UNSW SYDNEY

SciX @ UNSW Projects 2022

Applications open 11th October; sign up to SciX EOI mailing list for reminder and direct links.
Project positions are allocated on a first-come, first-served basis.

This project list is final; please see unsw.to/scix for full project details and application process.

Aircraft Wing Design

Many industries globally are dependent on our understanding of aerodynamics, such as travel, freight, motorsports, and power generation. Accurate design and analysis of airfoils and wings allow us to increase the performance of all kinds of things, from aircraft and wind turbines to F1 cars. Good design helps scientists and engineers increase the output (speed, power generation) and minimise the costs.

What Students will do

During this project students will design, manufacture, and experimentally test an airfoil or wing section. Students will learn how to use the XFoil (an open-source software) to design and theoretically test a wing or airfoil section. They will then test a 3D printed model of their wing section using our wind tunnels to compare the real and theoretical flight performance characteristics.

CRICOS Provider Code 00098G

Making Better Batteries

Batteries are all around us. Different battery chemistries are used for different applications depending on aspects such as energy storage density, cost and power. For example, lead acid batteries are used for starter motors in conventional petroleum vehicles.

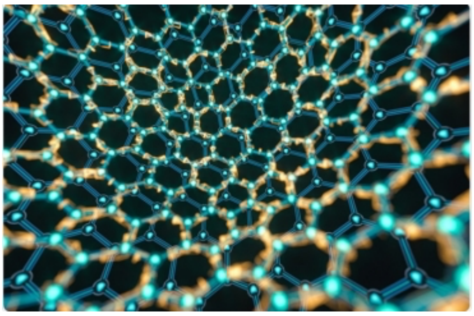
Lithium-ion batteries were commercialised in 1991 and the scientists/engineers working on this were awarded the Nobel prize in Chemistry in 2019. Lithium-ion batteries power mobile phones, laptops and electronic devices and are widely used in electric vehicles and grid scale energy storage, e.g., the Hornsdale plant in South Australia.

There remain challenges in lithium-ion batteries, ranging from energy storage density to safety and cost. To develop the next generation of battery materials and entirely new battery chemistries, we need research and development. This is where science comes in, and this project will give students a taste of this.

What Students will do

Students will be shown how research-scale lithium-ion batteries are made. From the electrode active materials to electrode preparation and finally to coin cell assembly. This will either be via a session in the laboratory or via online videos/walk-through. Following this, students will be given electrochemical performance data also known as charge-discharge curves. They will be able to compare the performance each cycle and after several cycles. Students can compare between batteries of the same electrodes/composition, between electrodes of different compositions and between entirely different battery systems, e.g., next generation sodium-ion and lithium-sulfur batteries.

Biomimetic Materials



Inspired by the vibrant colours displayed by some of the most beautiful creatures and objects in Nature like butterflies, beetles and opals, materials scientists have, for a long-time, been trying to mimic these into artificial materials. Using innovative materials fabrication techniques, we have developed sponge-like porous materials that mimic the principles of light modulation in nature. 3D printing is an emerging manufacturing technology pushing the boundaries beyond restrictive and wasteful conventional manufacturing methods. 3D printing, in last decade has become a household name with benchtop 3D printers becoming extremely affordable enabling rapid development and prototyping.

Combining biomimicking materials with advanced 3D printing can open doors for the development of devices and tools that could not even be imagined previously. There are endless possibilities of creating devices that can be personalised or purpose-built.

What Students will do

Students will use their creativity to create new patterns for biomimicking porous photonic crystals to use as colour changing sensors. Students will learn 3D CAD designing and 3D printing to create patterns and utilise their 3D printed patterns to carry out device prototyping and experimental validation of the sensors.

Quantum Chemistry & Spectroscopy

Aliens are out there! (Probably.) But how will we find them? Probably by finding unexpected molecules produced by life – called biosignatures – in their planet's atmosphere using infrared astronomical spectroscopy.

Ozone-destroying chemicals are being replaced by new gases, but will these cause global warming? How can we determine if a country is violating international agreements and burning too many fossil fuels? Are cars producing harmful pollutants?

Infrared spectroscopy (Module 8, HSC Chemistry) is an essential tool to answer these and many other questions regarding our planet and universe.

What Students will do

Students will use research-level computer programs to solve quantum mechanical equations that model how molecules absorb infrared radiation. The resulting infrared spectra will be used by students to explore hypotheses both terrestrial and extra-terrestrial.

Student hypotheses are driven by their interests, focusing on identification of gaseous small molecules remotely in astrophysical, industrial or environmental contexts. For example, one hot research topic is determining how biosignature gases such as phosphine (maybe on Venus!) could be distinguished from other common atmospheric gases. You could explore how to find technosignatures (gases only produced by intelligent life) or help follow through on a recent UNSW discovery that new refrigerant gases called hydrofluoroolefins (HFOs) could have extremely dangerous global warming potential. Industrial processes, pollution or bushfire modelling; pick something that interests you and follow a scientific journey to find out something new.

Astronomy

Astronomy is a rich and diverse scientific research area, covering a range of topics from star formation to galaxy evolution. Fortunately for SciX students, telescopes worldwide are continually producing huge amounts of data that is often freely available and can be analysed in new and unique ways to explore student-driven hypotheses and discover new scientific knowledge.

What Students will do

Students will be introduced to cutting-edge astronomical understanding of stars and galaxies by the researchers discovering the knowledge of the future right now. Students will learn how to access and process astronomical data using Python. They will be supported in designing then investigating their own individual hypothesis with this data. Research questions to be explored might include determination of star formation rates or the relationship between galaxy colour and shape.

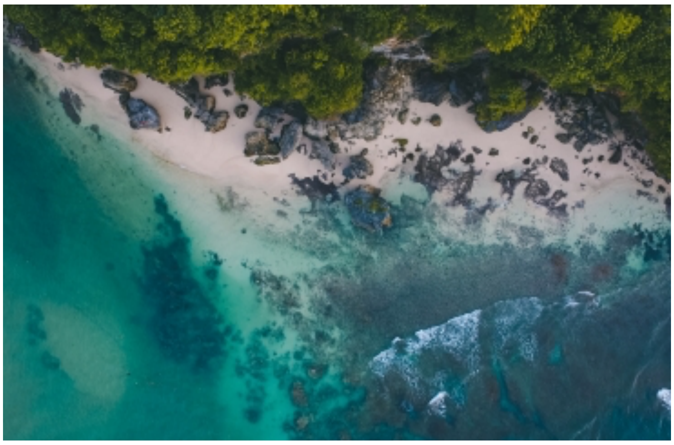
Hot springs and the origins of life!

Understanding the origin of life on Earth is one of the key tools we have in figuring out if we are alone in the universe. However, how life formed on Earth is still relatively unknown. Scientists have suggested different hypotheses (including life forming in deep sea vents, or in bubbling hot spring pools), however these are rarely tested in "real world" conditions. In this project you will explore one of the leading hypotheses, that life formed in a hot spring pool, by testing if rock particles (which are found in all hot springs) help or hinder the formation of the basic build blocks of life, the primitive cell membrane.

What Students will do

Students will create model "protocells". These fatty-acid compartments are considered by many to be one of the first steps towards the formation of living cells. Once these protocells are made, students will expose them to a series of different hot spring conditions, i.e. mineral grains, salts, high temperatures and acidic environments. Using a microscope, students will image the protocells in these "real world" conditions and analyse the data to understand if their protocells can withstand these hot spring environments.

Exploring Marine Biodiversity



Species distributions are important for understanding how whole ecosystems function. The rocky shore is a great place to see this concept in action because there is a huge variety in environmental factors (temperature, water retention, habitat type) contained in a very small area. Marine ecologists use these same foundational skills across a wide variety of ecological fields, such as monitoring the effects of climate change and sea level rise and how these are impacting species distributions and interactions.

What Students will do

Students will visit a coastal rock pool to get a close-up look at the organisms that call this inter-tidal zone home. They will then have the opportunity to carry out an experiment in this environment, learning how to take random samples to ensure that the data is representative of the whole area. They will also learn how to ID some of the most common species on the rocky shore and some basic statistical analysis. With a range of possible organisms and factors to investigate, this project can be tailored to individual interests of the students. If you have accessibility concerns, please contact the SciX coordinator to discuss; field-work assistance is available if required

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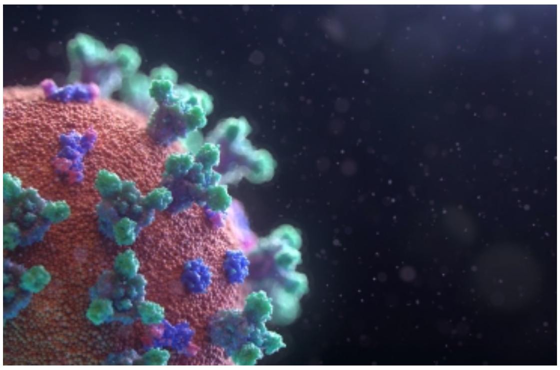
Cognitive Science

As a discipline, cognitive science explores how the brain takes in information about the world, how it represents information about the world, and how it uses it. Through elegant experiments, cognitive scientists have learned a lot about how perception, attention, and memory work.

What Students will do

In this project, students will learn about classic experiments in this field and will have the opportunity to analyse previously collected data using well-established tasks. All data was collected using an online tool called Mechanical-Turk, which collects responses from participants across the world. All experiments were approved by the School of Psychology's in-house ethics panel. Working with their mentor, students will create unique hypotheses (related to the available data) that they are interested in exploring and testing. Additionally, students will be shown how to analyse this de-identified data for trends that support the drawing of a conclusion related to their hypotheses. Students will also have the opportunity to learn some basics in R, which is a programming language, to help understand, analyse, and visualize their data.

Tracing a Viral Outbreak



Viruses are the cause of many diseases worldwide such as the flu, measles, gastroenteritis and COVID19. When an outbreak occurs, there is limited time to find the cause and quickly implement control measures, including quarantine, rapid testing and lockdowns. The current coronavirus pandemic is a prime example of many research institutes and industries coming together with different approaches to help manage the outbreak. Sydney has an extensive wastewater surveillance system to identify coronavirus fragments in suburbs combined with genomic sequencing to identify the strain and epidemiologists undertaking contact tracing. By combining these techniques, it is easier to trace and control viral outbreaks.

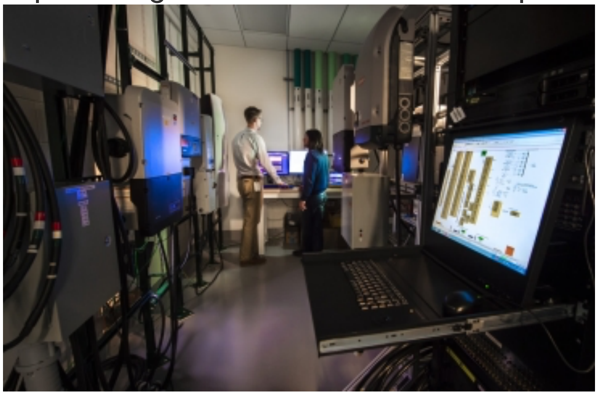
Our research lab at UNSW undertakes testing of both clinical samples and wastewater to help track viral outbreaks including norovirus and SARS-CoV2. This project will introduce students to virology and epidemiology concepts and methods in a state-of-the-art molecular biology laboratory.

What Students will do

In this project, students will get a chance to think like an epidemiologist and virologist to find patient zero of a viral outbreak. Students will learn how to diagnose viral infections and use techniques including phylogenetics and gene analysis to trace viral evolution. Students will be able to explore their hypothesis using a combination of computer (dry-lab) and wet-lab methods.

Exploring the Human Genome

Bioinformatics is the use of large datasets and computer algorithms to answer complex biological questions. There has been a recent explosion in freely available RNA sequencing data and computer programs. With this has created exciting opportunities for researchers, who are able to investigate the role of genetics in health and disease. In our research, we focus on diseases of the brain, with the aim of contributing to the development of diagnostic and therapeutic tools to treat brain diseases.



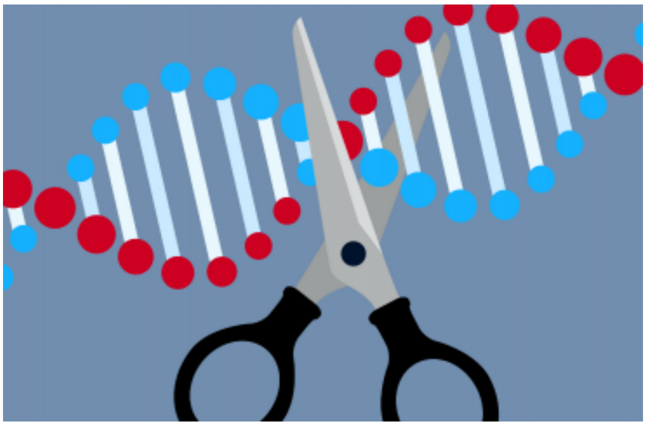
What Students will do

Students will perform a bioinformatic analysis on RNA sequencing data from healthy and diseased brain tissues to quantify transcriptomic expression. Students will follow an established pipeline to assess and improve data quality, map sequencing reads to the human genome and then quantify gene and transcript abundances. With this information, students will be able to determine the small changes between healthy and diseased individuals.

In this study we will provide sequencing data from Alzheimer’s disease, Parkinson’s disease and Multiple System Atrophy datasets. Like all research, this project will have no 'correct' answers; it is up to the student to ask interesting questions of the data and draw useful conclusions, using the peer-reviewed literature as guidance.

CRISPR – Editing Genes in Red Blood Cells

Curing 'incurable' genetic diseases, making 'super-crops' that can survive climate change, and wiping out disease-causing parasites. What may have once been a sci-fi fantasy is now reality, thanks to a revolutionary technology called CRISPR. CRISPR is a type of 'molecular scissors' that lets us cut and modify specific parts of the DNA. In molecular biology labs we use CRISPR as a tool to figure out what genes do inside living cells.



What Students will do

In this project, students will learn how to design and use CRISPR technology to 'knock-out' a gene of their choice inside a red blood cell line. Students will use software to design a personalised CRISPR strategy and will learn how to assemble and introduce the CRISPR components inside living cells. Students will get hands-on wet-lab experience in common molecular and cell biology techniques, including mammalian cell culture, DNA extraction techniques, Polymerase Chain Reaction (PCR) and agarose gel electrophoresis.

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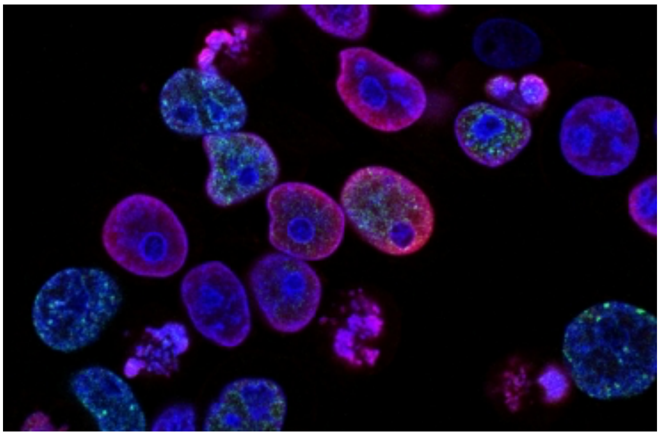
A journey into cancer cells



All life starts from one single cell. That cell then divides into two, four, eight...but sometimes, things go wrong. One cell gets mutated, and becomes a cancer cell. How can we catch this difference early? How can we use this knowledge to battle cancer?

In this project, students will use advanced microscopy to see how cancer cells are different from healthy cells, and investigate how we can use the differences to battle to cancer cells.

What Students will do

Students will use microscopy to examine the difference between healthy and normal cells, analysising the data using computer program. For additional data for analysis and comparison, students will have access to a secondary dataset of cell sizes.

Making Medicines

Medicinal chemistry has saved countless human lives, and has alleviated untold suffering, during the 20th – 21st centuries. And it continues to be a vitally important endeavour today: for example, at this very moment, medicinal chemists are working feverishly around the globe to discover a cure for COVID-19.

When developing a new medicine, it is important to ensure that the molecule can travel to the correct location within the body. As part of this, a careful balance must be struck between the molecule’s solubility in water (which enables the drug to be swallowed as a tablet, and dissolve in the gut) and its solubility in fat (which enables the drug to cross the lining of the gut, and get into the bloodstream).

What Students will do

Medicinal chemists can alter the structure of a drug molecule, in order to fine-tune its properties such as water / fat solubility and thereby identify the optimal drug.

In this SciX experiment, students will do just that: they will systematically modify the structure of a drug candidate, and they will measure the properties of their “analogues” to identify which chemical structure gives the best drug-like properties.

This experiment will give students an insight into the grand challenge that is medicine development in the 21st century.

Nanomaterials for Medicine

Nanomaterials are becoming increasingly prominent in medicine, with the ability to selectively target a specific tissue for drug and gene delivery. Learn how to synthesise, modify and characterise nanoparticles using research laboratory equipment and techniques.

What Students will do

Students will work in a research lab to synthesis gold nanoparticles and change the properties by tethering polymers to their surface. They will then characterise the nanoparticle using UV-Vis spectroscopy and compare the unique spectral properties caused by a change in shell thickness compared to the unmodified gold nanoparticles. How a polymer can change the size and physical properties of gold nanoparticles will be discussed in the context of frontier biomedical applications.

Upcycling Coffee and Nets

Are you keen to save turtles from waste fishing nets? Have you seen massive amount of waste coffee in your local coffee shops and thought is there any use for this waste?

In this project, we will use ghost net (discarded fishing net in the oceans) and coffee waste (coffee ground) as the resources for producing new products that can be used in the built environment.

This project will enable us to look at waste differently and see how we can use the inherent properties of materials and using them as part of the process for manufacturing high-quality products. This project is a demonstration of how we can turn waste into resources if we change our perspective.

What Students will do

Using cutting-edge technology, students will characterise different waste materials, especially polymers, using this information to strategising the best way to turn their waste material to usable products. Using our laboratories, students turn these creative ideas into reality and test how well their plans worked compared to industry standards.

Creating New Metal Alloys

With the development of new technologies and changing environments, we need new materials to cope with stress, high temperatures and environmental attacks. It is the job of a materials scientist to create and develop new materials for future applications and understand how the materials get their properties.

These new materials have applications everywhere you imaginable! From spacecraft, fighter jets, buildings, scientific instruments to medical devices and biological implants.

Finding new materials is a creative process involving predictions and testing properties using a variety of sophisticated scientific instruments. There are millions of different potential compositions. Some of these are not particularly useful, while others have exceptional properties like high strength, temperature tolerance or resistance to corrosion.

What Students will do

Students will dream up and create a new metal alloy made up of many metallic elements in similar proportions. They will then learn to predict and test its properties using a variety of sophisticated computational and experimental techniques.

Quantum Computers

Quantum computing is the latest tech innovation promising to change the way we do science. When we make components of computers small enough, they start to follow the rules of quantum physics, which produces some very strange results. In the last few decades, we've realised that we can use this to our advantage. The properties of quantum mechanics can be used to solve extremely large problems, from modelling the weather or the economy, to cracking codes. The very first quantum computers are being built right now, all over the world.

What Students will do

In this project, students will get to use a real quantum computer, located in IBM's quantum computing laboratory. Using the online IBM Q Experience program, they will run a variety of quantum algorithms on both a simulator and a quantum computer and compare the results to determine the accuracy of the quantum computer.