

**SCHOOL OF CHEMISTRY****CHEM01: USING VIRTUAL REALITY TO AID IN TEACHING**

Virtual Reality (VR) has become a much more common household commodity thanks to the proliferation of more affordable VR devices. It is highly likely that you have encountered a VR device as a gaming tool either at home, at a shopping centre or during a gaming convention. We are particularly interested in using this equipment to aid in the teaching and learning of chemistry, and we need your help with that. As an undergraduate student, you are best placed to consider the value of the technology from the perspective of your peers. This project would involve using the Unity engine to code/create organic chemistry learning materials which will then be trialled (COVID-19 depending) with CHEM1 volunteer students and/or academic staff.

**Primary Supervisor:** Stephen George-Williams

**Mode of delivery:** In-person or online

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** None, but first year chemistry and/or unity coding experience preferred

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [stephen.george-williams@sydney.edu.au](mailto:stephen.george-williams@sydney.edu.au)

**CHEM02: FLUORESCENT SENSORS FOR OXIDATIVE STRESS**

Oxidative stress is linked to diseases of aging, such as cancer, cardiovascular disease, and neurodegeneration. This project involves the synthesis of fluorescent sensors to study oxidative stress in various models of disease. It will involve organic synthesis, fluorescence studies, with the opportunity to observe biological investigations.

**Primary Supervisor:** Professor Elizabeth New

**Mode of delivery:** F11 (Camperdown Campus)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First Year Chemistry

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [elizabeth.new@sydney.edu.au](mailto:elizabeth.new@sydney.edu.au)

**CHEM03: SENSING GLUCOSE AND FRUCTOSE IN BIOLOGICAL SYSTEMS**

Glucose and fructose levels are key markers of metabolic activity in biological systems. This project will involve synthesising new fluorescent sensors for glucose and fructose. The sensors will be used, in the first instance, to study yeast metabolism, but will also be tested for use in biomedical research. The project will involve organic synthesis, fluorescence studies, with the opportunity to observe biological investigations.

**Primary Supervisor:** Professor Elizabeth New

**Mode of delivery:** F11 (Camperdown Campus)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First Year Chemistry

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [elizabeth.new@sydney.edu.au](mailto:elizabeth.new@sydney.edu.au)

#### **CHEM04: FINDING MISSING H ATOMS USING NEUTRON DIFFRACTION AND QUANTUM MECHANICAL CALCULATIONS**

Crystal structures of materials are typically determined using X-ray diffraction. Hydrogen atoms ( $Z=1$ ) scatter X-rays very weakly and often cannot be located and are missing in many published crystal structures of inorganic materials. In this project, neutron diffraction (which is much more sensitive) will be used to find positions of H atoms in several inorganic materials and the results will be confirmed using ab initio quantum mechanical calculations.

**Primary Supervisor:** Associate Professor Max Avdeev

**Mode of delivery:** In-person. On Campus, School of Chemistry

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Hands on lab experience in inorganic synthesis, interest in crystal structures and scientific computing

**Maximum number of places available in a project:** 7

**Final assessment:** Project report, 1-2 pages

**For more information:** [maxim.avdeev@sydney.edu.au](mailto:maxim.avdeev@sydney.edu.au)

#### **CHEM05: SYNTHESIS OF SMALL MOLECULE INHIBITOR ANALOGUES FOR TARGETING TELOMERES**

In our lab (LauGroup.net), one of our main projects is to target cancer by inhibiting replication of their telomeric DNA. The primary target is FANCM-RMI, a protein-protein interaction that is essential for certain types of cancers, such as many osteosarcomas.

This project involves med-chem synthesis - designing and making analogues of "PIP-199", the only currently reported inhibitor of this target, which has sub-optimal properties that we aim to improve.

NB: If you are a final year undergraduate intending to do Honours, doing a Denison project will exclude you from being able to join the same group for Honours.

**Primary Supervisor:** Dr Yu Heng Lau

**Mode of delivery:** In-person. Chemistry Building (F11)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Prior experience working in chemistry laboratories

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [yuheng.lau@sydney.edu.au](mailto:yuheng.lau@sydney.edu.au)

#### **CHEM06: TARGETED DRUG DELIVERY IN THE BRAIN USING DNA COMPUTATION**

In the past several years, high-throughput neuroscience methods have yielded a comprehensive blueprint of the entire brain. Recently, we have been using machine learning to analyse this whole-brain neuroscience data, to determine patterns of molecular signals, such as mRNA and protein concentrations, that uniquely identify specific brain areas. These signals represent a molecular 'postcode' of a specific brain location. In this project, the student will design and test DNA systems that will compare local chemical signals to a stored chemical postcode. Ultimately, the aim is for these DNA circuits to be used to guide a nanoparticle drug delivery system to a specific target in the brain.

**Primary Supervisor:** Dr Shelley Wickham

**Mode of delivery:** In-person. Chemistry Building (F11)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** CHEM1XXX and/or PHYS1XXX experience

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [shelley.wickham@sydney.edu.au](mailto:shelley.wickham@sydney.edu.au)

#### **CHEM07: ROLLING NANOBOTS ON MOLECULAR OBSTACLE COURSES**

Cells and viruses often move around by rolling on biological surfaces, a type of motility that is facilitated by weak interactions with surface-bound ligands. Building synthetic systems with this type of motility can teach us more about how biological systems work and can lead us to new bio-nanotechnological discoveries (eg. Nano Lett. 2019, 19(12), 9138). Using our expertise in DNA

nanotechnology, surface functionalisation and microscopy this project will focus on building DNA-based nanobots that roll on surfaces patterned with tiny obstacle courses, allowing us to answer fundamental questions about biology with a view towards molecular medicines.

**Primary Supervisor:** Dr Shelley Wickham

**Mode of delivery:** In-person. Chemistry Building (F11)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** CHEM1XXX and/or PHYS1XXX experience

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [shelley.wickham@sydney.edu.au](mailto:shelley.wickham@sydney.edu.au)

#### **CHEM08: SYNTHESIS OF BLOCK-TYPE MOLECULAR POLYMER BOTTLEBRUSHES**

Molecular polymer bottlebrushes (MPBs) are macromolecules that resemble the structure of a bottlebrush flower. Their highly dense architecture allows them to be used for advanced applications in self-assembly and nanomedicine. In this project, you will design and synthesise polymeric macromonomers (MM) via atom transfer radical polymerisation. The MMs will then be polymerised to form long cylindrical MPBs. Aside from modern polymerisations you will also learn how to characterise polymers using spectroscopy, chromatography, and scattering techniques.

**Primary Supervisor:** Associate Professor Markus Muellner

**Mode of delivery:** In-person. Chemistry Building (F11)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First year chemistry units, interest in polymer chemistry, hands on lab experience, and independence

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [markus.muellner@sydney.edu.au](mailto:markus.muellner@sydney.edu.au)

#### **CHEM09: METAL-ORGANIC FRAMEWORK GLASSES**

2022 is the International Year of Glass. This project harnesses a newly reported phase of Metal-Organic Frameworks (MOFs) known as "MOF glass." MOFs are an exciting class of nanoporous materials exhibiting multifunctional properties, from gas sorption and separation to applications in photonics, optics and electronics, amongst others. A key problem is the stability of the MOF materials; for example, they often degrade under light irradiation, limiting their real-world applications. In this project, we will coat materials with MOF glasses which have recently been

shown to overcome the stability problems. By comparing the coated and uncoated materials, we will develop a generalisable protocol that could be widely used to improve MOF properties.

**Primary Supervisor:** Professor Deanna D'Alessandro

**Mode of delivery:** In-person. Chemistry Building (F11)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Interested in new types of materials and chemistry or physics laboratory experience.

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [deanna.dalessandro@sydney.edu.au](mailto:deanna.dalessandro@sydney.edu.au)

#### **CHEM10: MODELLING ATMOSPHERIC CHEMISTRY**

This project involves computational investigation and/or simulation of atmospheric chemical processes. For example, by addressing limitations in current models we can improve our understanding of key atmospheric species and predict in advance the impact of releasing new compounds into the atmosphere. Several projects are possible, including investigating new photochemical sources of atmospheric H<sub>2</sub>, studying new atmospheric reactions that can produce HO<sub>2</sub>, studying the dynamics of a new class of 'roaming' reaction and investigating the collisional cooling of a molecule after it has absorbed a UVA photon.

**Primary Supervisor:** Professor Meredith Jordan

**Mode of delivery:** In-person. Camperdown Campus.

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** An interest in understanding the chemistry of the atmosphere and how atmospheric modelling works.

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [meredith.jordan@sydney.edu.au](mailto:meredith.jordan@sydney.edu.au)

#### **CHEM11: SYNTHESIS OF CYCLIC PEPTIDE ANTIVIRALS FOR COVID-19**

The COVID pandemic caused by infection with the novel coronavirus – SARS-CoV-2 – need little introduction. We have developed a cutting-edge peptide display platform to discover large families of cyclic peptides that inhibit viral proteins essential for cell entry and replication of SARS-CoV-2. In this Denison scholarship project, you will synthesise cyclic peptide antivirals using modified solid-phase peptide synthesis and assess their activity in biochemical assays. Compounds will also be screened against SARS-CoV-2 (with A/Prof Turville, Kirby Institute).

**Primary Supervisor:** Professor Richard Payne

**Mode of delivery:** In-person. Camperdown Campus.

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** CHEM2XXX

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [richard.payne@sydney.edu.au](mailto:richard.payne@sydney.edu.au)

### **CHEM12: QUANTUM THERMODYNAMICS**

Quantum effects are important in many chemical applications and need to be included if we are to accurately predict physical and chemical properties and/or rationally design new materials. Feynman's path integral formalism, which is based on the isomorphism between the quantum time-dependent propagator and the thermal density matrix, allows fully quantum thermodynamic parameters to be calculated. This project applies path integral techniques to determine enthalpies and free energies of prototypical molecules to develop new methods that can be efficiently applied to large, chemically realistic systems.

**Primary Supervisor:** Professor Meredith Jordan

**Mode of delivery:** In-person. Camperdown Campus.

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** A solid background in mathematics. Python skills and/or programming experience are desirable but not essential.

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [meredith.jordan@sydney.edu.au](mailto:meredith.jordan@sydney.edu.au)

### **CHEM13: ANION TRANSPORTERS AS POTENTIAL THERAPEUTICS**

Ion transport across biological membranes is an important process, regulated by membrane-embedded pumps, channels and carriers that maintains ion and pH homeostasis in cells. The perturbation of ionic and pH gradients may be utilized in the replacement of faulty ion channels for those suffering with cystic fibrosis or as an anti-cancer therapeutic. A detailed understanding of pathogenetic mechanisms of these diseases requires the use of an intracellular chloride transporter that we can visualize as it disrupts these gradients within our cells. Our group has developed a highly potent chloride transporters based on bis-urea scaffolds (Chem 2019, 5, 1210).

**Primary Supervisor:** Professor Philip A Gale

**Mode of delivery:** In-person. F11, Camperdown Campus.

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Good background in chemistry and biology.

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [philip.gale@sydney.edu.au](mailto:philip.gale@sydney.edu.au)

#### **CHEM14: EXOBIOLOGY: LIFE BEYOND THE GOLDBLOCKS ZONE?**

The search for extra-terrestrial life is often equated to the search for liquid water - the so-called 'Goldilocks Zone.' In this project we will explore which of the necessary conditions for life to emerge can be met in exotic environments that exist beyond the stability range of liquid water.

**Primary Supervisor:** Professor Greg Warr

**Mode of delivery:** In-person. School of Chemistry, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First year chemistry units

**Maximum number of places available in a project:** 2

**Final assessment:** Project report, 1-2 pages

**For more information:** [gregory.warr@sydney.edu.au](mailto:gregory.warr@sydney.edu.au)

#### **CHEM15: SUPRAMOLECULAR IONOGELS**

Intermolecular forces such as H-bonds can be used to assemble small molecules into elongated, entangled fibres that can create gels in water. In this project we will adapt these principles to gel molten salts. These unusual liquids are constituted solely of ions and are finding many novel applications as environmentally friendly battery electrolytes and reaction media.

**Primary Supervisor:** Professor Greg Warr

**Mode of delivery:** In-person. School of Chemistry, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First year chemistry units

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [gregory.warr@sydney.edu.au](mailto:gregory.warr@sydney.edu.au)

#### **CHEM16: CRYSTAL STRUCTURE DETERMINATION FROM POWDER DIFFRACTION DATA**

Typically, crystal structures of materials are determined from single crystal diffraction data. However, for many materials single crystals cannot be (easily) grown. In that case, crystal structure determination can be attempted from powder diffraction data. The task is non-trivial and not always

successful but very stimulating and requires great intellectual effort and creativity. In this project, we will attempt to determine crystal structure of inorganic material, which was reported in 1989 but its crystal structure remains unsolved.

**Primary Supervisor:** Professor Max Avdeev

**Mode of delivery:** In-person. School of Chemistry, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Inorganic solid-state synthesis; X-ray powder diffraction; crystallography; various software codes.

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [maxim.avdeev@sydney.edu.au](mailto:maxim.avdeev@sydney.edu.au)

#### **CHEM17: FLUORESCENT PROBES FOR PHOSPHOLIPIDS**

Living cells synthesise and metabolise over 1000 different lipids, which assemble to form bilayer membranes. However, the relevance of this vast structural diversity and the function of each different lipid is not yet understood. To provide information answering this important biological question, fluorescent probes that are selective towards different phospholipid headgroups are required. This project will involve the synthesis of novel sensors for phospholipid headgroups such as phosphatidylcholine and phosphatidylethanolamine.

**Primary Supervisor:** Professor Kate Jolliffe

**Mode of delivery:** In-person. School of Chemistry, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Undergraduate level experience in Chemistry; familiarity with chemistry and/or molecular laboratory techniques

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [kate.jolliffe@sydney.edu.au](mailto:kate.jolliffe@sydney.edu.au)

#### **CHEM18: SUPRAMOLECULAR SELF-ASSEMBLY OF MOLECULAR DYES**

Self-assembled three-dimensional fiber networks have been extensively studied due to their wide range applications in optoelectronics, catalysis, and sensing. In this project, you will use supramolecular strategies to exploit weak, non-covalent interactions between conjugated molecular dyes to fabricate complex three-dimensional architectures and carry out optical studies to probe the mechanism of their self-assembly.



**Primary Supervisor:** A/Prof Girish Lakhwani

**Mode of delivery:** In-person. Rm 442 (F11) and Rm 248 (F09), Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Students with interest in supramolecular chemistry and nanoscience who are doing chemistry majors, have completed second year chemistry units with hands-on lab experience.

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [Girish.lakhwani@sydney.edu.au](mailto:Girish.lakhwani@sydney.edu.au)

### **CHEM19: ELECTROSTATIC SWITCH MECHANISM OF MEMBRANE PROTEIN REGULATION**

This is a bioinformatics project aimed at discovering the mechanism by which membrane proteins are regulated by searching for evidence of co-evolution between membrane proteins and regulatory kinases. We hope to uncover the hidden role that the surrounding lipid membrane plays in membrane protein regulation, in particular in that of ion pumps, such as the sodium, potassium pump and the proton pump.

**Primary Supervisor:** A/Prof Ron Clarke

**Mode of delivery:** Remote

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Comfortable with computers and computer analysis; basic knowledge of biology and chemistry (e.g. high school level)

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [ronald.clarke@sydney.edu.au](mailto:ronald.clarke@sydney.edu.au)

### **CHEM20: CONVERTING WASTEWATER INTO GREEN HYDROGEN**

Enabling the use of hydrogen as a green energy carrier is key to transition to decarbonized economies and limit the impact of climate change.

Green hydrogen is produced from renewable energy and water, and in a country like Australia, effectively managing water resources is important. Around 14,000 million litres of wastewater are available per year, just in the Sydney region. Currently the treated wastewater is disposed back to the environment. If this water could be re-utilized to produce green hydrogen through electrolysis, it would lead to a potential 1,530,000 million tons of hydrogen, i.e., 100% of Australia's potential green hydrogen export by 2030.

This project will look at ways wastewater can be efficiently electrolysed to produce green hydrogen.

**Primary Supervisor:** Francois Aguey-Zinsou

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Basic chemistry, electrochemistry, and laboratory skills

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [f.aguey@sydney.edu.au](mailto:f.aguey@sydney.edu.au)

### **CHEM21: PROTON-CONDUCTING MEMBRANE MATERIALS**

You will work on the synthesis, chemical and physical property characterisation of new proton-conducting materials with highly asymmetric crystal structures, designed for applications in solid-oxide fuel cells and photocatalytic water-splitting.

**Primary Supervisor:** Francois Aguey-Zinsou

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Basic chemistry, electrochemistry, and laboratory skills

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [f.aguey@sydney.edu.au](mailto:f.aguey@sydney.edu.au)

### **CHEM22: PROTON-CONDUCTING MEMBRANE MATERIALS**

You will work on the synthesis, chemical and physical property characterisation of new proton-conducting materials with highly asymmetric crystal structures, designed for applications in solid-oxide fuel cells and photocatalytic water-splitting.

**Primary Supervisor:** Professor Chris Ling

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First year chemistry units

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [chris.ling@sydney.edu.au](mailto:chris.ling@sydney.edu.au)

**CHEM23: ALL-SOLID-STATE BATTERIES**

Commercial lithium-ion batteries use liquid electrolytes, which are convenient but also the most toxic and flammable components. In this project we are working to discover and optimise solid-state electrolyte materials viable for use in the next generation of safer and longer-lasting batteries.

**Primary Supervisor:** Professor Chris Ling

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First year chemistry units

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [chris.ling@sydney.edu.au](mailto:chris.ling@sydney.edu.au)

**CHEM24: RE-EVALUATING FORMATIVE ASSESSMENT TO SUPPORT THE TRANSITION TO UNIVERSITY LEVEL CHEMISTRY**

The Chemistry Bridging Course has long been an important stepping stone for students in need of a refresher (or introduction) to chemistry concepts prior to first-year chemistry. One of the key features has been the use of formative feedback to emphasise understanding rather than "grade chasing". With the recent shift to online learning, it is an opportune time to re-evaluate how this process runs and implement a research approach to understand how students use this feedback and how it could be improved.

**Primary Supervisor:** Reyne Pullen

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Teaching, assessment, supporting students entering University, some knowledge of quantitative or qualitative research methods beneficial

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [reyne.pullen@sydney.edu.au](mailto:reyne.pullen@sydney.edu.au)

**CHEM25: RESTRUCTURING SECOND-YEAR CHEMISTRY LABORATORY MANUAL AND RESOURCES TO REFLECT RESEARCH PRACTICES AND PROMOTE LEARNING**

Historically, many laboratory manuals have taken an approach more reflective of a cookbook than a research laboratory - typically not an ideal outcome when preparing our students to be graduates! This project would involve identifying novel approaches to structuring scaffolded laboratory materials with the intention of building toward real-world skills. Once designed, testing would occur with academic staff and students to investigate the effectiveness of the revised materials.

**Primary Supervisor:** Reyne Pullen

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Knowledge of chemistry teaching laboratory, undergraduate level experience in laboratory techniques, some knowledge of qualitative research methods beneficial

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [reyne.pullen@sydney.edu.au](mailto:reyne.pullen@sydney.edu.au)

#### **CHEM26: MO NMR AS A PROBE OF LI**

There are several measures of the interactions between ligands and metals, but most rely on a remote "reporter" ligand. We aim to probe the metal directly using 95-Mo nmr to determine these fundamental effects and triangulate the results using ir spectroscopy and electrochemistry. Students will learn synthetic inorganic chemistry techniques, as well as physical characterisation techniques such as 95-Mo nmr.

**Primary Supervisor:** Professor Tony Masters

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Second year chemistry with good laboratory skills

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [anthony.masters@sydney.edu.au](mailto:anthony.masters@sydney.edu.au)

#### **CHEM27: COMPUTER SIMULATION OF NEXT-GENERATION SOLAR CELLS**

Organic semiconductors can be made into next-generation photovoltaics for truly green energy. However, we still do not fully understand the fundamental processes by which these devices function and are aiming to develop new theories to explain them and help develop better ones. You will learn how to program computer simulations of the fundamental processes of charge and energy transport in organic solar cells, which will help explain their remarkable properties.

**Primary Supervisor:** Associate Professor Ivan Kassal

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Interest in computational science. Programming experience helpful but not required.

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [ivan.kassal@sydney.edu.au](mailto:ivan.kassal@sydney.edu.au)

### **CHEM28: QUANTUM CHEMISTRY ON QUANTUM COMPUTERS**

Quantum computers could simulate chemical processes much faster than conventional supercomputers, making chemistry one of the most promising applications of quantum technology. You will join an active research program that is aiming to carry out the first simulation of a chemical reaction on a quantum computer. Possible projects include developing quantum algorithms, understanding the impact of noise on algorithm performance, and collaborating with experimental colleagues to interpret the experimental data.

**Primary Supervisor:** Associate Professor Ivan Kassal

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Familiarity with basic quantum mechanics

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [ivan.kassal@sydney.edu.au](mailto:ivan.kassal@sydney.edu.au)

### **CHEM29: SYNTHESIS, STRUCTURE AND MAGNETISM IN RE HALIDES**

The magnetic properties of the heavy 4d and 5d halides are relatively poorly studied. This project will prepare several halides of the type  $A_2ReX_6$  ( $A = Na, K, Rb$ ;  $X = Cl, Br$ ) and characterise their crystal structure and magnetic properties. The aim is to establish the correlation between the crystal structure and the anti-ferromagnetic ordering temperature of the halides.

**Primary Supervisor:** Professor Brendan Kennedy

**Mode of delivery:** In-person. Chemistry Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Experience in working in a chemical laboratory and interested in inorganic chemistry

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [brendan.kennedy@sydney.edu.au](mailto:brendan.kennedy@sydney.edu.au)

## SCHOOL OF GEOSCIENCES

### GEOS01: FAULT AND FRACTURE MECHANICS IN SYDNEY BASIN

In an urban environment, faults and fractures pose a range of environmental, engineering and hazard issues that need to be understood to be mitigated. These structures change the strength of the geological framework that supports surface and underground infrastructures, and they may be at the origin of seismic activities. In this field-based and/or laboratory-based project you will analyse the structure and geometry of fault and fracture networks in Greater Sydney Region, documenting their geohazard consequences.

**Primary Supervisor:** Vasileios Chatzaras

**Mode of delivery:** In-person. Madsen Building F09, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First-year Geology units

**Maximum number of places available in a project:** 2

**Final assessment:** Project report, 1-2 pages

**For more information:** [Vasileios.chatzaras@sydney.edu.au](mailto:Vasileios.chatzaras@sydney.edu.au)

### GEOS02: MICROTOMOGRAPHY OR DEEP EARTH MATERIALS

One of the aspects of Plate Tectonics that has not been explored in detail is three-dimensional deformation in the Earth's mantle, particularly along plate boundaries. In this project, you will use X-ray computed tomography data, to analyse the 3D shape of minerals from rocks that formed in the Earth's oceanic upper mantle. The results will inform models of 3D mantle flow in subduction zones.

**Primary Supervisor:** Vasileios Chatzaras

**Mode of delivery:** In-person. Madsen Building F09, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Comfortable with computers

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [Vasileios.chatzaras@sydney.edu.au](mailto:Vasileios.chatzaras@sydney.edu.au)

**GEOS03: HALO - HALIMEDA BIOHERM ORIGINS, FUNCTION AND FATE IN THE NORTHERN GREAT BARRIER REEF**

Calcareous green alga Halimeda is a major contributor to coral reef shelf sediments and is found along the entire Great Barrier Reef (GBR), Australia. Previous studies of extensive Halimeda deposits, or bioherms, show they represent important inter-reef habitats and potential carbon sinks in the GBR Marine Park, covering ~26% of the northern shelf, equal to the modern coral reef system. We will study these enigmatic features, building directly on a recent (\$3 mill) RV Investigator cruise (Project Halo). We have collected extensive new high-resolution multibeam mapping, sub bottom profiling, sediment coring, innovative seabed/habitat imaging, oceanography, and bio-geochemical data. This will increase our understanding of the fundamental processes that control bioherm development and have direct implications for environmental managers tasked with predicting how these poorly studied inter-reef environments might respond to future climate change.

NB: This project is funded by grants from National Geographic and the Ian Potter Foundation.

**Primary Supervisor:** Jody Webster

**Mode of delivery:** In-person. Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Interest in the Great Barrier Reef, sediments, marine geosciences, ecology

**Maximum number of places available in a project:** 3

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [jody.webster@sydney.edu.au](mailto:jody.webster@sydney.edu.au)

**GEOS04: THE GEOGRAPHIES OF CLIMATE INFRASTRUCTURE AND THEIR EXTRACTIVE INDUSTRIES**

Protecting urban environments in the face of climate threats will involve investment in, and the building of, protective and resilient infrastructure. However, this infrastructure can be maladaptive, either producing new vulnerabilities or moving existing vulnerabilities somewhere else in urban or rural landscapes. One example of this is the extraction of raw materials for concrete, and the negative landscape, livelihood, and labour effects this has. In this project, we will examine the extractive industries that support climate infrastructures with a goal of understanding their social, ecological, and economic effects across spaces and scales.

**Primary Supervisor:** Senior Lecturer and ARC DECRA Fellow Sophie Webber

**Mode of delivery:** In-person. Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Students will have experience with Geography and Environmental Studies Units and be willing and able to review grey literature and policy documents about climate infrastructure.

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [sophie.webber@sydney.edu.au](mailto:sophie.webber@sydney.edu.au)

#### **GEOS05: PEERING INTO THE UNDERWORLD - MAPPING SLAB WINDOWS THROUGH TIME**

A slab window forms when an oceanic spreading centre interacts with a subduction zone, creating a gap for hot mantle material to rise to shallow depths. This leads to significant uplift on the overriding plate, a distinctive signature of anomalous volcanism and changing sedimentation patterns. As part of this project, you will map migrating slab windows in southern South America and the Antarctic Peninsula and compare your results with maps of present-day mantle structure using a combination of seismic tomography images and the geological record. This work will feed into a major industry funded project related to the formation of porphyry copper, which is critically important for our transition to a green energy future.

**Primary Supervisor:** A/Prof Maria Seton

**Mode of delivery:** In-person. Madsen Building F09, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First-year geology; comfortable with computers, familiarity with python is a plus but not mandatory.

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [maria.seton@sydney.edu.au](mailto:maria.seton@sydney.edu.au)

#### **GEOS06: HOW SENSITIVE IS TROPICAL PACIFIC CLIMATE TO TURBULENT MIXING PHYSICS?**

Turbulent mixing is a key process that governs how heat and salt is moved around the ocean and is known to influence ocean circulation and climate up to global scales. For example, climate variability in the tropical Pacific ocean associated with El Nino-Southern Oscillation events is known to depend on how heat moves between the surface and interior ocean and is thus influenced by mixing. However, turbulent mixing occurs at spatial scales (of order centimetres) that are too small to be resolved by current-generation numerical climate models, and thus must be represented through approximate analytical relationships known as parameterizations. Through analysis of output of several high-resolution regional coupled atmosphere-ocean and ocean-only numerical models run with different turbulent mixing parameterizations, this project aims to evaluate which parameterizations lead to the best representation of tropical Pacific circulation and quantify the sensitivity of the circulation to the mixing. This project would suit a student with a background in physics and mathematics and experience with a programming and data analysis language such as python or Matlab.

**Primary Supervisor:** Ryan Holmes

**Mode of delivery:** In-person. Madsen Building F09, Camperdown Campus



**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** This project would suit a student with a background in physics and mathematics and experience with a programming and data analysis language such as python or Matlab.

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [r.holmes@sydney.edu.au](mailto:r.holmes@sydney.edu.au)

### **GEOS07: UNDERSTANDING THE EFFECT OF SEA-LEVEL CHANGES IN DELTAS**

More than two thirds of the worlds' largest and highly populated cities are coastal delta cities or are situated on estuaries vulnerable to rising sea levels. This project seeks to understand the effect of sea-level changes in river-deltas with contrasting shelf gradients by using cutting-edge numerical models. This project provides an extraordinary opportunity to learn about the natural processes that shape the coastlines where we live and will help us prepare for future environmental change.

**Primary Supervisor:** Dr. Sara Polanco

**Mode of delivery:** In-person (Madsen Building F09, Camperdown Campus) or remote

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Comfortable with computers and statistical analysis, familiarity with programming (ideally python)

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [sara.moronpolanco@sydney.edu.au](mailto:sara.moronpolanco@sydney.edu.au)

### **GEOS08: MAPPING SYDNEY'S HIGH STREETS**

What impact have events like COVID and trends like online shopping had on traditional shopping streets in Sydney? In this project, you will contribute to on-going research mapping the occupancy of diverse high streets across Sydney and studying the kinds of activities and interactions that they facilitate. The project is part of an on-going collaboration with the Committee for Sydney and Cox Architecture.

**Primary Supervisor:** Associate Professor Kurt Iveson

**Mode of delivery:** In-person. Location: Various suburbs in Sydney

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Some background in geography/urban geography, comfortable with Excel and spreadsheets, willingness/ability to travel to field sites across Sydney (all accessible by public transport)

**Maximum number of places available in a project:** 2

**Final assessment:** Project report, 1-2 pages

**For more information:** [kurt.iveson@sydney.edu.au](mailto:kurt.iveson@sydney.edu.au)

## SCHOOL OF MATHEMATICS AND STATISTICS

### **MATH01: RIEMANN-ROCH THEOREM AND DIRAC OPERATOR**

We start with the book "Introduction to Algebraic Curves" by Griffiths to appreciate the classic Riemann-Roch Theorem, then move on to its modern generalisation for general dimensions through index theory for Dirac operator.

**Primary Supervisor:** Zhou Zhang

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** MATH3979 and MATH3968

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [zhou.zhang@sydney.edu.au](mailto:zhou.zhang@sydney.edu.au)

### **MATH02: DATA-INTENSIVE SCIENCE TO UNDERSTAND THE MOLECULAR AETIOLOGY OF DISEASE**

Biotechnological advances have made it possible to monitor the expression levels of thousands of genes and proteins simultaneously promising exciting, ground-breaking discoveries in complex diseases. This project will focus on the application and/or development of statistical and machine learning methodology to analyse a high-dimensional biomedical experiment. Our lab works on projects spanning multiple diseases including melanoma, ovarian cancer, acute myeloid leukemia, Alzheimer's disease, multiple sclerosis, and HIV. We also work with various high-throughput technologies including single-cell RNA-Seq, SWATH-MS, flow cytometry, CyTOF, CODEX imaging and imaging mass cytometry.

**Primary Supervisor:** Ellis Patrick

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** DATA2X02

**Maximum number of places available in a project:** 4

**Final assessment:** TBC

**For more information:** [ellis.patrick@sydney.edu.au](mailto:ellis.patrick@sydney.edu.au)

**MATH03: MODELLING SENSORY DATA FROM THE RED MEAT INDUSTRY**

The beef industry in Australia is worth \$15 billion annually and the sheep meat industry is worth another \$5 billion. A key question concerning the red meat industry is the ability to predict the eating quality of cuts of meat. Doing this well has major financial implications for the industry. This project would focus on the statistical issues associated with analysing consumer sensory data to predicting meat eating quality. Examples of projects include: robust multi-level and multi-class modelling of consumer sensory data which often contains many outliers; determining the relative importance of eating quality factors such as flavour, tenderness and juiciness for overall palatability and purchasing intention; evaluating the importance of "link product" as a common starting benchmark across consumers; developing methods and protocols to evaluate new objective grading technologies; and designing dashboards to help inform the decision making of processors and producers across Australia.

**Primary Supervisor:** Garth Tarr

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** DATA2002/2902

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [garth.tarr@sydney.edu.au](mailto:garth.tarr@sydney.edu.au)

**MATH04: NEW DATA SCIENCE APPROACHES FOR SINGLE CELL SPATIAL GENOMICS**

Recent developments in single cell RNA-sequencing and spatially resolved genomics (e.g. seqFISH, 10X Visium) have resulted in immense datasets corresponding to hundreds of thousands of observed cells and thousands of measured features. The overarching goal is to understand these data and develop new data science approaches to addressing questions in biology. There are opportunities to build capacity in terms of computational modelling, effective data visualisation and interaction, and software scalability.

**Primary Supervisor:** Shila Ghazanfar

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** DATA2002/2902

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [shila.ghazanfar@sydney.edu.au](mailto:shila.ghazanfar@sydney.edu.au)

**MATH05: A DATA SCIENCE APPROACH TO INVESTIGATE HUMAN DEVELOPMENT**

Recent generation of artificial human blastoids that recapitulate the early human embryos is a ground-breaking achievement. These technologies are transforming our understanding of early human development and hold promise to revolutionise regenerative medicine that utilises stem cell-derived tissues and organs. While a panel of experimental protocols have been established for generating human blastoids, the fidelity of these blastoids for modelling early human embryos remains to be assessed. This project aims to use a data analytics approach (e.g., machine learning, feature selection, statistical prediction) to investigate single cell transcriptomics data to assess the quality of artificial human blastoids in recapitulating early human embryos.

**Primary Supervisor:** Pengyi Yang

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** DATA2002/2902

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [pengyi.yang@sydney.edu.au](mailto:pengyi.yang@sydney.edu.au)

**MATH06: HIGHER-DIMENSIONAL SELF-SIMILAR ACTIONS**

The project will look at self-similar actions of groups on directed graphs and their higher-dimensional analogues, called k-graphs. We will investigate constructing groupoids from such actions, and if time permits, will explore the C\*-algebras (think infinite-dimensional matrices) associated to these objects.

**Primary Supervisor:** Nathan Brownlowe

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** 2nd year mathematics

**Maximum number of places available in a project:** 1

**Final assessment:** TBC

**For more information:** [Nathan.brownlowe@sydney.edu.au](mailto:Nathan.brownlowe@sydney.edu.au)

**MATH07: Equilibrium states on the C\*-algebras of undirected graphs**

Equilibrium states (more commonly called KMS states) have origins in Statistical Mechanics but can be studied from a purely mathematical point of view. We will examine the structure of the KMS states on  $C^*$ -algebras (think infinite-dimensional matrices) built from undirected graphs.

**Primary Supervisor:** Nathan Brownlowe

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** 2nd year mathematics

**Maximum number of places available in a project:** 1

**Final assessment:** TBC

**For more information:** [Nathan.brownlowe@sydney.edu.au](mailto:Nathan.brownlowe@sydney.edu.au)

#### **MATH08: ASSIGNING SIGNIFICANCE WITH THE THREE-PARAMETER GAMMA NULL**

The three-parameter Gamma distribution (3-Gamma for short) adds a location parameter to the usual shape and scale/rate parameters that define the canonical Gamma distribution. The 3-Gamma is a flexible family of distributions that was empirically found to offer excellent fits to the null distribution of various maximization problems. We are interested in exploring some ideas on how to assign significance to an observed result assuming the underlying null distribution is the 3-Gamma.

**Primary Supervisor:** Uri Keich

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** STAT2911

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [uri.keich@sydney.edu.au](mailto:uri.keich@sydney.edu.au)

#### **MATH09: UNUSUAL BILLIARDS**

Everybody knows about the game of billiards on the standard rectangular desk. How would it be to play that game on a desk of another shape: circle, oval, triangle? Can we imagine billiard on a three-dimensional desk or on some surface? This project will aim to answer to those questions.

**Primary Supervisor:** Milena Radnovic

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** first year linear algebra.

**Maximum number of places available in a project:** 3

**Final assessment:** TBC

**For more information:** [milena.radnovic@sydney.edu.au](mailto:milena.radnovic@sydney.edu.au)

### **MATH10: FRACTAL GEOMETRY**

Fractals are intriguing geometrical objects that appear in mathematics, but also are found in nature. This project aims to explore those beautiful sets, from the points of geometry, dynamics, topology.

**Primary Supervisor:** Milena Radnovic

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** first year linear algebra and calculus

**Maximum number of places available in a project:** 3

**Final assessment:** TBC

**For more information:** [milena.radnovic@sydney.edu.au](mailto:milena.radnovic@sydney.edu.au)

### **MATH11: THE NATURE OF PLATONIC AND ARCHIMEDEAN SOLIDS**

The aim is to study regular and semi-regular polyhedra, and search for their applications in mathematics and/or occurrence in nature.

**Primary Supervisor:** Milena Radnovic

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First year linear algebra.

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [milena.radnovic@sydney.edu.au](mailto:milena.radnovic@sydney.edu.au)

### **MATH12: METHODS TOWARDS PRECISION MEDICINE**

Over the past decade, new and more powerful -omic tools have been applied to the study of complex disease such as cancer and generated a myriad of complex data. However, our general ability to analyse this data lags far behind our ability to produce it. This project is to develop computational methods that helps towards identify disease pathways and deliver better prediction

of outcome. This project could also investigate whether it is possible to establish the patient or sample specific accuracy by integrating public repository of multi-omics data.

**Primary Supervisor:** Jean Yang

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** DATA2002

**Maximum number of places available in a project:** 3

**Final assessment:** TBC

**For more information:** [jean.yang@sydney.edu.au](mailto:jean.yang@sydney.edu.au)

### **MATH13: STATISTICAL DATA SCIENCE TO UNLOCK THE POTENTIAL IN NUTRIOMICS DATA**

There is global interest in the development of high-value foods to improve animal production or human wellbeing. The major challenge is that different individuals given identical foods do not all respond in the same way. The inability to predict the response is essentially a data science problem related to the complex nature of biological systems that intrinsically yield messy data. Advances in the understanding of microbiomes (especially the gut) over the past decade have revealed a possible explanation; diet and microbiome are both heterogeneous in the natural populations and their influence on animal health is inextricably interlinked. One project in this space is to identify actionable nutritional markers or signatures for outcomes that is robust and generalisable. Two potential projects are (a) to build an interpretable nutri biome classification workflow to unravel the association between diet and initial microbiome history (stage) with an experiment-driven animal model. (b) to construct predictive markers for phenotype outcome in natural populations incorporating nutri biomic heterogeneity.

**Primary Supervisor:** Jean Yang

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Knowledge and ability to use R

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [jean.yang@sydney.edu.au](mailto:jean.yang@sydney.edu.au)

### **MATH14: AFFINE SEGRE SURFACES**

Take two quadratic polynomials  $P$  and  $Q$  in four variables. The set of their common zeros forms what is known as a Segre surface. Much is known about Segre surfaces in complex projective space,

including the remarkable fact that they always contain precisely 16 lines. In a recent application however, a major role is played by Segre surfaces in complex affine space. This project is about exploring such affine Segre surfaces. Can we find a normal form for them? How do we compute the lines on these surfaces, and can we visualise them? What happens when the surface has a singularity?

**Primary Supervisor:** Pieter Roffelsen

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** First year calculus and algebra and ideally also MATH2023 or equivalent

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [pieter.roffelsen@sydney.edu.au](mailto:pieter.roffelsen@sydney.edu.au)

#### **MATH15: WHAT CAN TRIANGLES TELL US ABOUT DONUTS**

A diagonal triangulates a square. Generalization of such a triangulation to study surfaces has powerful consequences in several fields from representation theory to computer graphics. In this project, we will study the triangulation of a torus.

**Primary Supervisor:** Harini Desiraju

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** basic understanding of complex variables is desirable but not necessary

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [harini.desiraju@sydney.edu.au](mailto:harini.desiraju@sydney.edu.au)

#### **MATH16: HEUN POLYNOMIALS AND HYPERBOLIC POLYGONS**

The Heun equation is a differential equation with deep connections to hyperbolic geometry. Any solution to the Heun equation gives rise to an angle preserving map from the upper half-plane to a hyperbolic polygon. In this project we will study the polygons corresponding to the simplest solutions of the Heun equation, the fascinating Heun polynomials.

**Primary Supervisor:** Harini Desiraju, Pieter Roffelsen

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023



**Pre-requisites:** MATH2023, some experience with numerical plotting is desirable but not necessary

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [harini.desiraju@sydney.edu.au](mailto:harini.desiraju@sydney.edu.au)

### **MATH17: DESIGN AND ANALYSIS OF BILEVEL OPTIMISATION ALGORITHMS**

Bilevel optimisation models are used in quantitative decision-making models when we are required to consider multiple objective functions. The goal is to choose a vector that minimizes an upper-level objective function, where our choice is constrained to be from the set of vectors which minimize a lower-level objective function. This problem enjoys a rich theoretical structure, and finds applications in various fields including transportation, revenue management, energy markets, logistics, and machine learning. This project aims to develop new algorithms for a class of convex bilevel optimisation models, along with rigorous performance guarantee proofs. The student will explore traditional single-level optimisation algorithms, such as gradient descent and Frank-Wolfe, and their adaptation to the bilevel setting. The student will develop proficiency in proving algorithmic performance guarantees, coding for numerical testing of these algorithms, literature review techniques and written communication of mathematics.

**Primary Supervisor:** Nam Ho-Nguyen

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** The student should be comfortable with reading and writing mathematical proofs, analysis and linear algebra at an advanced second year level and have basic proficiency in a high-level programming language (e.g., Python).

**Maximum number of places available in a project:** 2

**Final assessment:** TBC

**For more information:** [nam.ho-nguyen@sydney.edu.au](mailto:nam.ho-nguyen@sydney.edu.au)

### **MATH18: EXPLORATION OF THE FULL 2-BODY PROBLEM**

When non-spherical bodies attract each other through Newtonian gravity the force between two bodies depends on their relative position and their orientation (hence the word "full"). We will consider the simplest such case where both bodies have rotational symmetry, but are not spherical, and consider simple periodic solutions of the corresponding differential equations. This can be applied to decide whether there are binary systems of spinning stars in which the centre of mass of each star orbits in distinct planes.

**Primary Supervisor:** Holger Dullin

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** ideally MATH3977, possibly some programming experience

**Maximum number of places available in a project:** 3

**Final assessment:** TBC

**For more information:** [holger.dullin@sydney.edu.au](mailto:holger.dullin@sydney.edu.au)

## SCHOOL OF PHYSICS

### PHYS01: PROBING INSIDE STARS USING ASTEROSEISMOLOGY

Asteroseismology involves using the oscillation frequencies of a star to measure its internal properties. Many stars, including the Sun, are observed to oscillate. This project will use data from NASA's TESS Mission, which is a space telescope that has discovered thousands of planets transiting other stars and is also perfect for studying stellar oscillations.

**Primary Supervisor:** Prof. Tim Bedding

**Mode of delivery:** In-person. Location: School of Physics (A28)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** first-year Physics units and some experience with programming in python

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [tim.bedding@sydney.edu.au](mailto:tim.bedding@sydney.edu.au)

### PHYS02: TRAPPED ION CRYSTALS AND LARGE-SCALE ENTANGLEMENT

Trapped atomic ions are a leading candidate system for experiments in quantum simulation and quantum-enhanced sensing. In quantum simulation, we attempt to realize a controllable quantum system capable of simulating more complex, uncontrolled quantum systems, e.g., for material discovery and design. Quantum-enhanced sensing can be used to perform ultra-sensitive force detection, as e.g., proposed for dark matter detection. This project will focus on the development of these types of experiments using large ion crystals in a Penning trap. This effort will build on successful experimental demonstrations of quantum control of hundreds of qubits and will leverage new insights into the manipulation and application of quantum systems.

This project will be conducted within the new Sydney Nanoscience Hub. This project will incorporate experience in experimental atomic physics, charged-particle trapping, custom experimental system design, and electromagnetic simulation.

**Primary Supervisor:** Robert Wolf

**Mode of delivery:** In-person. Location: Sydney Nanoscience Hub, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** second-year Physics units

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [robert.wolf@sydney.edu.au](mailto:robert.wolf@sydney.edu.au)

### **PHYS03: HOW DOES THE BRAIN COMPUTE? DISTRIBUTED DYNAMICAL COMPUTATION IN NEURAL CIRCUITS**

One of the most fundamental problems about the brain is how it computes. To answer this question, we have presented a concept of distributed dynamical computation (DDC), in which neural computation or information processing is carried out by interacting, propagating neural waves. This concept can unify dynamical and computational perspectives of the brain, which used to have great gaps between each other. The project will involve making further links between neural dynamics and computation, including studying the neural circuit models developed by our group to reveal the physical principles of key brain functions such as visual processing and attention.

**Primary Supervisor:** A/Prof Pulin Gong

**Mode of delivery:** In-person. Location: Madsen Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** first-year Physics units

**Maximum number of places available in a project:** 3

**Final assessment:** Project report, 1-2 pages

**For more information:** [pulin.gong@sydney.edu.au](mailto:pulin.gong@sydney.edu.au)

### **PHYS04: THE PHYSICS OF DEEP LEARNING IN ARTIFICIAL INTELLIGENCE**

Deep neural networks (DNNs) widely used in artificial intelligence can be trained to effectively solve many real-world problems such as speech recognition, object detection, and drug discovery. However, our understanding of why they are so effective is lacking. The project will involve studying how fractal, self-similar geometry structures of loss function landscapes interact with a learning algorithm (i.e., stochastic gradient descent) to give rise to complex learning dynamics and the resultant effectiveness of DNNs. These complex learning dynamics will then be applied to develop new learning algorithms.

**Primary Supervisor:** A/Prof Pulin Gong

**Mode of delivery:** In-person. Location: Madsen Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** first-year Physics units

**Maximum number of places available in a project:** 3

**Final assessment:** Project report, 1-2 pages

**For more information:** [pulin.gong@sydney.edu.au](mailto:pulin.gong@sydney.edu.au)

#### **PHYS05: FEATURE-BASED TIME-REVERSAL ASYMMETRY METRICS**

Measures of temporal irreversibility, estimated from time series, have wide ranging utility, from inference of nonlinearity in systems to metrics of conscious level from measured neural dynamics. In this project, students will evaluate the ability of methods for analysing dynamics to index the underlying time reversibility of a dynamical process, with the potential to develop novel metrics with wide-ranging applications. Students should have an interest in dynamics and computational methods.

**Primary Supervisor:** Ben Fulcher

**Mode of delivery:** In-person. Location: Madsen Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Students should have competency in coding and interest in dynamical processes.

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [ben.fulcher@sydney.edu.au](mailto:ben.fulcher@sydney.edu.au)

#### **PHYS06: QUANTUM COMPUTING WITH TRAPPED-ION SYSTEM**

One of the most promising architectures for quantum computation and the simulation of other less accessible quantum systems is based on trapped atomic ions confined by electric potentials in an ultrahigh vacuum environment. Record coherence times and the highest operational fidelities among all qubit implementations have enabled remarkable progress in recent years. The quantum control laboratory works at the forefront of research in this area. This project seeks to improve the quality of quantum gates in a ytterbium ion qubit through the studies of light-atom interactions and to employ quantum control techniques. The project involves laboratory works, including laser optics and microwave systems, complementary software programming, and numerical simulations.

**Primary Supervisor:** Ting Rei Tan

**Mode of delivery:** In-person. Location: Sydney Nanoscience Hub, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Basic quantum physics and programming

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

For more information: [tingrei.tan@sydney.edu.au](mailto:tingrei.tan@sydney.edu.au)

**PHYS07: GIVING SI SOLAR PHOTOVOLTAICS ANOTHER CHANCE: CAN WE MAKE SECOND-LIFE SOLAR MODULES MORE EFFICIENT?**

By 2035, more than 100,000 tonnes of Si solar modules will become obsolete which will need to be disposed of. At present, there is a lack of financial incentive for recycling resulting in modules being sent to landfill. Apart from policies that encourage sustainable practices, upcycling options that encourage return on investment on the cost of collecting, processing of used modules and extraction of materials and components need to be considered.

This project will research into these options including upcycling of single junction solar modules to multi junction solar modules with boosted power outputs. This will have implication on original single junction solar cell and module designs and manufacturing for recyclability. This will also have implication on the design and manufacturing of multi junction solar cells and modules using recycled materials. There will be an opportunity for students to take part in developing metrics and methodologies for integration of solar photovoltaics into circular economy and suitable for an entrepreneurial student interested in sustainability for a translatable outcome.

**Primary Supervisor:** Anita Ho-Baillie

**Mode of delivery:** In-person. Location: Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Basic quantum physics and programming

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

For more information: [anita.ho-baillie@sydney.edu.au](mailto:anita.ho-baillie@sydney.edu.au)

**PHYS08: THE ROLE OF SYMMETRIES IN QUANTUM COMPUTING WITH CONTINUOUS-VARIABLE CODES**

Full-fledged quantum computers could efficiently run algorithms tackling tasks that are considered out of the reach of current classical machines, including supercomputers. Quantum computers, at some level, will run on "qubits", a very delicate building block. A large part of quantum computing research is dedicated to overcoming this inherent fragility using error-correcting schemes. Different architectures rely on different physics and are affected by different types of errors. In this project, we will be exploring error correction with "bosonic codes", whose underlying state space is much richer than products of 2-level systems. There is a large "zoo" of qubit codes, whereas bosonic codes are a rather unexplored field (<https://errorcorrectionzoo.org/>).

A bosonic code mimics a qubit while at the same time introducing a layer of error correction. It has become increasingly clear that a bosonic code can be characterised in terms of continuous symmetry transformations acting upon its codewords, but this realisation has yet to be used to either generate

new bosonic codes or give categorizations of the current ones that point to the existence of new classes. In this project, we will deepen our understanding of this categorisation and explore the possibility of generalisations that could lead to the invention of new bosonic codes.

**Primary Supervisor:** Giacomo Pantaleoni

**Mode of delivery:** TBC

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** basic calculus and basic quantum theory

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [giacomo.pantaleoni@sydney.edu.au](mailto:giacomo.pantaleoni@sydney.edu.au)

#### **PHYS09: SUPERNOVA EARLY WARNING**

When a massive star dies it does so in a massive explosion called a supernova. To understand these dramatic and complex events better astronomers would ideally like to catch one in the act. Unfortunately, the prompt emission of light lasts only tens of seconds before dying away. However, using a mysterious type of fundamental particle called the neutrino we may have a way to do this. Neutrinos are generated in enormous quantities during supernovae and carry up to 99% of the total energy generated, despite the fact they are almost massless. Unlike photons which get caught up in the surrounding shock wave, neutrinos sail out of the collapsing stellar core unimpeded. This means that neutrinos arrive at Earth several hours before the light reaches us. A “Supernova Early Warning System” of neutrino detectors around the world will therefore be needed to warn if a star is about to explode.

We are currently building an underground lab in Australia that will be able to host such an experiment. The aim of this project will be to determine the specifications required to be able to warn of an imminent supernova and pinpoint its position on the sky.

**Primary Supervisor:** Ciaran O'Hare

**Mode of delivery:** In-person. Location: School of Physics (A28), Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** 2nd-year physics

**Maximum number of places available in a project:** 7

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [ciaran.ohare@sydney.edu.au](mailto:ciaran.ohare@sydney.edu.au)

**PHYS10: QUANTITATIVE MODELLING OF BRAIN RHYTHMS**

Why do we sleep and how does the brain transition into this seemingly unconscious state and out of it? How does sleep loss affect our alertness and memory, and why is long-term sleep loss associated with neurodegenerative disorders like Alzheimer's? We will use biophysical modelling, machine learning, and quantitative data analysis to address these and other neuroscience questions.

**Primary Supervisor:** Ciaran O'Hare

**Mode of delivery:** Madsen F09 OR Remote (fully online is fine)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Programming in Matlab, Python or similar (required); physics, maths, engineering, or computer science background is of benefit (optional)

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [svetlana.postnova@sydney.edu.au](mailto:svetlana.postnova@sydney.edu.au)

**PHYS11: BOUNDARIES FOR SYMMETRY-ENRICHED TOPOLOGICAL QUANTUM FIELD THEORIES**

Quantum spin lattice models for topological field theories and their boundaries form the basis of the popular surface code approach to quantum error correction, currently pursued by leading industry groups including Google, AWS and IBM. Recently these topological field theories were extended to incorporate the action of a symmetry group and its associated defects. In this project we aim to extend the model for their boundaries in a way that is compatible with the added symmetry.

**Primary Supervisor:** Dominic Williamson

**Mode of delivery:** In-person. Location: Sydney Nano Hub, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** at least second-year Physics and Mathematics units and an interest in abstract theoretical concepts in Mathematics and Physics

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [dominic.williamson@sydney.edu.au](mailto:dominic.williamson@sydney.edu.au)

**PHYS12: MODULAR QUANTUM POSITION AND MOMENTUM**

A simple argument demonstrates that the canonical commutation relation between position and momentum cannot be satisfied by finite dimensional complex matrices i.e., quantum mechanical

operators. Mathematicians routinely deal with representations, which can be thought of physically as quantum operators, over general number fields that have positive characteristic. In a field of positive characteristic, it is possible to satisfy the canonical commutation relation with finite dimensional matrices. In this project we will explore such finite dimensional solutions, and search for clues as to why quantum mechanics must be formulated with complex numbers.

**Primary Supervisor:** Dominic Williamson

**Mode of delivery:** In-person. Location: Sydney Nano Hub, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** at least second-year Physics and Mathematics units and an interest in abstract theoretical concepts in Mathematics and Physics

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [dominic.williamson@sydney.edu.au](mailto:dominic.williamson@sydney.edu.au)

### **PHYS13: PLASMONIC SLOT WAVEGUIDE: A REVOLUTION IN OPTICAL NOSE DEVICES**

The Holy Grail in molecular sensing is the capability to detect and identify any individual molecule in a mixture, like pollutants in air ( $\text{CO}_2$ ,  $\text{CH}_4$ ) or water (hydrocarbons, nitrides), biomarkers for diseases in body fluids (DNA, exosomes), very small pathogens in air/breath (coronaviruses, influenza). Plasmonic slot waveguides promise to detect the specific signature of any individual molecule or ensemble of molecules, via an integrated nanophotonic platform. In this project, you will help with outlining the processes to undertake the fabrication of such devices.

**Primary Supervisor:** A/Prof Stefano Palomba

**Mode of delivery:** In-person. Location: Research Prototype Foundry (RPF) and School of Physics

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Hands-on laboratory experience, preferably in chemical and physical fabrication

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [stefano.palomba@sydney.edu.au](mailto:stefano.palomba@sydney.edu.au)

### **PHYS14: BUILDING BETTER QUBITS**

Quantum computers are hard to make; performing a quantum computation requires precise.

control of many, incredibly fragile quantum systems. Though the basic recipe for a quantum computer is relatively concrete, finding and constructing real world quantum systems that can completely satisfy these criteria has proven difficult. In this project, you will explore schemes for



“next-gen” superconducting qubits that promise to be much more resilient to noise, at the cost of being more of a headache for experimentalists to engineer. Is the extra effort for experimental realisation worth it? How “idealised” do these systems need to be until we see the reduction in noise that the theoretical proposals are advertising?

**Primary Supervisor:** Thomas Smith

**Mode of delivery:** In-person. Location: Sydney Nanoscience Hub, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** None

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [thomas.b.smith@outlook.com.au](mailto:thomas.b.smith@outlook.com.au)

## SCHOOL OF PSYCHOLOGY

### PSYC01: THIS IS WHAT HAPPENED ... I THINK? INDICATORS OF UNCERTAINTY WHEN WITNESSES RECALL A SINGLE OR REPEATED EVENT

Sometimes witnesses are asked to recall an occurrence of an event that happened on multiple occasions (e.g., domestic violence, harassment). Previous research indicates that when this occurs, repeated-event witnesses are perceived as less credible than those who recall an event that only occurred once, and even liars (Deck & Paterson, 2020). This project aims to further understand the mechanisms behind this effect; specifically, are repeated-event witnesses more uncertain when describing what happened? Students will analyse the reports of mock-witnesses who observed a single or repeated-event and investigate whether there are differences in verbal indicators of uncertainty.

**Primary Supervisor:** Associate Professor Helen Paterson

**Mode of delivery:** In-person and remote. Location: Brennan MacCallum Building

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** 1st year Psychology

**Maximum number of places available in a project:** 2

**Final assessment:** Project report, 1-2 pages

**For more information:** [helen.paterson@sydney.edu.au](mailto:helen.paterson@sydney.edu.au)

**PSYC02: PILOT OF A FRUSTRATION TASK IN MICE**

In this project, the student will assist the researcher in piloting a task of frustrative non-reward and testing subsequent irritability. The task will involve scoring behaviour in the irritability task and basic handling of research mice.

**Primary Supervisor:** Caitlin Cowan

**Mode of delivery:** In-person. Location: Brain and Mind Centre

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** 1st year Psychology

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [caitlin.cowan@sydney.edu.au](mailto:caitlin.cowan@sydney.edu.au)

**PSYC03: CHILDREN'S THINKING**

This project examines how children think, how they learn new concepts, and how they control their behaviour to achieve new goals. This project examines what conditions support learning and successful goal-directed behaviour, and what conditions make it harder. Further, this project examines how these factors change as children develop.

**Primary Supervisor:** Micah Goldwater

**Mode of delivery:** In-person. Location: Brennan MacCallum 3rd floor; potential to collect data offsite around Sydney.

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Working with children check & experience; deal, but not mandatory: computer programming experience in either javascript, R, or Python, or a willingness to learn.

**Maximum number of places available in a project:** 4

**Final assessment:** Project report, 1-2 pages

**For more information:** [micahbg@gmail.com](mailto:micahbg@gmail.com)

**PSYC04: EXPLORATORY STATISTICAL ANALYSIS OF MICROBIOME AND PSYCHOLOGICAL DATA IN A DEVELOPMENTAL PROJECT**

The student(s) would assist the researcher in conducting preliminary analyses of the relationship between the microbiome and psychological variables within a large, longitudinal dataset. Data has already been collected, so the student(s) will only be conducting statistical analyses, which will be quite complex and require coding in R.

**Primary Supervisor:** Dr Caitlin Cowan

**Mode of delivery:** In-person. Location: Brain and Mind Centre (with option to do most of the project remotely)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Comfortable using R and RStudio to conduct data cleaning and analysis. Comfortable with statistical analysis for psychological science (PSYC2012 – Distinction level minimum). Undergraduate level knowledge of psychology and human health sciences. Interest in/knowledge about the gut-brain axis and the overlap between psychology and nutrition.

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [caitlin.cowan@sydney.edu.au](mailto:caitlin.cowan@sydney.edu.au)

**PSYC05: SYSTEMATIC REVIEW OF ABORTION STIGMA INTERVENTIONS**

Safe and accessible abortion is an important part of high quality reproductive healthcare, but is a procedure widely stigmatised around the world. In this project we are aiming to systematically identify and review interventions designed to reduce abortion-related stigma. Using PRISMA guidelines we will conduct a systematic review to extract and synthesise data to provide a summary of interventions and their potential effectiveness in reducing abortion-related stigma..

**Primary Supervisor:** A/ Professor Haryana Dhillon

**Mode of delivery:** Griffith Taylor Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Interest: in psychological aspects of health, systematic reviews, reproductive healthcare.

**Maximum number of places available in a project:** 3

**Final assessment:** Project presentation, 5- 10 minutes

**For more information:** haryana.dhillon@sydney.edu.au

**PSYC06: COGNITIVE INTERVIEWS EVALUATING INSTRUMENTS DESIGNED TO CAPTURE ABORTION-RELATED STIGMA**

Safe and accessible abortion is an important part of high quality reproductive healthcare, but is a procedure widely stigmatised around the world. To evaluate interventions it is critical to use psychometrically valid and culturally appropriate measures of abortion related stigma. In this project we are aiming to transcribe/edit cognitive interviews already completed and to analyse these interviews using qualitative methods

**Primary Supervisor:** A/ Professor Haryana Dhillon

**Mode of delivery:** Griffith Taylor Building, Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Interest: Interest in psychological aspects of health, reproductive healthcare, instrument development, qualitative research methods.

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5- 10 minutes

**For more information:** haryana.dhillon@sydney.edu.au

## SCHOOL OF LIFE AND ENVIRONMENTAL SCIENCES

### **SOLE01: MAPPING OF FARM-SCALE SOIL CONSTRAINTS**

The project is part of a larger program where we are survey and mapping soil constraints across 75 farms in Australia. The student will gain experience in taking spectral measurements of soil in the laboratory, the analysis of spatial data and applying machine learning models for mapping of soil constraints. If interested there is potential to take part in field work on one of the farms to experience the whole workflow from sampling to map production.

**Primary Supervisor:** Professor Tom Bishop

**Mode of delivery:** In-person. Location: Australia Technology Park

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Familiarity with R and GIS

**Maximum number of places available in a project:** 2

**Final assessment:** Project report, 1-2 pages

**For more information:** [thomas.bishop@sydney.edu.au](mailto:thomas.bishop@sydney.edu.au)

### **SOLE02: QUANTIFYING BIOMASS PRODUCTION AND QUALITY USING DRONES AND IMAGE ANALYSIS**

Capturing feed production at large scales is complex due to spatial and temporal variation. Drones capture hyperspectral imagery across a range of scales, but conversion of images to production is still underdeveloped. This project will develop a pipeline for image processing. Field work to capture images using drones is an option.

**Primary Supervisor:** A/Prof Willem Vervoort

**Mode of delivery:** In-person. Location: Biomedical Building, Eveleigh, and Narrabri

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Familiar with Python and coding, interest in image analysis, interest in machine learning

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [willem.vervoort@sydney.edu.au](mailto:willem.vervoort@sydney.edu.au)

### **SOLE03: QUANTUM GRAVIMETRY FOR GROUND WATER MAPPING**

Local mass density variations give rise to variations in local gravity in the underground. Sensitive and accurate measurements of local gravity can be made through quantum sensors developed at ANU. This creates an opportunity to map changes in groundwater storage and flow. This project will develop field tests on known cave and groundwater systems. You will make surface measurements of gravity, invert the data, and make quantitative comparisons.

**Primary Supervisor:** A/Prof Willem Vervoort

**Mode of delivery:** In-person. Location: Biomedical Building, Wee Jasper, Canberra

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Programming in R or Python

**Maximum number of places available in a project:** 2

**Final assessment:** Project report, 1-2 pages

**For more information:** [willem.vervoort@sydney.edu.au](mailto:willem.vervoort@sydney.edu.au)

### **SOLE04: WHAT GRUB IS THAT? IDENTIFYING CURL GRUB SPECIES IN HOME GARDENS**

Gardeners often find curl grubs, the larvae of scarab beetles, in their gardens. In some cases, this leads to the use of destructive broad-spectrum insecticides due to the fear that the grubs are killing plants. But there are hundreds of species of 'curl grubs' including Christmas beetles, flower beetles and cowboy beetles many of which are not problematic for plants. In this project, you will help us collect and identify curl grub larvae from gardens around Sydney. You will also help feed and care for these cute 'baby beetles'.

**Primary Supervisor:** A/Prof Tanya Latty

**Mode of delivery:** In-person. Location: Heydon Laurence (A08)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Must be comfortable handling curl grubs

**Maximum number of places available in a project:** 3

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [tanya.latty@sydney.edu.au](mailto:tanya.latty@sydney.edu.au)

#### **SOLE05: USING ARTIFICIAL FLOWERS TO STUDY BEE BEHAVIOUR**

Artificial flowers are an excellent tool for studying the behaviours of flower visiting insects. In this project, you will help us design and test artificial flowers, analyse video data, and help build/maintain artificial flowers.

**Primary Supervisor:** A/Prof Tanya Latty

**Mode of delivery:** In-person. Location: Heydon Laurence (A08)

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Must be comfortable working with insects; not suitable for anyone with an anaphylactic bee allergy

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [tanya.latty@sydney.edu.au](mailto:tanya.latty@sydney.edu.au)

#### **SOLE06: THE QUOLL BEHAVIOUR PROJECT**

This project looks at the effect of different lures and lure placement on the detection of spotted-tailed quolls at camera traps, but a lot of other species visit the lures too. You will be analysing camera trap images, identifying species etc. (hence mainly computer work) so we can quantify visits by other species and see if that effects quoll detection. There may also be an opportunity, for the right person, to assist on a field trip to northern NSW. There is scope, if you wish, to develop your own research question to answer for your presentation using the image data.

**Primary Supervisor:** Professor Clare McArthur

**Mode of delivery:** In-person. Location: A combination of on-campus at Camperdown, working from home and possibly a field site in regional NSW (departure from Sydney).

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Ecological experience at undergraduate level

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [clare.mcarthur@sydney.edu.au](mailto:clare.mcarthur@sydney.edu.au)

**SOLE07: INVESTIGATING EPIGENETIC INHERITANCE**

In the Ashe lab we study epigenetic inheritance. In this project you will test genes for their involvement in initiating epigenetic inheritance. This will involve PCR, genotyping, learning how to work with our model organism and other general molecular biology skills.

**Primary Supervisor:** Alyson Ashe

**Mode of delivery:** In-person. Location: Charles Perkins Centre

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** undergraduate level experience in basic molecular techniques

**Maximum number of places available in a project:** 1

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [alyson.ashe@sydney.edu.au](mailto:alyson.ashe@sydney.edu.au)

**SOLE08: FIGHTING ANTIMICROBIAL RESISTANCE**

Antimicrobial and antibiotic resistance is a major health issue in the 21st century. Resistance to currently available antimicrobials is increasingly responsible for deaths globally. Our lab has been exploring novel and smarter ways to fight antimicrobial resistance from new antibiotic development and target identification, earlier diagnostic methods of infectious diseases to the development of antimicrobial coatings for medical implants.

**Primary Supervisor:** Ann Kwan

**Mode of delivery:** In-person. Location: Camperdown Campus

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Has experience with working in a wet lab, preferably with experience with working with proteins, studying biochemistry and/or molecular biology units

**Maximum number of places available in a project:** 1

**Final assessment:** Project report, 1-2 pages

**For more information:** [ann.kwan@sydney.edu.au](mailto:ann.kwan@sydney.edu.au)

**SOLE09: HUNTING THE GENOME: IDENTIFYING TARGETS FOR IMMUNE ATTACK OF KIDNEY TRANSPLANTS**

Kidney transplants frequently fail because of immune recognition of differentially expressed proteins. Usually this involves the HLA but more recently recognition of other proteins has been identified. This project will target children with kidney transplants without donor specific antibodies to look for potential target antigens using genomics.



**Primary Supervisor:** Stephen Alexander

**Mode of delivery:** In-person. Location: Centre for Kidney Research

**Project dates:** 9 January 2023 to 12 February 2023

**Pre-requisites:** Experience with large data and statistics and an interest in biology/immunology

**Maximum number of places available in a project:** 2

**Final assessment:** Project presentation, 5-10 minutes

**For more information:** [stephen.alexander@sydney.edu.au](mailto:stephen.alexander@sydney.edu.au)