# SCIENCE SUMMER RESEARCH PROGRAM PROJECTS 2020-21
## For Denison Research Scholarship

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## SCHOOL OF CHEMISTRY

### CHEM01: Computer-aided design of magnetic 3D printed molecular models

You will learn how to use computer-aided design (CAD) software to design 3D printable molecular models that convey intermolecular interactions like hydrogen-bonding. The models will incorporate movable (i.e., rotation, flexion) and magnetic design elements to represent the formation of dynamic/weak bonds, which will serve as a useful visualisation and communication tool for complex molecular structures. The designs will be printed remotely and students will be able to keep their printed designs.

**Project location:** Online
**Mode:** Online only
**Attendance:** Evening
**Expected workdays/hours:**
**Pre-requisites:** N/A
**Available as a group project:** Yes
**Primary supervisor information:** Dr Derrick Roberts
**For more information contact:** derrick.roberts@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/derrick-roberts.html

**CHEM02: Developing process-based study strategies for undergraduate learning**

Have you ever considered the process of thinking when you approach studying? Do you have specific 'guidelines' or strategies that you use? The focus of this project will be to explore potential scaffolding that will assist students when undertaking their undergraduate studies. This project will appeal to those interested in education (while chemistry-based, this is applicable in other fields of study). The project will include reviewing literature, designing an intervention to support students, and potentially running some trials with students or staff to collect feedback.

**Project location:** Online
**Mode:** Online only
**Attendance:** Block
**Expected workdays/hours:** 38 hour work week, 4 weeks
**Pre-requisites:** N/A
**Available as a group project:** Yes
**Primary supervisor information:** Dr Reyne Pullen
**For more information contact:** reyne.pullen@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/reyne-pullen.html

**CHEM03: Embedding Creative Exercises to support the linking of chemistry topics**

One of the ongoing challenges in chemistry education is supporting students in developing the ability to link and cross between topics. Creative Exercises (a published activity) offers an opportunity for students to reflect on their knowledge and link between topics. Some preliminary work has been completed over 2019/20 and this project will focus on the next iteration of this study. A tentative direction is the use of educational technology to create an ongoing 'portfolio' for student groups to continue building on their activities from week to week. This project will include some review of the literature, development and evaluation of potential interventions, and, if time permits, some trials with students and/or staff.

**Project location:** Online
**Mode:** Online only
**Attendance:** Block
**Expected workdays/hours:** 38 hour week, 4 weeks
**Pre-requisites:** First year CHEM.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Reyne Pullen
**For more information contact:** reyne.pullen@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/reyne-pullen.html

**CHEM04: Using Virtual Reality to aid in the teaching and learning of chemistry**

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.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Mon-Fri, 9-5 (with in-built flexibility)
**Pre-requisites:** First year CHEM.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Stephen George-Williams
**For more information contact:** stephen.george-williams@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/stephen-george-williams.html

**CHEM05: 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. A number of projects are possible, including investigating new photochemical sources of atmospheric H2, studying new atmospheric reactions that can produce HO2, 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.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 5 days per week, 9am-5pm (with lunch break!), or equivalent, for 4 weeks to be negotiated with candidate
**Pre-requisites:** N/A
**Available as a group project:** Yes
**Primary supervisor information:** Professor Meredith Jordan
**For more information contact:** meredith.jordan@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/meredith-jordan.html

**CHEM06: 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 in order to develop new methods that can be efficiently applied to large, chemically realistic systems.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 5 days per week, 9am-5pm (with lunch break!), or equivalent, for 4 weeks to be negotiated with candidate
**Pre-requisites:** A solid background in mathematics. Python skills and programming experience are desirable but not essential.
**Available as a group project:** No
**Primary supervisor information:** Professor Meredith Jordan
**For more information contact:** meredith.jordan@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/meredith-jordan.html

**CHEM07: 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 use computational design tools to develop 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.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 4 weeks full-time
**Pre-requisites:** N/A
**Available as a group project:** Yes
**Primary supervisor information:** Dr Shelley Wickham
**For more information contact:** shelley.wickham@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/shelley-wickham.html

**CHEM08: Computational design and simulation of DNA nanostructures**

To physical and chemical scientists, DNA has huge potential as a programmable building material for biocompatible nanostructures, which can be self-assembled from the bottom up. Recently, we have developed a new method for hierarchical assembly of many DNA origami nanostructures into a larger assembly, which also allows for shape-changing designs. In this project, the student will use a variety of computational tools to design and simulate potential designs for future experiments. This project could be tailored to students with a range of programming experience from beginner to experienced, or those interesting in learning programming in python for the first time.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 4 weeks full-time
**Pre-requisites:** N/A
**Available as a group project:** Yes
**Primary supervisor information:** Dr Shelley Wickham
**For more information contact:** shelley.wickham@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/shelley-wickham.html

**CHEM09: Computer simulation of the fundamental processes in next-generation solar cells**

Organic solar cells combine the flexibility and low weight of plastics with the semiconducting properties of conventional photovoltaics. We aim to understand the fundamental physics of organic solar cells and to formulate precise design principles for better devices. In this project, you will have an opportunity to develop state-of-the-art computer software for simulating processes that were never before simulated.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Flexible, but ordinarily full-time (~37 hrs/week)
**Pre-requisites:** First year CHEM or PHYS.
**Available as a group project:** No
**Primary supervisor information:** Associate Professor Ivan Kassal
**For more information contact:** ivan.kassal@sydney.edu.au
https://www.kassal.group

**CHEM10: Increasing the context- and inquiry-based nature of first year teaching laboratories**

This project seeks to alter laboratories in the first-year environment in order to greatly increase the number of context- and inquiry- based activities. You will aid in the generation of these laboratories, followed by trials with demonstrators and undergraduate students. You may also, if time permits, consider the best use of pre-laboratory quizzes/tasks alongside in-class assessment of technical skills.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Monday-Friday 9am-5pm
**Pre-requisites:** First year CHEM.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Shane Wilkinson
**For more information contact:** shane.wilkinson@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/shane-wilkinson.html

**CHEM11: Carbon Capture via Burial of Pyrolyzed Plant Material: Feasibility**

Complementary to the switch to carbon neutral energy sources, the capture and sequestration of atmospheric carbon can contribute significantly to reducing the concentration of atmospheric CO2. A simple strategy for carbon capture and sequestration is to use rapidly growing plants to capture carbon, then pyrolyze them to reduce their non-carbon content and then bury the compacted residue, ideally in old mines. The aim of this project is to establish whether this is a feasible scheme. The project will involve collecting data on all the relevant aspects of the scheme: growth rate of possible plant species, efficiency of pyrolysis in removing non-carbon content, storage capacity of non-functioning mines, etc and preparing a report on the potential capacity of the scheme.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:**
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Professor Peter Harrowell
**For more information contact:** peter.harrowell@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/peter-harrowell.html

## SCHOOL OF GEOSCIENCES

### GEOS01: Deep-time geographic and tectonic evolution of Southeast Asia

Southeast Asia is a key region linking the Pacific and Indian oceans, as well as an important biogeographic bridge between Gondwana and Eurasian fauna and flora. This continental region has been deformed by the northward motion of the Indian and Australian continents. By combining published data into models of tectonic motions, this Denison project will help improve our understanding of the mountain-building processes and the "paleo-geography" of this critical region. In addition, the project will help us find mineral resources and understand the implications for deep-time climate, biological evolution, deep carbon cycling, and ocean circulation. No geology or coding experience is required, all students interested in better understanding our planet are welcome to apply.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Flexible to suit students - totalling 4 weeks equivalent.
**Pre-requisites:** N/A
**Available as a group project:** Yes
**Primary supervisor information:** Dr Sabin Zahirovic
**For more information contact:** sabin.zahirovic@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/sabin-zahirovic.html

**GEOS02: Rural land ownership change and land use transformation**

This is a joint University of Sydney-NSW Department of Primary Industries project on the implications of changes to who owns rural land in rural NSW. The project has a unique dataset of all rural landholdings between 2004-2020. You will work with a team of 3 postgraduate and Honours students already employed on the project to answer questions about who is buying land, whether they are altering its uses, and what the environmental and economic impacts of this might be. Students must be proficient in Microsoft Excel and experience in ArcGIS is highly recommended.

**Project location:** Madsen Building F09
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Working week days 9:00 to 16:00
**Pre-requisites:** Students must be about to commence of have completed 3rd year studies in Geography or Environmental Studies .
**Available as a group project:** No
**Primary supervisor information:** Professor Bill Pritchard
**For more information contact:** bill.pritchard@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/bill-pritchard.html

**GEOS03: Peering into the underworld: mapping slab window migration in southern South America and the Antarctic Peninsula**

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 (through seismic tomography) and the geological record. This project is in collaboration with Prof Karin Sigloch at the University of Oxford. This project can operate as online-only, if requested.

**Project location:** Madsen Building F09
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 35 hours a week (5 days @ 7 hours a day)
**Pre-requisites:** At least 6 CP of first or second year GEOS units.
**Available as a group project:** No
**Primary supervisor information:** Dr Maria Seton
**For more information contact:** maria.seton@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/maria-seton.html

**GEOS04: Climate policy in a post-COVID world**

In the early stages of the pandemic, we celebrated images of nature relaxed and rebounding in the absence of humans. And, the grounding of much international travel and reorganisation of localised production networks suggested our perilously high carbon emissions may finally turn a corner. So, what has been the effect of COVID on Australian – and global – climate policy? Has the pandemic provided opportunities to build more socially, economically and environmentally just climate action, or will we continue down our business-as-usual path? This research project will analyse post-COVID climate policy, comparing Australian action with selected global climate policies (e.g. Europe's Green Deal, US Green New Deal). As a result, it will determine whether or not the pandemic has affected our ability to meet mitigation and adaptation responsibilities.

**Project location:** An office in the Madsen Building will be available as the student desires (an online option is available)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 25 January-19 February, 9-5pm ish per day
**Pre-requisites:** Students will have completed some GEOS (specifically, geography and/or environmental studies Units). GEOS2X21 or GEOS3X20 is preferable.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Sophie Webber
**For more information contact:** sophie.webber@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/sophie-webber.html

**GEOS05: What have we learned from the 2017-2020 drought?**

Just a few months ago, the worst drought on record finally broke with a week of torrential rain and flash-flooding around Sydney and NSW. While we were all initially relieved at the bushfires finally contained, the streams and rivers beginning to flow, and the towns reconnected with a water source, it remains to be seen how the state and city is responding to the new climate normal of water scarcity and insecurity. What has the state and city learned from the 2017-2020 drought, and what have they learned from responses to the Millennial drought? This project will assess how the Sydney, NSW, and Federal governments have sought to achieve water security in the face of drought, analysing whether the responses are maladaptive or socio-spatially and environmental just.

**Project location:** An office in the Madsen Building will be available as the student desires (an online option is available)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 25 January-19 February, 9-5pm ish per day
**Pre-requisites:** Students will have completed some GEOS (specifically, geography and/or environmental studies Units). GEOS2X21 or GEOS3X20 is preferable.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Sophie Webber
**For more information contact:** sophie.webber@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/sophie-webber.html

**GEOS06: Climate impacts on coastal livelihood security in the South Pacific**

Livelihoods and food security in many Pacific communities are inextricably linked with coastal ecosystem health and directly exposed to the long-term stressors and short-term shocks of climate change. This project will integrate biophysical spatio-temporal models of predicted shifts in coastal environments with local knowledge of climate change impacts on fisheries and other coastal ecosystem services. Data has been collected as part of an existing research program on climate smart landscapes for enhancing environmental livelihood security in the context of the water-energy-food nexus. The aim would be to investigate how biophysical processes and existing coastal ecosystem service flows result in differentiated risks of climate stressors within coastal communities reliant on small-scale fisheries.

**Project location:** Madsen Building F09
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 4 weeks x 5 days
**Pre-requisites:** Advantage to have some GIS experience but not necessary.
**Available as a group project:** Yes
**Primary supervisor information:** A/Prof Eleanor Bruce
**For more information contact:** eleanor.bruce@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/eleanor-bruce.html

## SCHOOL OF HISTORY AND PHILOSOPHY OF SCIENCE

### HPSC01: Early Modern Mathematical Sciences

We will read and discuss original early modern texts in the mathematical science and develop a small original research project according to the student's interest.

**Project location:** Madsen Building F09
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 30
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Professor Ofer Gal
**For more information contact:** ofer.gal@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/ofer-gal.html

**HPSC02: Community Mental Health in Australia**

In 1983, the well-known Richmond report on mental health care recommended the development mental health services in the community to support those individuals who had been discharged from mental hospitals. In the 1970s, with the introduction of Medicare, several initiatives in community health care were funded. Feminists physicians opened small centres for women's health care; in Leichhardt, they opened an place for women suffering mental problems. Volunteers had established group housing for ex-patients. The 1970s and 1980s saw an unusual amount of mental health activism that resulted in various community mental health services. In this research project, we explore such grass-roots services through archival research and interviews.

**Project location:** Madsen Building F09
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 30
**Pre-requisites:** Some background knowledge of the history of medicine but not essential.
**Available as a group project:** Yes
**Primary supervisor information:** Professor Hans Pols
**For more information contact:** hans.pols@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/hans-pols.html

## SCHOOL OF MATHEMATICS AND STATISTICS

### MATH01: The polynomial method in additive combinatorics

The project with focus on the new polynomial method in (additive) combinatorics which allowed to resolve long standing problems such as Kakeya problem over finite fields, cap set problem and Erdos distance problem. We will study the method as it was introduced in the celebrated paper by Dvir, and will go over its applications such as cap set problem and (if time will permit) Erdos distance problem. The method provides a new way of bounding from above the cardinality of a set A inside a vector space over a finite field which does not contain a certain algebraic (geometric) structure. In the original paper by Dvir, the set A does not contain a whole line in any direction. The aim of the project is to study the method, and try to attack problems of a similar flavour. For instance, it is unknown whether the set A in F_p^2 which does not contain an equilateral triangle has to be O(p^{\alpha}) for \alpha < 2.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Linear Algebra, some sort of abstract algebra (a weak requirement), this project is suitable for students with a minimal background (after year 1)
**Available as a group project:** No
**Primary supervisor information:** Dr Alexander Fish
**For more information contact:** alexander.fish@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/alexander-fish.html

**MATH02: Glasner property for (semi)-group actions**

Assume that a group G acts on a compact metric space X. We say that the action has Glasner property if for any infinite set A in X, and for any eps > 0 there exists g in G such that gA is eps-dense in X. Examples of actions which have Glasner property include the action of N on R/Z by multiplication, the action of SL_n(Z) on (R/Z)^n, and others. It follows from compactness argument that if an action has Glasner property then for every eps > 0, there exists k(eps) such that every set A in X with at least k(eps) elements and an element g in G such that gA is eps-dense. In the case of the action of N on R/Z, Alon and Peres proved that k(eps) < eps^{-2-delta} for any delta > 0. It is also known that the lower bound has to be at least quadratic. In the project we will try to provide a quantitative version of the statement that the action of SL_n(Z) on (R/Z)^n has Glasner property.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Linear Algebra, Analysis, Metric spaces (preferable, but not essential). This is suitable for students after the second year of studies.
**Available as a group project:** No
**Primary supervisor information:** Dr Alexander Fish
**For more information contact:** alexander.fish@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/alexander-fish.html

**MATH03: Circle Packings on Surfaces**

Circle packings are arrangements of circles in the plane, the sphere, or on a more general surface that have tangencies in a prescribed pattern. This project will focus on circle packings on negatively curved surfaces and their associated symmetric infinite circle packings in the plane. The aim is to understand how these packings vary as the geometry of a surface transitions from the negatively curved hyperbolic geometry to more general real projective geometries.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Essential: MATH2922 (or MATH2022), Desirable: MATH2921 (or MATH2021).
**Available as a group project:** Yes
**Primary supervisor information:** Professor Stephan Tillmann
**For more information contact:** stephan.tillmann@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/stephan-tillmann.html

**MATH04: Graph encoded manifolds**

It is quite easy to visualise orientable surfaces such as the sphere or the torus (the surface of a donut) embedded in three-dimensional space. Surfaces are two-dimensional manifolds. It is a challenging task to visualise manifolds of higher dimensions. One general - and perhaps surprising - way of achieving this is by representing a manifold by a graph with coloured edges. Such graph encoded manifolds, or gems, can always be drawn on a sheet of paper while containing all the information about the surface or manifold. While some of this information is very hard (or impossible) to access, some information can be read off the graph quite easily and other bits and pieces can be recovered by simple combinatorial rules. This project is about using these simple combinatorial rules to deduce interesting facts about manifolds, to construct large families of such gems satisfying some given properties (which is interesting for all kinds of reasons), to design a method to randomly generate such gems in certain settings (which is important for even more kinds of reasons), or to do more theoretical work.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Dr Jonathan Spreer
**For more information contact:** jonathan.spreer@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/jonathan-spreer.html

**MATH05: Sequential inference for large Bayesian networks.**

Bayesian network is a powerful framework to model hierarchical structure of multiple variables whose independencies are represented by the underlying directed acyclic graph (DAG). The classic inference of a Bayesian network includes structure learning and parameter learning, among which the structure learning poses challenges to researchers. The challenge originates from the discontinuity and huge size of the parameter space. Many methods have been proposed to alleviate the challenge, including structure MCMC, order MCMC and partition MCMC. However, performance of these approaches are not satisfactory in the following perspectives: (a) the approaches are not robust with respect to the starting point of DAG structure; (b) the approaches are incapable to explore full parameter space especially for large Bayesian networks. The goal of this project is: (a) to measure and evaluate robustness of existing methods; (b) to reduce the size of parameter space by using sequential inference techniques.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Background from Statistics, Mathematics or computer science. Knowledge of Bayesian inference. Experience with R.
**Available as a group project:** No
**Primary supervisor information:** Dr Wanchuang Zhu
**For more information contact:** wanchuang.zhu@sydney.edu.au

**MATH06: Emulator Models for Accelerating Inverse Problem Solutions**

Inverse problems in geology and geophysics -- inferring the history and structure of a region of the Earth's crust from observations -- occur in a range of applications including mining, groundwater, and natural hazard assessment. These problems are by their nature ill-posed and uncertain, and adequately exploring and characterizing the space of possibilities consistent with the data involves repeated evaluations of numerical models for different geophysical sensors and their derivatives with respect to parameters. These models can be computationally intensive and/or black boxes, making it difficult to scale their use to high-dimensional problems. This project will investigate emulators, or proxies for the numerical likelihood, that can be learned to create adaptive, scalable methods for quantifying uncertainty in high-dimensional inverse problems. Possible emulator methods might include Gaussian processes, Bayesian neural networks, and/or probabilistic graphical models.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Programming in Python including standard scientific computing libraries (numpy, scipy, matplotlib). Familiarity with mathematical foundations for machine learning (multivariable calculus and linear algebra) Familiarity with contemporary machine learning f
**Available as a group project:** No
**Primary supervisor information:** Dr Richard Scalzo
**For more information contact:** richard.scalzo@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/richard-scalzo.html

**MATH07: Improving Anomaly Detection with Transfer Learning**

Anomaly detection is a challenging problem in machine learning because there are very few training examples of the anomaly to fit a model. Often times there could be related datasets which can be used to improve the learning process. However, currently there are no good ways of combining the models we have trained on different datasets. We are interested in developing new transfer learning techniques to combine anomaly detection models that have been trained on different datasets. The research project involves a literature review of the techniques currently used and implementing the state-of-the-art techniques in python. For more details please contact s.luo@sydney.edu.au.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Experience implementing statistical machine learning models in python (not just using packages).
**Available as a group project:** No
**Primary supervisor information:** Dr Simon Luo
**For more information contact:** s.luo@sydney.edu.au

**MATH08: An eigenvalue problem for the 1-Laplacian**

The 1-Laplace operator is a nonlinear differential operator which is often employed in image processing for smoothening images. But in order to be able to take advantage of this operator, one needs first reveal some/all of his properties. Therefore, we want to study in this summer research project the spectrum of this operator. You will learn about the theory of functions of bounded variation and its differentiability properties, approximation schemes which lead to the eigenvalue problem for the 1-Laplace operator equipped with homogeneous Dirichlet boundary conditions and if time permits, we try to derive an isoperimetric inequality providing lower bounds of the first and second eigenvalue of the 1-Laplace operator.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Dr Daniel Hauer
**For more information contact:** daniel.hauer@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/daniel-hauer.html

**MATH09: Cellular Automata**

Cellular automata are mathematical models based on very simple rules, which have an ability to reproduce very complicated phenomena. (If you have played the "Game of Life" on a computer, then you have already seen automata with complicated behaviours.) This project is concerned with the mathematical analysis of their solutions. In particular, we will consider a family of cellular automata called parity filter rules, for which initial data are given on an infinite set.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** MATH2921 (or MATH2021)
**Available as a group project:** No
**Primary supervisor information:** Professor Nalini Joshi
**For more information contact:** nalini.joshi@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/nalini-joshi.html

**MATH10: 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.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** DATA2X02
**Available as a group project:** Yes
**Primary supervisor information:** Dr Ellis Patrick
**For more information contact:** ellis.patrick@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/ellis-patrick.html

**MATH11: Interactive visualisation of trans-omic data**

Mass spectrometer (MS) and next generation sequencer (NGS) have become the methods of choices for high-throughput profiling of global proteome, phosphoproteome, transcriptome, and epigenome of cell systems. Data visualisation and summarisation is critical for making sense of these large-scale multilayered omic (i.e. trans-omics) datasets. We hypothesise that these techniques are essential step in understanding complex diseases and biological systems. The aim of this project is to develop an interactive data visualisation tool using R and Shiny application. You will be working with the state-of-the-art multi-omic datasets generated from various cellular systems with metabolic disease and development relevance. Methods you will learn include essential omic data analytics, R programming, and Shiny application development, which are highly valued skills in omic sciences and data sciences. Furthermore, this project will provide a unique opportunity for developing computational methods for discovery and comprehensive understanding of cell systems, their decision-making process, and their malfunction in disease states.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Dr Pengyi Yang
**For more information contact:** pengyi.yang@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/pengyi-yang.html

**MATH12: Clustering analysis for differential combinatorial binding of transcription factors in embryonic stem cells**

Transcription factors (TFs), chromatin remodellers (CRs), and transcription co-factors (TCs) are key regulators in governing cell identities and cell-fate decisions. We have previously developed PAD (http://pad2.maths.usyd.edu.au/) for integrative clustering analysis of a large collection of ChIP-seq data from a compendium of more than 100 TFs, CRs and TCs generated from embryonic stem cells (ESCs). The aim of this project is to explore the differential combinatorial binding of TFs, CRs and TCs at different functional genomic regions so as to identify cooperation of TFs, CRs, and TCs at different genomic regions in controlling transcription of genes in ESCs. You will learn the basics of clustering and interactive data exploration in this project.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Dr Pengyi Yang
**For more information contact:** pengyi.yang@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/pengyi-yang.html

**MATH13: Modelling consumer data from the red meat industry**

The beef industry in Australia is worth $13 billion annually and the sheep meat industry is worth another $4 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 trial data to predicting meat eating quality. Examples of possible projects include: the analysis of consumer data which often contains many outliers; determining the relative importance of eating quality factors such as flavour, tenderness and juiciness; looking at the importance of "link product" as a common starter across consumers; and evaluating new objective grading techniques.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Full time over 4 weeks
**Pre-requisites:** DATA2002 or DATA2902
**Available as a group project:** Yes
**Primary supervisor information:** Dr Garth Tarr
**For more information contact:** garth.tarr@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/garth-tarr.html

**MATH14: 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.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** DATA2002
**Available as a group project:** Yes
**Primary supervisor information:** Professor Jean Yang
**For more information contact:** jean.yang@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/jean-yang.html

**MATH15: Time-series analysis of Twitter hashtags**

Social media plays an increasingly important role in our society and economy. Data from social media can give insights on how the interest and opinion of users change over time. In this project we will look at how often individual hashtags were used in Twitter. We will then apply time-series analysis methods and simple mathematical models to describe the observations. We are particularly interested in Hashtags related to the Australian Bushfire season in 2019/2020 and how it impacted the overall discussion on climate change. Our goal is to describe how different hashtags interact with each other and contribute to some of the hashtags to show a rapid increase in interest across the population. Models from complex systems and mathematical ecology will be considered. Coding is required (preferably in Python).

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Associate Professor Eduardo Altmann
**For more information contact:** eduardo.altmann@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/eduardo-altmann.html

**MATH16: Adding spatio-temporal convection to classical Snowball Earth models**

This project will look at adding spatial diffusion to the classical ice-albedo feedback models of Budyko, Sellers and Jormungand. In particular we will look at a model by North, and another by Wadiasih, which examine the effects of incorporating heat convection via diffusion across latitudes in the location and temperature (and stability) of polar ice caps.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Full time over 4 weeks
**Pre-requisites:** Background study in the Budyko and Sellers ice-albedo feedback models.
**Available as a group project:** No
**Primary supervisor information:** Dr Robert Marangell
**For more information contact:** robert.marangell@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/robert-marangell.html

**MATH17: Beyond the Dzhanibekov effect**

The Dzhanibekov effect www.youtube.com/watch?v=1x5UiwEEvpQ beautifully illustrates the instability of the rotation of a rigid body about its middle principal axis. What is not part of that theorem is the observation the Russian cosmonaut Dzhanibekov made in space that the body flips orientation. This project is about the design of a gadget that would flip not by 180 degrees, but by possibly 120 or 90 or ... degrees. The design to be found is a rigid body with some rotors attached in a particular way. The project will involve deriving the equations of motion of this gadget and its simulation on the computer.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Dynamical Systems, Lagrangian and Hamiltonian Dynamics, some experience in Matlab or Mathematica would be good.
**Available as a group project:** Yes
**Primary supervisor information:** Professor Holger Dullin
**For more information contact:** holger.dullin@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/holger-dullin.html

**MATH18: Lightsail Dynamics**

The Breakthrough Starshot project aims to build tiny Lightsail driven spacecraft that can be accelerated to 20% of the speed of light. The description of the dynamics of such a Lightsail can be approximated by the dynamics of a symmetric rigid body without a fixed point. The aim of this project is to investigate whether a rotation of the Lightsail about its axis of symmetry can provide attitude stability.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Dynamical Systems, Lagrangian and Hamiltonian Dynamics, some experience in Matlab or Mathematica would be good.
**Available as a group project:** Yes
**Primary supervisor information:** Professor Holger Dullin
**For more information contact:** holger.dullin@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/holger-dullin.html

**MATH19: 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.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** First year linear algebra.
**Available as a group project:** No
**Primary supervisor information:** Associate Professor Milena Radnovic
**For more information contact:** milena.radnovic@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/milena.radnovic.html

**MATH20: Research in false discoveries**

The multiple testing problem arises when we wish to test many hypotheses at once. Initially people tried to control the probability that we falsely reject at least one true null hypothesis. However, in a ground breaking paper Benjamin and Hochberg suggested that alternatively we can control the false discovery rate (FDR): the expected percentage of true null hypotheses among all the rejected hypotheses. Shortly after its introduction FDR became the preferred tool for multiple testing analysis with the original 1995 paper garnering over 55K citations. There are several related problems in the analysis of false discoveries that would be intriguing to explore.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** STAT2911
**Available as a group project:** No
**Primary supervisor information:** Associate Professor Uri Keich
**For more information contact:** uri.keich@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/uri.keich.html

**MATH21: FDR in mass spectrometry**

In a shotgun proteomics experiment tandem mass spectrometry is used to identify the proteins in a sample. The identification begins with associating with each of the thousands of the generated peptide fragmentation spectra an optimal matching peptide among all peptides in a candidate database. Unfortunately, the resulting list of optimal peptide-spectrum matches contains many incorrect, random matches. Thus, we are faced with a formidable statistical problem of estimating the rate of false discoveries in say the top 1000 matches from that list. The problem gets even more complicated when we try to estimate the rate of false discoveries in the candidate proteins which are inferred from the matches to the peptides. We will look at some of these interesting statistical questions that are critical to correct analysis of the promising technology of shotgun proteomics.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Associate Professor Uri Keich
**For more information contact:** uri.keich@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/uri.keich.html

**MATH22: Conics and Cubics**

It has been known since the antiquity that there are infinitely many positive integers whose square is a nontrivial sum of two squared integers (Pythagorean triples). Surprisingly as soon as we consider higher powers the opposite is true; there are no such integers. This is the so-called Fermat's last "theorem" which took more that 300 years to be resolved - in 1994! Remarkably plane cubics capture the heart of this problem. The aim of this project is to study (irreducible) plane algebraic curves, with an emphasis on degree 2 (conics) and 3 (cubics). Of special interest is how (over real numbers) their points form an Abelian group and how "projective geometry" (as opposed to the Euclidean geometry) helps with finding the intersections of such curves.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** first year calculus and linear algebra.
**Available as a group project:** No
**Primary supervisor information:** Dr Behrouz Taji
**For more information contact:** behrouz.taji@sydney.edu.au
http://www.maths.usyd.edu.au/u/behrouzt/index.html

**MATH23: The Okounkov-Vershik approach to the representation theory of symmetric**

In this project we'll study the representation theory of symmetric groups.

**Project location:** Online and Carslaw Building F07
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** Group theory and linear algebra.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Oded Yacobi
**For more information contact:** oded.yacobi@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/oded-yacobi.html

**MATH24: Impact of feature selection in single-cell COVID data**

COVID-19 patients suffer from a wide range of disease progression, varied largely from no symptoms, moderate, severe, and critical symptoms with high mortality risk. Recent advance in single-cell transcriptomics technology applied in COVID19 patients has provided unprecedented resolutions in characterising cell identities, cell functions and cell interaction across patients with different disease progression. This project is to investigate how different combinations of feature selection, dimension reduction and clustering methods will impact the cell type identification of COVID19 patients using multiple scRNA-seq datasets. We will also investigate how such different results will impact the downstream analysis including cell type composition and cell type interaction analysis of COVID 19.

**Project location:** Online
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 36 hours a week
**Pre-requisites:** DATA2X02
**Available as a group project:** Yes
**Primary supervisor information:** Professor Jean Yang
**For more information contact:** jean.yang@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/jean-yang.html

## SCHOOL OF PHYSICS

### PHSY01: Topological aspects of particle physics

In this theoretical project, we investigate topological solutions in relativistic fields theories - kinks, strings, monopoles and instantons. We adress the stability of these solutions and classify them according to homotopy classes. Finally, applications of these mathematical solutions in particle physics will be discussed.

**Project location:** Physics A28, Camperdown
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** TBD
**Pre-requisites:** NONE
**Available as a group project:** Yes
**Primary supervisor information:** Dr Archil Kobakhidze
**For more information contact:** archil.kobakhidze@sydney.edu.au

**PHSY02: Metal Halide Perovskite Optoelectronics**

Metal halide perovskites have recently excited the photovoltaic research community owing to their high solar-conversion efficiencies and ease of solution processing. They also hold great promise for optoelectronic applications, such as light-emitting diodes and lasers. You will synthesise metal halide perovskites, characterise their optoelectronic properties, and explore one of their applications in light-emitting diodes, lasers, or photodetectors.

**Project location:** Madsen Building F09, Camperdown Campus.
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 35 hours/week
**Pre-requisites:** First year physics/chemistry
**Available as a group project:** Yes
**Primary supervisor information:** Dr Rongkun Zheng
**For more information contact:** rongkun.zheng@sydney.edu.au

**PHSY03: DNA logic circuits for guiding molecular machines**

DNA encodes the genetic information in our cells. To physicts, it can also be used as a molecular way to store information and instructions, and to perform computations. For example, DNA circuits can be designed from simple AND and OR logic gates, up to complex systems that can compute the square root of a number, analyse handwriting, or even guide a nanorobot through a maze of tracks to sort cargo. In this project, the student will use a range of computational tools to design and simulate DNA circuits that could guide a nanorobot through a complex environment to identify a target. This project could be tailored to students with a range of coding experience from beginner to experienced, or those interested in learning python for the first time.

**Project location:**
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 4 weeks full-time
**Pre-requisites:** Students must have some experience with or interest in coding.
**Available as a group project:** No
**Primary supervisor information:** Dr Shelley Wickham
**For more information contact:** shelley.wickham@sydney.edu.au

**PHSY04: Neurophotonic waveguide**

We are developing a Neurophotonic interface, which is capable of bidirectionally addressing photoactive neurons via light emitted/collected by a photonic chip. In order to achieve this goal, we need first to design and model a waveguide with input/output gratings. This project is therefore purely focusing on modelling using Matlab and COMSOL. The outcome of the project will deliver the fundamental geometrical parameter for fabricating and then testing the waveguide with photoactive neurons.

**Project location:** A28 Physics building
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** flexible
**Pre-requisites:** understanding of light propagation and foundations of electromagnetism
**Available as a group project:** No
**Primary supervisor information:** Dr Stefano Palomba
**For more information contact:** stefano.palomba@sydney.edu.au

**PHSY05: Direct investigation of antibody-antigen binding on plasma activated surfaces using polarized light in the ellipsometry**

High radical density in plasma activated coatings enables them to form covalent bonds with biomolecules without using chemical linkers. However, the orientation of the immobilized biomolecules greatly influences the subsequent activity such as the antibody-antigen or ligand-receptor interaction. A buffer solution with low ionic strength can extend the Debye length of the surface electrical double layer which orients the approaching biomolecules (ref Nature). In this project, the student will use an ellipsometer to directly investigate tethering events occurring on plasma coatings from changes of polarized light reflected from the surface in different pH buffers and the subsequent binding to their counterpart molecules.

**Project location:** Building A28, Physics Rd, Camperdown campus
**Mode:** On campus only (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Monday to Friday 9am-4pm
**Pre-requisites:** Optics knowledge would be advantageous
**Available as a group project:** Yes
**Primary supervisor information:** Dr Clara Tran
**For more information contact:** clara.tran@sydney.edu.au

**PHSY06: Making and studying synthetic cell membranes using electric fields and ellipsometry**

Generating surfaces that repel cell and protein attachment is desirable for biomedical implants and bio-sensors to reduce device fouling. In biology lipid bilayers are naturally anti-adhesive in the absence of integrated proteins and molecules. We are going to use the advantages of Plasma Activated Coatings (PAC) to covalently immobilize phospholipids onto the surface of silicon wafers to mimic the cell membrane. The phospholipids need to be aligned on the surface to function correctly, electrostatic interactions will be explored as a method to achieve optimal alignment. Ellipsometry will be used to investigate the formation of this layer and to evaluate its effectiveness to inhibit protein binding.

**Project location:** Camperdown, A28 Physics building
**Mode:** On campus only (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Monday - Friday 9am - 4pm
**Pre-requisites:** Knowledge of optics and biomolecular interactions would be advantageous.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Aaron Gilmour
**For more information contact:** aaron.gilmour@sydney.edu.au

**PHSY07: Lightsail dynamics**

Breakthrough Starshot is an exciting and ambitious project that aims send a small probe attached to a lightsail (mass of one gram and surface area of 10-20 square metres) to Alpha Centauri (4.37 light years away) by accelerating it to 20% of the speed of light using a powerful Earth-based laser array (100 gigawatts power). There are many practical and conceptual challenges that must be overcome for this dream to become a reality. One of these challenges is sail stability as the acceleration of the sail by the laser will lead to generation of torques which will cause the sail to veer off. This must be overcome by sail and laser beam designs that lead to a stable motion of the sail towards the intended target. We offer theoretical and numerical projects in this area that involve theoretical mechanics, optics and electromagnetism.

**Project location:**
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Full time (35 hours per week)
**Pre-requisites:** Desirable MATH3977, vector calculus and differential equations
**Available as a group project:** Yes
**Primary supervisor information:** Prof. Martijn de Sterke
**For more information contact:** martijn.desterke@sydney.edu.au

**PHSY08: Lightsail thermal management**

Breakthrough Starshot is an exciting and ambitious project that aims send a small probe attached to a lightsail (mass of one gram and surface area of 10-20 square metres) to Alpha Centauri (4.37 light years away) by accelerating it to 20% of the speed of light using a powerful Earth-based laser array (100 gigawatts power). There are many practical and conceptual challenges that must be overcome for this dream to become a reality. One of these challenges is thermal management of the sail which goes far beyond simple thermal engineering, as heat transport between close thin layers of sail is insufficiently explained by the usual black body radiation laws. Instead, heat transport through evanescent waves needs to be taken into account, as well as how the sail structure affects photonic and thermal properties. We offer theoretical and numerical projects in this area that involve optics, electromagnetism and thermal physics.

**Project location:**
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** Full time (35 hours per week)
**Pre-requisites:** PHYS3934 and PHYS3935
**Available as a group project:** Yes
**Primary supervisor information:** Dr Boris Kuhlmey
**For more information contact:** boris.kuhlmey@sydney.edu.au

**PHSY09: THz Nano-optics**

Terahertz (THz) frequencies are at the heart of several enabling multidisciplinary technologies, including security, telecommunications, and medical diagnostics. However, most current THz technologies are large, bulky and impractical. We have recently proposed a method to produce an on-chip nano-source of terahertz radiation. This summer project will jump-start this novel research direction via a series of far-field and near-field measurements on different materials and waveguides (including silicon and gold films, polymer fibers, and 3D-printed ceramic circuits) at the University of Sydney THz laboratory.

**Project location:** School of Physics A28
**Mode:** On campus only (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 4 weeks full time
**Pre-requisites:** MATLAB or Python, introductory optics preferable. Students should have a keen interested in developing experimental methods.
**Available as a group project:** No
**Primary supervisor information:** Dr Alessandro Tuniz
**For more information contact:** alessandro.tuniz@sydney.edu.au

**PHSY10: Perovskite solar cells**

Metal halide perovskites have excellent properties, enabling high energy conversion efficiency solar cells in thin film form and therefore also suitable for light weight flexible applications or semi-transparent glazing. In the summer research program, you will be part of a team conducting research on perovskite solar cell to understand their unique properties including advantages. You will also take part in the development of new generations of perovskite cell technology for specific applications while maintaining high performance and durability.

**Project location:** A31 Sydney Nano Hub and A28 School of Physics
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 35 to 50
**Pre-requisites:** Get yourself familiar with the general knowledge of solar cells and perovskite solar cells
**Available as a group project:** Yes
**Primary supervisor information:** Prof. Anita Ho-Baillie
**For more information contact:** anita.ho-baillie@sydney.edu.au

**PHSY11: Large scale quantum simulation with trapped ions**

The controlled simulation of dynamics in quantum-many body systems is of central interest in the pursuit to further our understanding of phenomena such as superconductivity and quantum magnetism. Specially designed Penning traps enable experimental investigations into these topics using hundreds of ions trapped simultaneously inside a large, superconducting magnet. We have recently brought online the first and only such system in Australia at the Sydney Nanoscience Hub and now routinely trap large crystals of beryllium ions. Possible summer student projects involve the characterization of coupling between the ions using a custom UV laser system, hardware-software interfacing, hardware development, and operation of the trap. These topics involve experimental work in the laboratory as well as complementary numerical simulations and will adapt based on starting date and current needs.

**Project location:** A31 Sydney Nanoscience Hub
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Daily, 18 Jan - 19 Feb 2021
**Pre-requisites:** Undergraduate quantum mechanics: spin-1/2 and/or atomic physics
**Available as a group project:** Yes
**Primary supervisor information:** Dr Robert Wolf
**For more information contact:** robert.wolf@sydney.edu.au
http://www.physics.usyd.edu.au/~mbiercuk/QCL%40Sydney.html

**PHSY12: Inferring time-reversibility of dynamic processes or (2) Recurrence Quantification Analysis**

Time-varying systems are all around us, from biomedicine (heart and brain dynamics) to astrophysics (light curves of stars). Methods to understand the structure of the dynamics produced by these systems have wide-ranging consequences across industry (developing new brain-machine interfaces) and the sciences (understanding astrophysical systems), and have recently been surveyed. In this project, students will use statistical methods to infer the relationship of new measures of time-reversal asymmetry in diverse natural systems, and see how unique they are relative to conventional methods of characterizing dynamics. Students should have a strong background in coding, and an interest in dynamics. (2) Recurrence Quantification Analysis (RQA) is a popular method for quantifying interesting dynamical patterns in time series, and has been applied to the dynamics of earthquakes, heart rates, and stars. But, despite its popularity, it has never been benchmarked against alternative methods, which may provide far more powerful representations of the patterns but with a clearer interpretation and at far lower computational cost. In this project, the student will learn about RQA and investigate whether or not this popular method uncovers novel structures in data. The student should have an interest in complex systems, dynamics, and have some familiarity with coding.

**Project location:**
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 4 weeks full time (flexible within 18-Jan, 19-Feb time period)
**Pre-requisites:** Matlab or python coding
**Available as a group project:** Yes
**Primary supervisor information:** Dr Ben Fulcher
**For more information contact:** ben.fulcher@sydney.edu.au

**PHSY13: Trapped ion quantum computation**

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 ultra-high vacuum environment. Record coherence times and the highest operational fidelities among all qubit implementations have enabled remarkable progress in recent years and, with the only two fully-operational systems in Australia, the quantum control laboratory works at the forefront of research in this area. Our current efforts focus on the development and experimental implementation of new control methods and their application to practical quantum computation and simulation, e.g. of quantum chemistry. This project is laboratory-based and – depending on preference, current needs and prior experience – can range from work with laser optics and microwave systems, to software programming, analytical calculations and numerical simulations.

**Project location:** SNH Building A31
**Mode:** On campus only (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 18 Jan 2021 - 12 Feb 2021
**Pre-requisites:** Basic Quantum Physics
**Available as a group project:** No
**Primary supervisor information:** Dr Ting Rei Tan
**For more information contact:** tingrei.tan@sydney.edu.au
http://www.physics.usyd.edu.au/~mbiercuk/QCL%40Sydney.html

**PHSY14: Inflows and Outflows in Milky Way Analogues with MUSE**

By studying "Milky Way Analogues" we can challenge the existing paradigm that our own Galaxy is the Rosetta Stone of galaxy formation. In this project we will study the inflow and outflow of ionised gas in such a Milky Way Analogue. Characterising the rates of gas flow is crucial for understanding the details of the "galactic fountain" model, where gas is first blown out of the disk by exploding stars and eventually cools and rains back down. The state-of-the-art spatially-resolved optical spectroscopic observations of UGC 10738, an edge-on Milky Way Analogue, will provide unique insights in this galactic fountain model from an extragalactic perspective.

**Project location:** School of Physics, Building A28
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Mo-Fri, 8 hrs
**Pre-requisites:** Basic physics and astronomy background.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Jesse van de Sande
**For more information contact:** jesse.vandesande@sydney.edu.au

**PHSY15: Asteroseismology with NASA's Kepler and TESS missions**

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 Kepler and TESS space telescopes, which have discovered thousands of planets transiting other stars and are also perfect for studying stellar oscillations.

**Project location:** Physics A28
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** flexible
**Pre-requisites:** physics and maths
**Available as a group project:** Yes
**Primary supervisor information:** Dr Tim Bedding
**For more information contact:** tim.bedding@sydney.edu.au

**PHSY16: A miniature experiment to explore interstellar travel with a photon drive or (2) The TOLIMAN space Telescope.**

The Starshot program explores the possibility that interstellar flight may be within our reach by way of a photon-powered lightsail propelling a low-mass, high speed space probe. This project will explore whether a tiny scale model of this same physics is possible. Using equipment from a classic physics experiment, you will attempt to demonstrate photon-propulsion in a laboratory setting. (2) The TOLIMAN space Telescope project will help to establish the design for the TOLIMAN space telescope: a small satellite being developed at the University of Sydney dedicated to the detection of exoplanets. Your role will be to will model the innovative principles underlying the detection strategy and help specify the following phases of construction and launch.

**Project location:** A28/Physics
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 4 weeks full time from late January 2021
**Pre-requisites:** (1) Experimental Physics or (2) Physics, Optics.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Peter Tuthill
**For more information contact:** peter.tuthill@sydney.edu.au

**PHSY17: How does the brain compute? Distributed dynamical computation in neural circuits. or (2) The physics of deep learning in artificial intelligence**

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 merge 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 computations, 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. (2) Deep learning networks 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 the gradient descent learning algorithm to give rise to complex learning dynamics and the resultant effectiveness of deep neural networks. These learning dynamics will then be used to develop new learning algorithms.

**Project location:** Madsen Building
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 4 weeks
**Pre-requisites:** NONE
**Available as a group project:** Yes
**Primary supervisor information:** Dr Pulin Gong
**For more information contact:** pulin.gong@sydney.edu.au

**PHSY18: Hardware efficient quantum fault tolerance**

This project will explore Floquet engineering as a tool to fault tolerantly prepare bosonic error correcting codes

**Project location:** Sydney Nanoscience Hub A31
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** 4 weeks of full time (5 full time days per week) from Jan 18 to Feb 12.
**Pre-requisites:** Third year advanced quantum mechanics
**Available as a group project:** No
**Primary supervisor information:** Dr arne.grimsmo@sydney.edu.au
**For more information contact:** arne.grimsmo@sydney.edu.au

**PHSY19: Supercontinuum generation in a quartic dispersion fibre**

Supercontinuum (SC) generation occurs when a narrow bandwidth pulse undergoes extreme nonlinear spectral broadening to yield a broadband (very often a white light) spectrally continuous output. Traditionally, this phenomenon is generated in waveguides with dominant second-order dispersion, but recently, waveguides with fourth-order dispersion have attracted interest for nonlinear optics. In this project you will use advanced numerical simulations to investigate SC generation in this new type of waveguide.

**Project location:**
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 3-4 days a week, 6 hours
**Pre-requisites:** Fundamental physics and optics
**Available as a group project:** Yes
**Primary supervisor information:** Dr Antoine Runge
**For more information contact:** antoine.runge@sydney.edu.au

**PHSY20: Untangling the social web**

In this project you will work on developing automated methods for quantifying information exchange on a social network. This could for instance include identifying hashtags in Twitter that have similar meanings, determining characteristics of viral messages, or quantifying networks of influence. This will be applied to specific contexts such as political messaging or climate action denial. This project will involve techniques in data science.

**Project location:** Optional meetings will occur in Room 303A Physics Building, Camperdown campus, subject to COVID Safe Plan
**Mode:** Online only
**Attendance:** Day
**Expected workdays/hours:** 5 days per week, 7 hours per day
**Pre-requisites:** Programming skills, preferably python
**Available as a group project:** Yes
**Primary supervisor information:** Dr Tristram Alexander
**For more information contact:** tristram.alexander@sydney.edu.au

## SCHOOL OF PSYCHOLOGY

### PSYC01: Helping clinicians and patients make sense of HPV-related oropharyngeal cancer: an information resource

High quality information is a key component of supporting cancer patients and their families. We have developed an evidence-based booklet for HPV-oropharyngeal cancer (OPC) patients, informed by interviews with health professionals, patients and their partners. The booklet was designed using a question and answer format to answer the questions most frequently asked by patients, and to provide a support tool for health professionals communicating about HPV as a cause of OPC to patients. This project will use qualitative methods to test the booklet with patients. Cognitive interviews with up to 15 patients will identify target population reactions to the resource. Interviews will assess acceptability, readability, and comprehensibility of the booklet.

**Project location:** Chris O'Brien Lifehouse (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** The successful student should have a keen interest in communication of healthcare. The successful student should have excellent verbal and written communication skills, with an attention to detail and an interest in qualitative research. Previous qualitat
**Available as a group project:** Yes
**Primary supervisor information:** A/Prof Haryana Dhillon
**For more information contact:** haryana.dhillon@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/haryana-dhillon.html

**PSYC02: The transmission of VR-induced nocebo effects**

This project will investigate factors that facilitate the transmission of the nocebo effect (measured as the experience of cybersickness following an immersive VR experience). Participants will be sent a VR headset to keep and all hour-long testing sessions will be run via Zoom (requiring students assigned to the project to be present to test participants online). The project will provide experience with experimental design, participant recruitment, data collection and aggregation.

**Project location:** Griffith Taylor (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** Preference for students with an interest in the placebo/nocebo effect.
**Available as a group project:** Yes
**Primary supervisor information:** A/Prof Ben Colagiuri
**For more information contact:** ben.colagiuri@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/ben-colagiuri.html

**PSYC03: The development of children's thinking**

This project will involve researching what changes about how children think as they develop. You will be involved in multiple phases of the research process: developing experimental materials; collecting data; analysing data, and writing about the results. Depending on your skillsets and interests, this may involve both behavioural and neuroimaging experiments.

**Project location:** Brennan MacCallum (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** No prerequisites, but quantitative and computer programming skills are preferred.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Micah Goldwater
**For more information contact:** micah.goldwater@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/micah-goldwater.html

**PSYC04: Decoding the representation of semantic memory in the human brain**

This project will study how the brain represents the relationships between real world objects. The study will involve: (1) designing a study collect behavioural data studying semantic similarity in an online environment. (2) analysing the behavioural data in the context of brain imaging data (EEG), and (3) reviewing the literature and then preparing a written report of the study findings.

**Project location:** Griffith Taylor (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** Background in either Cognitive Psychology, Computer Science and Neuroscience. Programming skills a must.
**Available as a group project:** No
**Primary supervisor information:** A/Prof Thomas Carlson
**For more information contact:** thomas.carlson@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/thomas-carlson.html

**PSYC05: Emerging technology and behavioural addictions**

People increasingly report excessive and harmful use of technologies (including social media, and online gaming, and online gambling) that significantly impacts their physical and mental health and wellbeing. The Technology Addiction Team and Gambling Treatment and Research Clinic at the world-leading Brain and Mind Centre conduct cutting-edge applied research to tackle these issues and inform real-world policy and practice. In this project you will gain experience across research methodologies in this area while immersing yourself in an active lab comprised of both researchers and clinicians. You will gain valuable experience working in the multidisciplinary environment afforded by the Brain and Mind Centre, including experience with the Technology Addiction Team executive team across psychology, medicine, economics, law, and ethics. You will work on projects designed to understand how technology contributes to harmful and addictive behaviour such as the convergence of online gambling and gaming.

**Project location:** Brain & Mind Centre (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** Desirable: some experience in psychology; statistics and research methods; qualitative analysis; and/or working with data.
**Available as a group project:** Yes
**Primary supervisor information:** A/Prof Sally Gainsbury
**For more information contact:** sally.gainsbury@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/sally-gainsbury.html

**PSYC06: What makes a good liar?**

In the "what makes a good liar" project, we have collected video footage of people trying to convince another person they have made particular choice in a strategy game. Some of the people are lying about the choice they made, and some are not. The scholars would be involved in watching and rating the video data for behavioural indicators of lying (e.g., eye contact, hand movements etc), developing and fine-tuning rating schemes, and conducting literature reviews of deception ability, and possibly video editing.

**Project location:** Brennan MacCallum (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** A strong ability to communicate and read in English. A preliminary ability to complete database searches and reference in APA. All other skills required will be taught.
**Available as a group project:** No
**Primary supervisor information:** A/Prof Carolyn MacCann
**For more information contact:** carolyn.maccann@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/carolyn-maccann.html

**PSYC07: Understanding and improving research in law and psychology and in criminology**

There is a reproducibility and credibility crisis in multiple sciences, due to a failure to encourage publication of replication studies and share data and materials. You will help evaluate the credibility of research at the intersection of law and psychology and gather the information needed to improve them. This will mean assessing journal articles and researchers' practices to determine if findings are reproducible and transparent.

**Project location:** Griffith Taylor (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** Experience with statistics coursework preferred but not required.
**Available as a group project:** No
**Primary supervisor information:** Professor Alex Holcombe
**For more information contact:** alex.holcombe@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/alex-holcombe.html

**PSYC08: The impact of body-worn camera footage in criminal trials**

Body-worn cameras (BWC) are becoming increasingly common in policing, however very little research has investigated the impact of BWC footage on juror-decision-making. In this project, students will conduct an online experiment, in which participants read a trial transcript and view associated BWC footage. We will manipulate various factors associated with the trial and BWC footage to determine how they influence verdicts. Students will be expected to write a literature review and method section. Once data has been collected, students will be required to conduct simple analyses and write up the results.

**Project location:** Brennan MacCallum (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** A strong ability to communicate in written and oral English. A preliminary ability to complete database searches, write literature reviews, and conduct simple analyses (e.g., ANOVAs) using SPSS. All other skills required will be taught.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Helen Paterson
**For more information contact:** helen.paterson@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/helen-paterson.html

**PSYC09: 'Ooh, that body looks nice!': Is Fitspiration and the desire to look 'fit' as healthy as claimed?**

The portmanteau of terms 'fitness' and 'inspiration', fitspiration social media content has taken the world by storm. On a daily basis, millions of men and women are exposed to messages purported to empower and inspire individuals to be fitter and healthier, often accompanied by depictions of overtly fit and athletic looking bodies. However, emerging research suggests that such messages may be counterproductive, eliciting body dissatisfaction, negative mood and poorer self-esteem in those that view them. This project, at the nexus among clinical, social, and health psychology, will build upon this research and explore the potential unhealthy consequences of the desire to look 'fit' and muscular (e.g., disordered eating, compulsive exercise, negative emotional syndromes). In assisting with studies under this umbrella project, the Denison Scholar(s) will gain familiarity with a variety of key research methods (e.g., literature review, data cleaning and analysis, data visualisation and interpretation) within a close-knit collaborative team environment. The primary output from these activities will be a literature review (TBD pending COVID19 restrictions).

**Project location:** Griffith Taylor (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** PSYC3010 & PSYC3018 (preferable). Knowledge of Psychological Research Methods (required). Experience conducting literature reviews and analysis of data using SPSS (preferable).
**Available as a group project:** Yes
**Primary supervisor information:** Dr Rebecca Pinkus
**For more information contact:** rebecca.pinkus@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/rebecca-pinkus.html

**PSYC10: Comorbid conditions in cancer survivors**

Many people with cancer have coexisting chronic diseases, known as comorbidities. The presence of comorbidities, such as high blood pressure and diabetes, is negatively associated with health outcomes. This project will involve extracting data from the Sydney Cancer Survivorship service to explore the prevalence of comorbidity in cancer survivors seen through the service. Associations between comorbidities and quality of life will also be explored.

**Project location:** Concord Hospital
**Mode:** On campus only (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** Experience using Microsoft Excel, medical terminology (preferred), healthcare (preferred).
**Available as a group project:** No
**Primary supervisor information:** Dr Jasmine Yee
**For more information contact:** jasmine.yee@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/jasmine-yee.html

**PSYC11: Literature review of high-density EEG methodology in animal and human studies for application in sleep health**

Research studies using high-density electroencephalography EEG (HdEEG) to understand the brain and behavioural states have rapid grown recently in the biomedical field. While HdEEG provides high resolution brain activity data in spatial and temporal dimensions, there is no appropriate methodology for analysing spatio-temporal data during sleep. A systematic literature review of published HdEEG studies would provide useful information to build computational tools for application in our sleep and brain health research program.

**Project location:** Woolcock Institute (in-person meetings with supervisor only)
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance:** Day
**Expected workdays/hours:** Equivalent to 4 weeks full time between 18 Jan 2021 to 19 Feb 2021
**Pre-requisites:** Basic knowledge of mathematics and programming/coding. Research interest in sleep medicine.
**Available as a group project:** No
**Primary supervisor information:** Dr Angela D'Rozario
**For more information contact:** angela.drozario@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/angela-drozario.html

**SCHOOL OF LIFE AND ENVIRONMENTAL SCIENCES**

**SOLE01: Are bee friendly plants really bee friendly?**

There is increasing public interest in conserving pollinators by planting 'bee friendly plants'. But how good is this information? In this project, you will investigate Australian websites to determine what information is being presented to the public, what type of biases might be present in the information, and what the quality of the information is.

**Project location:** online
**Mode:** Online only
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and internet searches
**Available as a group project:** No
**Primary supervisor information:** A/Professor Tanya Latty
**For more information contact:** tanya.latty@sydney.edu.au
www.tanyalatty.com

**SOLE02: Decoy effects in honey bees**

Decoy effects occur when a non-preferred or unavailable item (like a sold out menu item) causes individual's to change their preferences for other items in their choice sets. In essence, the crummy option makes the other options look better. We will be testing for the decoy effect in individual honeybees. You will learn how to train bees and how to read the bees incredible dance language. The student must not be allergic to honeybees.

**Project location:** Camperdown, A12
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable around stinging insects; not allergic to bee stings
**Available as a group project:** No
**Primary supervisor information:** A/Professor Tanya Latty
**For more information contact:** tanya.latty@sydney.edu.au
www.tanyalatty.com

**SOLE03: Developing a database of pollinator-relevant flower traits**

**Project location:** online
**Mode:** Online only
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** comfortable with computers and internet searches
**Available as a group project:** No
**Primary supervisor information:** A/Professor Tanya Latty
**For more information contact:** tanya.latty@sydney.edu.au
www.tanyalatty.com

**SOLE04: Developing novel lead molecules to fight antibiotic resistance**

Antibiotic resistance continues to pose as a major health issue in the 21st century. Resistance to currently available antibiotics is increasingly responsible for deaths globally. Despite this pressing issue, in recent years, there have been few new classes of antibiotics introduced. Our project aims to alleviate this issue by developing a novel class of broad-spectrum antibiotics that targets a never-exploited interaction between bacterial Signal Recognition Particle (SRP) and its Receptor (SR).

**Project location:** G08
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Has experience with working in a web lab, preferably with experience with working with proteins
**Available as a group project:** no
**Primary supervisor information:** Dr Ann Kwan
**For more information contact:** ann.kwan@sydney.edu.au
https://www.kwanlabusyd.com/

**SOLE05: Development of practical class data generator and simulations**

I am developing simulations of experiments in 3D and VR using the Games Engine, Unity. The vision is to allow the user to experience the consequences of their actions so that they gain advanced trouble-shooting skills and are able to critically evaluate the limitations of the methods and resulting data. Prior programming skills not required.

**Project location:** ONLINE
**Mode:** Online only
**Attendance**: Day
**Expected workdays/hours:** Full time from 18/1/21 to 19/2/21
**Pre-requisites:** Good understanding of fundamental biochemistry techniques
**Available as a group project:** Yes
**Primary supervisor information:** Prof Gareth Denyer
**For more information contact:** Gareth.Denyer@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/gareth-denyer.html

**SOLE06: Engineering protein coating for biotech applications**

Hydrophobins are fungal proteins that can naturally self-assemble and coat structures and reverse their wettability. This property can be exploited for coating applications ranging from drug delivery to increasing the biocompatiblity of surfaces. You will be investigating how hydrophobins assemble and coat different materials, including bone scaffolds and drug delivery vehicles.

**Project location:** G08
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Has experience with working in a web lab, preferably with experience with working with proteins
**Available as a group project:** no
**Primary supervisor information:** Dr Ann Kwan
**For more information contact:** ann.kwan@sydney.edu.au
https://www.kwanlabusyd.com/

**SOLE07: Evaluating variation in the structural composition of coral reefs**

Coral reefs can vary greatly in their structural characteristics and these have a strong impact on the biodiversity they support. This project uses novel photo-based large-area mapping to generate 3D models of coral reefs. These models can then be interrogated to extract different measrues of structural complexity which are then used to explore the variation in structure across spatial gradients including the Coral Sea, Great Barrier Reef, and Sub-tropical and temperate reefs of NSW.

**Project location:** Camperdown, A11
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and new software, familiarity with marine ecology is preferred.
**Available as a group project:** Yes
**Primary supervisor information:** A/Professor Will Figueira
**For more information contact:** will.figueira@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/will-figueira.html

**SOLE08: Exploring the broad-spectral light-harvesting protein complexes**

Phycobiliprotein is a main antenna protein complexes for photosynthetic organisms. The changed spectral feature plays important role in improving photosynthetic efficiency. We established in vitro reconstitution systems to reveal the "secrets of switchable colour proteins", a pathway to enhance the light-harvesting efficiency.

**Project location:** LEES level *5*
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Full time from 18/1/21 to 19/2/21
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Prof Min Chen
**For more information contact:** min.chen@sydney.edu.au
https://www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/photosynthesis-lab.html

**SOLE09: Gene editing to modify the flavor of edible mushrooms**

Non-browning button mushrooms (Agaricus bisporus) were the first gene edited food targeted for the US market. This project uses a similar gene editing approach to alter flavor compounds in button mushrooms.

**Project location:** LEES level 7
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** A/Professor Brian Jones
**For more information contact:** brian.jones@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/brian-jones.html

**SOLE10: Identifying metabolites that change with radiotherapy schemes**

Radiotherapy is used commonly to treat cancers but often not without significant side effects that may not be apparent for weeks or months. You will be using a range of statistical tools to analyze data from mass spectrometry and nuclear magnetic resonance experiments to identify and quantify metabolites from prostate and lung cancer cell lines that have been treated with different radiotherapy schemes. These metabolite profiles and the associated pathways may inform about the effectiveness of different radiotherapy schemes and lead to better treatment plans.

**Project location:** Online
**Mode:** Online only
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and statistical analysis, familiarity with R is strongly preferred.
**Available as a group project:** no
**Primary supervisor information:** Dr Ann Kwan
**For more information contact:** ann.kwan@sydney.edu.au
https://www.kwanlabusyd.com/

**SOLE11: Improving identification and quantification of metabolites in biofluids**

You have probably had blood tests in the past to measure a particular indicator or two. However, techniques such as mass spectrometry and nuclear magnetic resonance spectroscopy have allowed the simultaneous identification and quantification of many tens of metabolites from a single biofluid sample. In this project, you will be developing and optimising experiments and sample preparation to improve the accurate identification and quantification of metabolites in plasma and serum.

**Project location:** G08 and online
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers, programming and spectra, and abillity to learn new techniques.
**Available as a group project:** no
**Primary supervisor information:** Dr Ann Kwan
**For more information contact:** ann.kwan@sydney.edu.au
https://www.kwanlabusyd.com/

**SOLE12: Inferring habitat diversity from lidar**

Can we infer habitat diversity across farming landscapes using lidar? Farms occupy most of Australia's land mass, and lidar obtained from light aircraft surveys is becoming more common (e.g.; ELVIS). This project will compare a canopy height raster of USyd Llara farm to on-ground habitat availability

**Project location:** Narrabri (USyd Plant Breeding Institute)
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** 20 x 8 hour days
**Pre-requisites:** N/A
**Available as a group project:** no
**Primary supervisor information:** Dr David Gallacher
**For more information contact:** d.gallacher@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/d-gallacher.html

**SOLE13: Interrogating Signal Transduction Networks using Bioinformatics**

Insulin and exercise activate extensive signalling cascades to regulate an array of cellular processes. Identifying the composition of these signalling networks and the proteins responsible for eliciting specific functions of insulin and exercise is essential in understanding the defects that cause metabolic disease where insulin signalling is defective, and in harnessing the power of exercise to promote health. This project will interrogate the insulin and exercise-regulated phosphoproteome, revealing the extent of these signalling networks and a number of new phosphorylation sites on proteins modified in response to these stimuli.

**Project location:** CPC
**Mode:** Combination of online and on campus (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** Prof David James
**For more information contact:** david.james@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/david-james.html

**SOLE14: Modelling 3D growth in corals**

This project uses novel photo-based modeling of individual coral colonies at multiple time points to look at their 3D growth. This information is used to assess inter and intra-colonly growth differences and relate them to other aspects of the corals structure and life history.

**Project location:** Camperdown, A11
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and new software, familiarity with marine ecology is preferred.
**Available as a group project:** Yes
**Primary supervisor information:** A/Professor Will Figueira
**For more information contact:** will.figueira@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/will-figueira.html

**SOLE15: Nanoneedle array transformation of plants**

Plant stem cell niches exist to produce the new cells required for continued growth. This project uses cutting edge nanotechnologies and CRISPR to directly modify plant stem cells. The project combines molecular biology and nanotechnology to modify the growth and environmental responses of legumes.

**Project location:** LEES level 7
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** A/Professor Brian Jones
**For more information contact:** brian.jones@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/brian-jones.html

**SOLE16: Precision agriculture technologies in cotton**

We have planted sveral dryland cotton experiments using the latest John Deere technology, CSIRO pest managment traps, moisture sesnors. This project will onvolve collecting agronomic and digital data.

**Project location:** Narrabri
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Block
**Expected workdays/hours:** Couple of two week blocks Jan and or Feb
**Pre-requisites:** Drivers licence
**Available as a group project:** Yes
**Primary supervisor information:** A/Professor Guy Roth
**For more information contact:** guy.roth@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/guy-roth.html

**SOLE17: Quantifying spatial and temporal patterns of sea urchins on rocky reefs in New South Wales**

Sea urchins are important herbivores on rocky reefs in New South Wales, possibly influencing competitive dynamics among habitat forming species, such as corals and seaweeds. In this project, you will use photographic maps of seafloor communities to quantify the abundance and spatial patterns of sea urchins on rocky reefs in New South Wales. This will help us understand the role of sea urchins in facilitating the poleward range expansion of corals along the New South Wales coastline.

**Project location:** Camperdown, A11
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and new software, familiarity with marine ecology is preferred. Experience with GIS is a bonus.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Brigitte Sommer
**For more information contact:** brigitte.sommer@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/brigitte-sommer.html

**SOLE18: Rethinking cropland contouring**

Sloped contour banks designed for drainage have been constructed throughout NSW inland farming regions. Natural sequence farming recommends converting these into true contours without banks, or into a series of ponds. This project will look at the impact of these banks on and uphill from the USyd Llara farm. Specifically, what patterns of silting and scouring occur where the banks meet the waterways. What are the implications for nutrient runoff and loss of soil structure?

**Project location:** Narrabri (USyd Plant Breeding Institute)
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** 20 x 8 hour days
**Pre-requisites:** N/A
**Available as a group project:** no
**Primary supervisor information:** Dr David Gallacher
**For more information contact:** d.gallacher@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/d-gallacher.html

**SOLE19: Simpson Snapshots: designing Citizen Science programs for identifying wildlife in remote camera trap images**

Remote camera traps are now commonly used in wildlife studies around the globe. They are a powerful and cost-effective method to survey wildlife due to their ease in deployment and ability to continually monitor populations across time. This project will work with DigiVol at the Australian Museum and the Desert Ecology Research Group, SOLES to design and test the utility of using citizen scientists to identify wildlife from remote camera photographs from the Simpson Desert.

**Project location:** Online
**Mode:** Online only
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and new software, familiarity with R is preferred.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Aaron Greenville
**For more information contact:** aaron.greenville@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/aaron-greenville.html

**SOLE20: Smart farming: incorporating biodiversity into farming decisions**

This project will develop and test an innovative system of acoustic recorders that can be used across pastures, crops and remnant patches of natural vegetation to evaluate the utility of ecoacoustics for monitoring biodiversity (Sub-project of DigiFarms https://sydney.edu.au/agriculture/our-research/Digifarm.html).

**Project location:** online
**Mode:** Online only
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and new software, familiarity with R and identifiying bird or bat calls are preferred.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Aaron Greenville
**For more information contact:** aaron.greenville@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/aaron-greenville.html

**SOLE21: The demography of corals on subtropical reefs in NSW**

Subtropical reefs in New South Wales are home to corals at their southern range limits and are already experiencing the effects of climate change. You will learn how to identify corals and other marine organisms and use photographic maps of seafloor communities to quantify the abundance and size distributions of these taxa on rocky reefs in New South Wales. This will help understand the ecology of these dynamic systems that are already being transformed by changes in species distributions and interactions in response to warming.

**Project location:** Camperdown, A12
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and new software, familiarity with marine ecology is preferred. Experience with GIS is a bonus.
**Available as a group project:** Yes
**Primary supervisor information:** Dr Brigitte Sommer
**For more information contact:** brigitte.sommer@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/brigitte-sommer.html

**SOLE22: The effect of oyster reefs on water quality**

Oysters are the kidneys of coastal environments, as they filter water while feeding, removing particles in suspension including contaminants. Most of this important oyster habitats have been lost in Australia and around the world due to harvesting and contamination, and numerous restoration projects are underway worldwide. This project aims to gather and combine published data in a meta-analysis on the capacity of these restored reefs to improve water quality. The information produced here will help guide future oyster restoration initiatives currently being developed in Australia.

**Project location:** Camperdown, A11
**Mode:** Online only
**Attendance**: Day
**Expected workdays/hours:** 4 weeks full time between 18/01 and 19/02, but flexible with time arrengements
**Pre-requisites:** Preferably familiar with GIS and R
**Available as a group project:** Yes
**Primary supervisor information:** Dr Ana Bugnot
**For more information contact:** ana.bugnot@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/ana-bugnot.html

**SOLE23: Understanding fish communites on oyster reefs through underwater video**

Oyster reefs provide a variety of ecosystem services, including as habitat for fishes. This project uses remote underwater video as a means to assess fish communites. The project will involve learning fish taxonomy in order to record fish from the videos as well as assisting with the collection of new data from oyster reefs.

**Project location:** Camperdown, A11
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** Comfortable with computers and new software, familiarity with marine ecology is preferred.
**Available as a group project:** Yes
**Primary supervisor information:** A/Professor Will Figueira
**For more information contact:** will.figueira@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/will-figueira.html

**SOLE24: Understanding how plants position and shape their leaves**

The project will use molecular genetics and confocal based live-imaging to investigate plant development. We use the model plant Arabidopsis thaliana.

**Project location:** LEES level 7
**Mode:** On campus only (with covid safety plan in place)
**Attendance**: Day
**Expected workdays/hours:** Daily for four weeks during this period but flexible within the requirements.
**Pre-requisites:** N/A
**Available as a group project:** No
**Primary supervisor information:** A/Professor Marcus Heisler
**For more information contact:** marcus.heisler@sydney.edu.au
https://www.sydney.edu.au/science/about/our-people/academic-staff/marcus-heisler.html