cell types (1). However, these are only useful for disease modelling *in vitro* if they replicate and sustain the normal eye morphology and function of the human neural retina.

Differentiation protocols to generate retinal organoids from iPSCs have to date explored environment modulation of through media composition. Very few studies have explored the addition of physical cues to enhance differentiation. Light is necessary for phototransduction cascade initiating in the light-sensing photoreceptor cells of the eye. Controlled exposure to different light wavelengths and intensities are features currently lacking from organoids differentiation protocols.

In this project we hypothesize that light exposure in vitro affects organoid maturation and functionality. We will deliver light using specially designed plates and investigate the molecular, morphological, and functional effects of light stimulation by performing RNA sequencing, immunohistochemistry, and micro-electrode arrays (MEAs) experiments. This will elucidate if biomimetic light treatments can improve the differentiation and maturation of iPSC-derived retinal organoids. Mature retinal organoids will offer better human models of disease.

**Keywords:** Organoids, stem cells, light stimulation, disease modelling,

**References:**

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**Supervisor:** 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

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**Supervisor:** 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℃) into practical applications involving DNA interaction, MRI and drug delivery.
2. DNA interaction
    - To investigate DNA recognition by variation of both the steric nature of the ligand type and the external stimulus (e.g., temperature and light);
    - 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;
    - 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

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**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

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**Supervisor:** Ryan McQuinn, Jay Bose, 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**:

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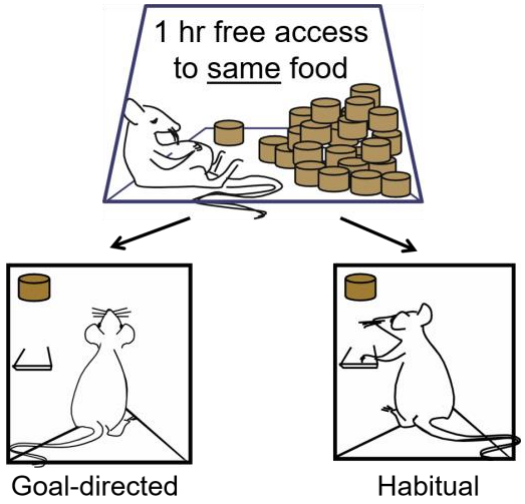
**Supervisor:** Sam Merlin, Teri Furlong (UNSW)

**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**:

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**Supervisor:** Michelle Moffitt, Oliver Morton and 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**:


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**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.

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**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**:
1. 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.

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**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

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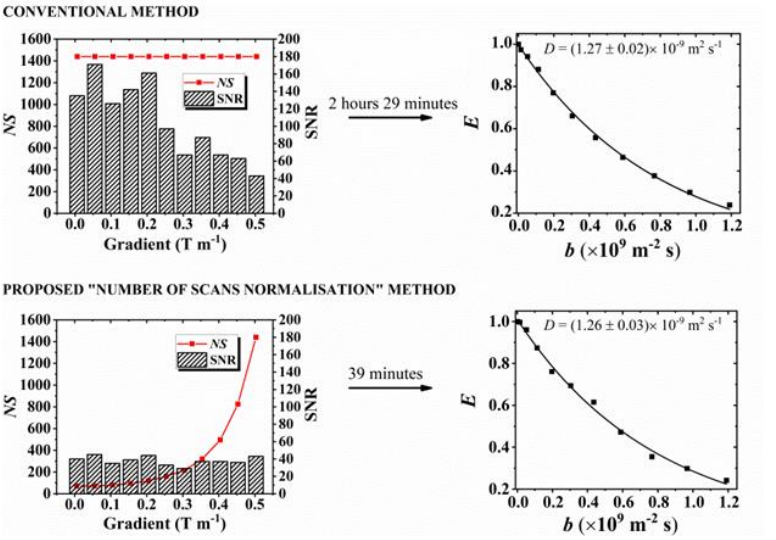
**Supervisor:** Prof. William S. Price, Dr Tim Stait-Gardner, Dr Abhishek Gupta, Dr Allan Torres + other members of the Nanoscale Group

**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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**Supervisor:** Prof. William S. 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

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**Supervisor:** Ricky Spencer, Michelle Ryan, Jenna Condiw (SoSc) and a team from UNE, La Trobe, University of Sydney, 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.

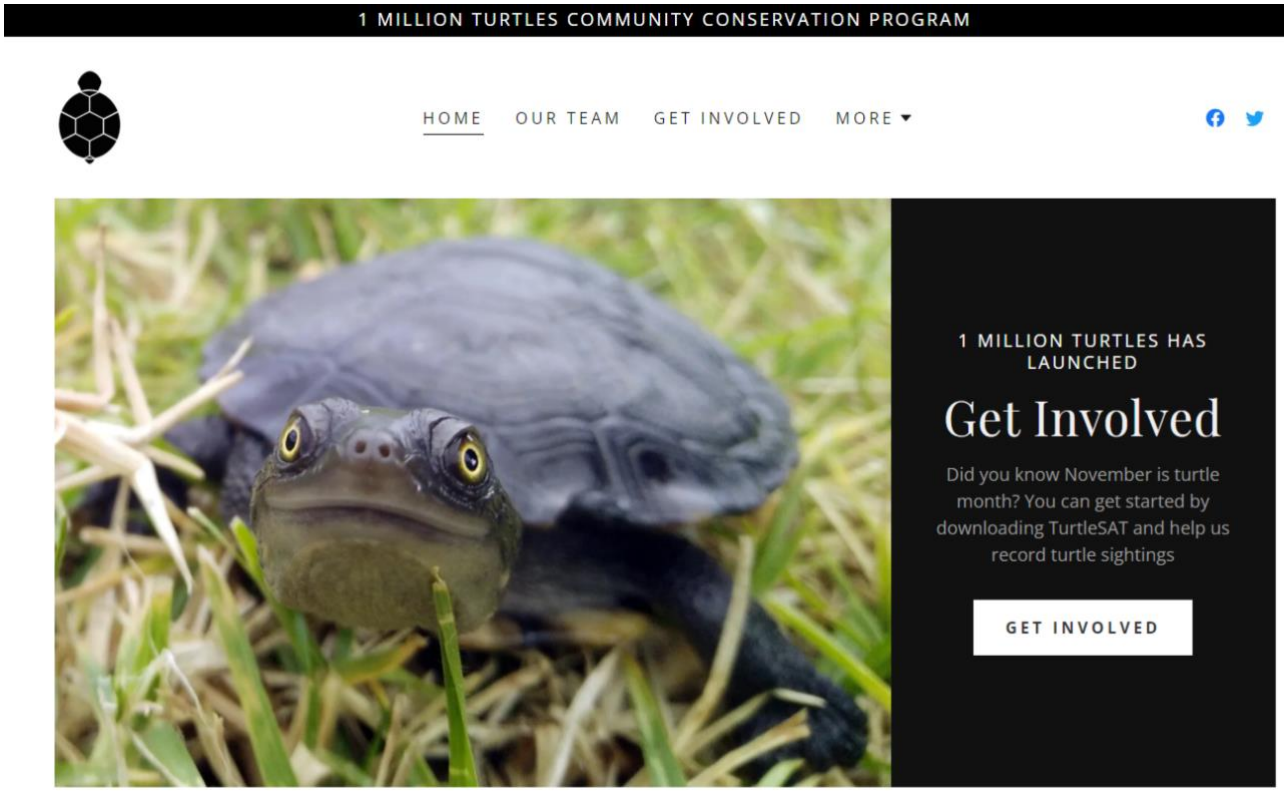
There are up to 10 research projects associated with this project including

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

Contact Ricky Spencer r.spencer@westernsydney.edu.au




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

**References**: See 1MillionTurtles.com

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**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**:

1. 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.

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**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

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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

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3. Backhouse, F., Dalziell, A. H., Magrath, R. D., Rice, A. N., Crisologo, T. L., & Welbergen, J. A. (2021). Differential geographic patterns in song components of male Albert's lyrebirds. Ecology and evolution, 11(6), 2701-2716.


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

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