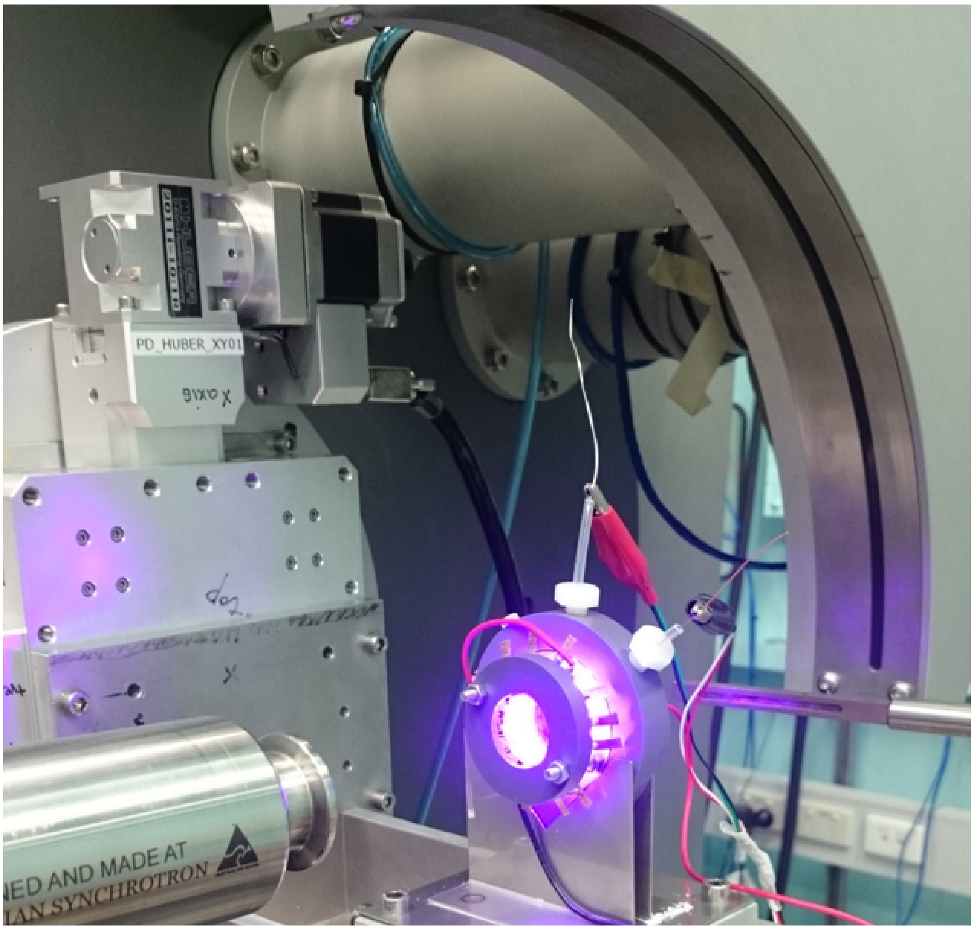
Talented Students Programme

Research Areas



Introduction

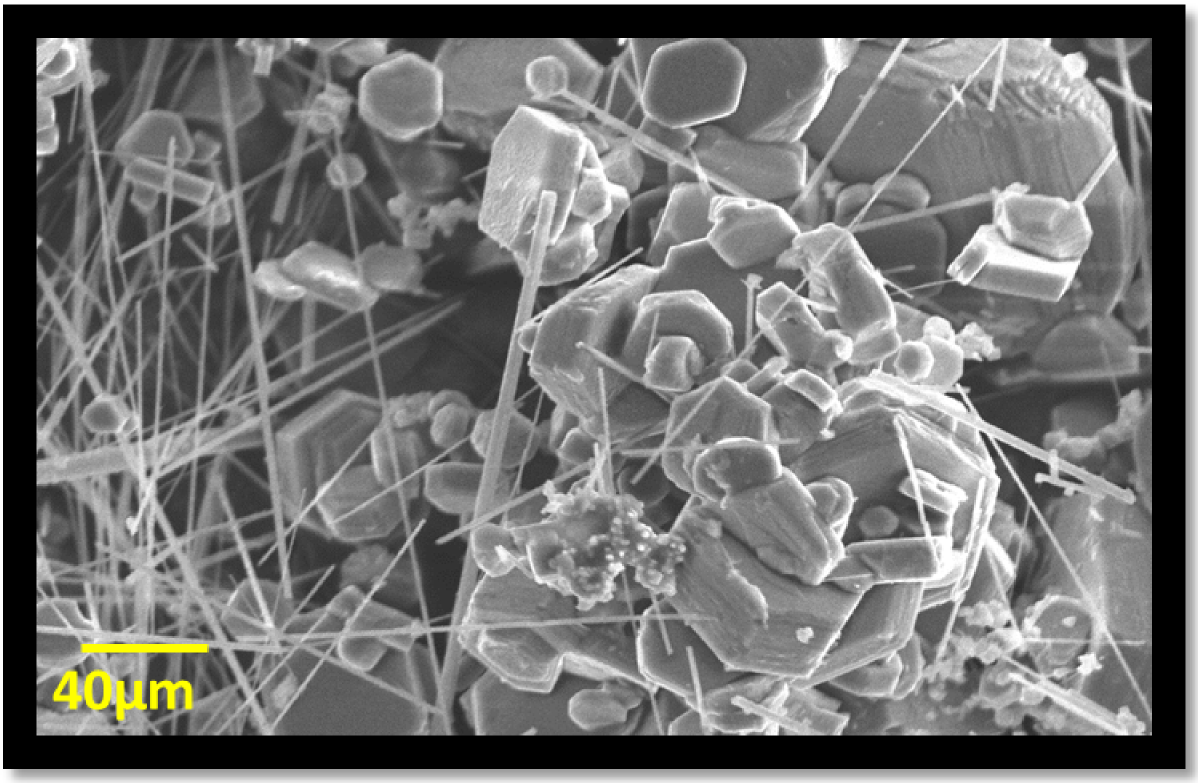
This information package contains outlines of the research interests of some of the high profile researchers from the various Schools across the Faculty of Science at the University of New South Wales along with directing you as to where you might find even more information. We also have contributions from members of staff in the School of Optometry and Vision Science and the School of Medical Sciences in the Faculty of Medicine.

You are strongly encouraged to read through the descriptions of research areas contained here and to browse the research pages of the Schools listed (most academics in the schools are interested in hosting you). Along with giving you an indication of the breadth of interests of academics at the University of New South Wales, it will allow you to consider what research groups you might want to consider being involved with through the mentoring portion of the Talented Students Programme (TSP).

Assignment of mentors is carried out at the School level by a TSP coordinator in that School. This means that initially you will be allocated to a School (after discussion with the Director) from which point your mentors will be assigned. We hope that this will ensure a high degree of interaction with the School.

We hope you have a fun and productive year.

Assoc. Prof. Neeraj Sharma
Directors, Talented Students Programme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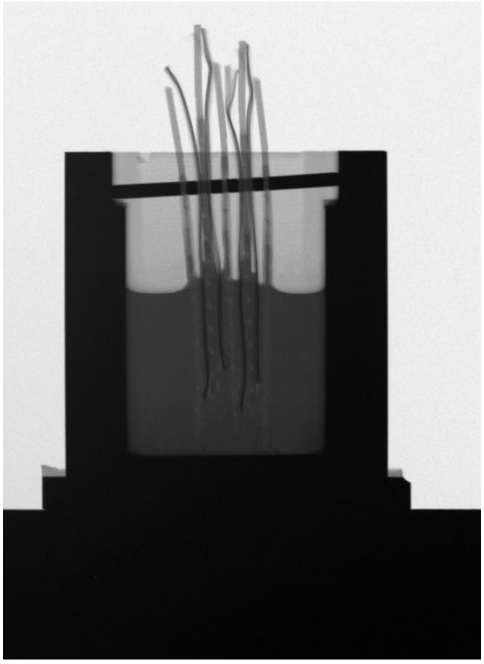

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School websites

- Biotechnology and Biomolecular Sciences (BABS): https://www.babs.unsw.edu.au/research
- Biological, Earth and Environmental Sciences (BEES): https://www.bees.unsw.edu.au/our-research
- Chemistry: https://www.chemistry.unsw.edu.au/research/research-themes
- Mathematics and Statistics: https://www.maths.unsw.edu.au/research/research
- Materials Science and Engineering: http://www.materials.unsw.edu.au/our-research
- Physics: https://www.physics.unsw.edu.au/research/research-areas-physics
- Psychology: https://www.psy.unsw.edu.au/research/areas-expertise
- Medical Science: https://medicalsciences.med.unsw.edu.au/research
- Optometry and Vision Science: https://www.optometry.unsw.edu.au/research/research-groups

My experience with the Talented Students Program

By Fahad Khan

I began studying at UNSW in 2017 and was fortunate enough to be invited to be a part of the Talented Students Program (TSP). My experience with the program in first year, I think, was slightly unorthodox because of the way I found my first research opportunity. I want to share with you my experience so that you can realise how unconfined and broad your horizons are as a member of the TSP.

For the longest time now I've been interested in dementia because of its debilitating effects which have widespread implications. I'm also extremely passionate about working to help people who are disadvantaged (particularly those who come from low SES and/or indigenous backgrounds) achieve the best they can and have the same opportunities as those from more fortunate backgrounds. Considering this, when given the TSP booklet with all the exciting research projects, I naturally scanned for a project that had some relation to dementia or disadvantaged people. I didn't find something that jumped out at me immediately. I then reminded myself that I was in UNSW and that our university does more than just the research projects outlined in the TSP booklet!

Having this in mind, I went online to the UNSW School of Medicine website to search for a project that aligned more with what I was interested in – a project on studying dementia in disadvantaged populations. I was not disappointed at all. I found a research team at Neuroscience Research Australia (NeuRA) that was studying dementia in Aboriginal Australians. Perfect! I then copied and sent the details from that research team to Neeraj who then put me in touch with Trevor Lewis in the School of Medical Science who then put me in touch with the NeuRA research team. The research team said they'd be more than happy to have me experience their work with them for some time. I felt very lucky at this moment because Trevor Lewis and Neeraj both explained to me that choosing and taking part in a research project that wasn't included in the TSP booklet was not guaranteed and that me taking part would be at the complete discretion of the researchers themselves.

I spent 3 months at NeuRA learning the most amazing things I've ever learnt in my life. These 3 months had given me many new insights and ways of thinking about the health of the population in general. In addition to this, the incidental lessons I learnt by asking questions and inquiring about the experiences of the researchers (among whom was a neurologist who had published hundreds of scientific papers and journal articles) were equally as valuable as the actual experience of the research itself. My approach to volunteering with disadvantaged people after being at NeuRA has become far more enthusiastic and my basic understanding of the indigenous population of Australia has been enhanced, given I had a very poor understanding about our indigenous population to begin with. I believe that working at NeuRA has definitely been one of the best experiences I've ever had.

In the beginning, I thought that it would be far too much to ask to have a project that would fit my interests since it seemed so very niche – I was so terribly wrong. I hope that after reading this you realise the breadth of opportunity available to you. I encourage all TSP students to take the opportunities available to them with both hands and to realise the perks that come with studying at a university that takes so much pride in its research. If there's one thing that you take away from reading this, I hope that it's the fact that you aren't limited to the awesome research projects in the TSP booklet. I wish you the best of luck and I anticipate that you will all have a wonderful time being part of the TSP.

School of Biotechnology and Biomolecular Sciences

www.babs.unsw.edu.au

School Contact:
Dr. Michael Janitz

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Prof. Marcel Dinger: Investigating the biological relevance of DNA/RNA structures

Professor Dinger's research laboratory seeks to establish new links between phenotype and genotype, particularly between rare and complex disease and underexplored regions of the genome, such as pseudogenes, repetitive elements, and those folding into non-canonical DNA structures or are transcribed into noncoding RNAs. Harnessing the potential of population scale genomic datasets, and sophisticated data science methods, the laboratory aims to bring an objective perspective to better understand how the genome stores information and how it is transacted in biology.

Prof. Andrew Brown: Balancing cholesterol/Cholesterol and cancer

An imbalance of cholesterol in certain cell types plays a role in several diseases. Therefore, knowing precisely how cells regulate their cholesterol levels is central to understanding the development of these diseases, and to identify new possible treatments. The statin class of drugs, worth >$40 billion a year, have been effective in treating heart disease but are not without their side effects. Statins inhibit a very early step in cholesterol synthesis. This research investigates the regulation of newly identified control points later in cholesterol synthesis, which have been largely overlooked.
Cells need cholesterol to grow and proliferate, while cancer is a consequence of unrestrained cell growth and proliferation. We have shown that there are fundamental links between cholesterol and cancer. In this work, we use molecular cell biological techniques to further explore this link in the setting of prostate cancer.

Dr Michael Janitz: Exploration of transcriptome in health and complex diseases

Our research focuses on studying transcriptome in the human brain and peripheral tissues using short- and long-read RNA sequencing. We are particularly interested in the role of circular RNAs (circRNAs), linear RNA splicing patterns and RNA modifications in regulation of molecular physiology of human tissues. Moreover, we aim at identifying RNA transcripts which can serve as biomarkers of early onset of human complex diseases including neurological disorders and cancer.

A/Prof. Vladimir Sytnyk: Synaptic mechanisms of memory formation

In the brain, information is transmitted, processed and memorised by neurons. To perform these functions, neurons must grow and form networks, in which individual neurons are connected to other neurons by specialised contacts called synapses. Neurons use synapses to communicate with other neurons and to process and store information. Formation of the networks and synapses is regulated by neural cell adhesion molecules. Our laboratory uses cutting-edge techniques of modern biochemistry, molecular biology, microscopy, biophysics and bioinformatics to understand the molecular and cellular mechanisms of neuronal network formation and regulation in health and disease. We also develop new technologies aimed at improving brain performance, enhancing learning and maintaining memory by analysing properties, functions and regulation of the neural cell adhesion molecules.

A/Prof. Kyle Hoehn: Obesity: The other pandemic

Obesity is associated with shortened lifespan and is a major risk factor for metabolic diseases including cardiovascular diseases, fatty liver disease, and many types of cancer. Identification of drugs that safely reverse obesity could increase healthspan, decrease disease burden, and improve quality of life on a global scale.

My lab is focused on developing new drugs that reverse obesity. Our molecules are mitochondrial uncouplers that lower metabolic efficiency so that more fat is burned to produce a given amount of ATP energy. We are seeking students to join projects that will test new mitochondrial uncouplers for bioactivity in vitro and for safety and efficacy to reverse obesity, reverse fatty liver disease, and slow ageing in mice.

A/Prof. Irina Voineagu: Understanding the molecular genetics of the human brain

My lab investigates the molecular genetic mechanisms underlying normal brain function and their perturbation in neurodevelopment disorders, e.g. Autism Spectrum Disorders and Fragile-X Syndrome. We aim to increase our understanding by comprehensively analysing the coding and noncoding genome in human brain tissue and neuronal cell culture systems with the help of advancing genomic sequencing technologies. We have several lines of research on topics such as non-coding RNA and trinucleotide repeats. For more details on our current research, visit http://www.voineagulab.unsw.edu.au/

Dr Dominic Glover: Synthetic biology

The folding and assembly of proteins into intricate supramolecular architectures is critical to many biological functions, ranging from cellular scaffolding provided by cytoskeletal proteins to the encapsulation of nucleic acids in viral capsids. Improvements in our understanding of protein assembly is enabling the creation of biomaterials that mimic and complement biological systems. The research projects in my laboratory use synthetic biology to build functional materials and devices from self-assembling proteins.

Dr Brendan Burns: Environmental microbiology and astrobiology

Our research is focused on unravelling the evolutionary and ecological significance of early Earth microbial ecosystems.

Stromatolites and microbial mats are model systems for studying the origins and evolution of life on our planet. They are geobiological structures composed of complex and diverse microbial communities. In particular, the impact of extreme stressors on microbial communities and critical pathways in threatened mat systems are being assessed and critical to ascertain before any irreversible ecosystem tipping points are reached. In particular we are pursuing the role of 'microbial dark matter' in these systems including the enigmatic group of Asgard archaea. We aim to break down the traditional distinctions between prokaryotic and eukaryotic life using the Asgardians as a 'missing link'.

Dr Matthew Baker: Evolutionary biophysics

My research group currently focuses on two streams of research:

1. The directed, molecular evolution of the bacterial flagellar motor to ascertain how the

motor arose and to learn what constrains the evolutionary pathways that govern the emergence of such complexity.

2. Bottom-up synthetic biology using DNA nanotechnology to control lipid interactions to investigate mechanosensing and build systems for intracellular communication.

Dr Jai Tree: Gene regulation in bacterial pathogens

The lab is interested in how bacteria regulate gene expression with a focus on understanding the contribution of non-coding RNAs. It is now apparent that the genomes of all organisms are transcribed into an array of regulatory non-coding RNAs (ncRNAs) and bacterial pathogens have not escaped the ncRNA revolution. Our major challenge now is to understand the functions of these RNA species and high throughput sequencing technologies and bioinformatics are providing the tools that will allow us to address these questions.

Prof. Marc Wilkins: Discovery and functional characterisation of intracellular protein networks

Almost all proteins interact with other proteins to deliver their function. These form intricate networks, including protein-protein interaction networks and signalling systems, which are critical for the regulation of the cell. Currently, we are focused on two particular projects. The first project aims to discover the regulatory network of histones. This has a strong biological focus and is seeking to address a remarkable gap in our understanding of histone-mediated effects on gene expression. This project is a wet lab project. The second project aims to address a 'grand challenge' – to measure all interactions between proteins in a cell, in a single experiment. This has a more technical focus and we have wet lab and dry lab (bioinformatics) researchers working on this project. We welcome all enthusiastic students to join the team!

School of Biological, Earth and Environmental Sciences

www.bees.unsw.edu.au

School Contact

Prof. Russell Bonduriansky
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Dr Gab Abramowitz: Climate, ecological and hydrological model evaluation - what defines a good natural system model?
For details of the research area see
http://web.science.unsw.edu.au/~gabrielabramowitz/UNSW_homepage/Gab_Abramowitz_home_page.html

Prof. Andy Baker: Groundwater, cave science, paleoclimate
My group has diverse research interests which focus on using cave stalagmites to reconstruct past climate and environmental change; the question "groundwater organic carbon: source or sink?" and computation modelling of cave and karst processes. For further details, see:
https://research.unsw.edu.au/people/professor-andy-baker

Assoc. Prof. Russell Bonduriansky: Evolutionary Biology
Evolutionary biology seeks to answer the "why" questions in biology: Why are organisms (including ourselves) the way they are? Why do they change over generations? My group investigates the evolution of genetic systems, the role of sexual selection and conflict in evolution, and the implications of environmental effects on trait expression within and across generations. For further details, see http://www.bonduriansky.net/index.htm.

Assoc. Prof. David Cohen: Soil Geochemistry - Mineral Deposits and Contamination
My group is involved in the detection of buried mineral deposits using regional to local scale mapping of soil geochemistry in various places around the globe such as - Cyprus, PNG, Australia and South America.

Assoc. Prof. Will Cornwell: Plant Ecology and Evolution
My group predominantly studies the ecology of plants across the world and how they affect the carbon cycle. For more information see http://www.willcornwell.org

Assoc. Prof. Darren Curnoe: Human and Primate Evolution and Pleistocene Archaeology
For details see http://www.evolution-anthropology.net/

Dr Suhelen Egan: Marine Microbial Ecology and Symbioses
Our research focuses on understanding host-microbe interactions in the marine environment. Projects include a) Deciphering the mechanism of microbial disease progression in marine macroalgae. b) Discovery of novel bioactive compounds from marine host-associated bacteria. C) Investigating the ecological roles of antibiotic producing bacteria. For more information see: https://research.unsw.edu.au/people/dr-suhelen-egan

Assoc. Prof. Jason Evans: Regional climate change, climate processes and modelling
How does the climate of a region, including its water cycle, work? How will a regions climate change due to global warming? or land-use changes? and what impact will these changes have on other natural and man-made systems? How can we best model these systems? What are the regional climate change implications for bushfires? or the Snowy Mountains? or urban air

quality? For more information see http://web.science.unsw.edu.au/~jasone/research.html

Dr. Dan Falster: Evolutionary biologist and ecologist
How do competitive interactions shape the ecology, population dynamics, and traits of species and communities? See http://danielfalster.com/

Prof. Emma Johnston: Marine Biological Invasions and Estuarine Health
My lab focuses on marine biology and the threats that impact their health. We have currently have projects on Estuarine Health and the processes and interactions that drive impacts on their health, to identify and develop effective management strategies to conserve biodiversity in these systems. We also have projects on the Antarctic marine communities, comparing the vulnerability of Antarctic assemblages to those of other regions and providing information on the responses of individuals, populations and communities to environmental stressors. For details of the research area see http://www.bees.unsw.edu.au/staff/emma-johnston

Dr Michael Kasumovic
We research the evolution of mating systems and how individuals maximize fitness in a variable environment. One aspect of our research focuses how changes in the intensity of male competition and female choice affect the traits that maximize fitness. You can find more information at www.michaelkasumovic.com

Dr. Laurie Menviel: Climate-Carbon cycle interactions
I combine numerical experiments and paleoproxy records to study climate-carbon cycle interactions on millennial to glacial timescales. I am particularly interested in the impact of oceanic circulation changes on the climate and the marine carbon cycle.
For details of the research area, see: http://myweb.science.unsw.edu.au/~lauriemenviel/

Dr Scott Mooney: Using the past (climate, people, fire) for contemporary environmental management
I am an environmental biologist with research primarily focused on reconstructing aspects of past environments and environmental change with a particular focus on human impacts. This includes investigating the fire (pre-)history of the humid environments of eastern Australia, primarily via the use of high resolution (macro-) charcoal analyses. In any explanation of how fire has varied through time both humans and climate must be considered (and potentially any complex inter-relationships between these factors). This means the research has obvious links with the palaeoclimate community, and with archaeology to examine changes in human systems in the prehistoric period.
For details of the research area see http://www.bees.unsw.edu.au/staff/scott-mooney

Assoc. Prof. Alistair Poore: Marine ecology and evolution
My research is focussed on the ecology and evolution of marine organisms with a focus on the impacts of herbivores on plant communities, the effects of disturbance on coastal ecosystems, and adaptation to environmental stresses. For more information, see:
http://www.eerc.com.au/alistair_poore/home.html

Dr. Lisa Schwanz: Understanding how animals deal with environmental variation
My group focuses on the impact of the environment on animal behaviour, reproduction, physiology and offspring traits to understand the evolutionary explanations behind plastic

traits and the ecological consequences in a changing world. For more details, see lisaschwanz.weebly.com

Associate Professor Wendy Shaw.
My lab studies human and interface Geographies; with projects on Human and Animal interactions (with Taronga Conservation Society), as well as on various People-based surveys and ethnographic research based in Papua New Guinea. For more see: http://www.bees.unsw.edu.au/wendy-shaw

Prof. Bill Sherwin: Molecular Ecology and Conservation Biology
We investigate appropriate ways of monitoring and managing genetic biodiversity. Our study species include dolphins, penguins, trees, plus harvested species such as prawns, and pests such as Queensland Fruit Flies and Macadamia Lacebugs. Our methods range through field studies, genomics and other molecular analyses, demographic and genetic modelling. The latter includes using information theory to better track genetic information, in collaboration with mathematicians and physicists. We also investigate the genetic determinants of social behaviour in wild populations, with a current focus on dolphins.

Prof. Steve Sherwood: Applying physics of the atmosphere to clouds and climate.
Research areas see http://www.ccrc.unsw.edu.au/staff/profiles/sherwood/research.html

Dr Paul Spence: Understanding geophysical fluid dynamics and the Ocean's role in past and future climate change
My research aims to improve our understanding of geophysical fluid dynamics with a particular focus on the Ocean's role in past and future climate change. I spend a lot of time developing high resolution ocean climate models to address questions such as:
i) What roles do mesoscale ocean processes play in the Atlantic and Southern Ocean overturning circulations?
ii) How will the ocean circulation respond to projected anthropogenic buoyancy and wind stress forcing?
iii) What role did changes in the ocean circulation play in past climate events such as the Permian-Triassic and Eocence-Oligocence mass extinctions?
For details of the research area see http://web.science.unsw.edu.au/~paulspence/

Prof. Iain Suthers: Marine ecosystems and oceanography
We examine marine ecosystems – from phytoplankton to fisheries – in estuaries and in the East Australian Current (www.FAMER.unsw.edu.au). Particular opportunities include the Sydney Institute of Marine Science (www.sims.org.au), the Integrated Marine Observing System (www.imos.org.au), and especially our recent and future voyages on Australia's brand new, 94 m long, Research Vessel Investigator. Many recent deployments of designed, offshore artificial reefs are in fact experiments relating biological oceanography with recreational fisheries, on an increasingly urbanised coast.

Assoc Prof. Torsten Thomas: Marine Holobionts
It is now increasingly recognised that eukaryotes ranging from humans to plants to invertebrates are not individual organisms, but are in fact complex communities comprised of the eukaryotic host and their associated microbial communities – that is, they are holobionts. We combine ecological and molecular approaches to gain insight into both positive (e.g. healthy development of the host) and negative aspects (e.g. disease) of holobionts in a range

of marine systems. For further information see: http://www.cmb.unsw.edu.au/

Dr John Triantafilis: Digital Soil Mapping

My research interests producing biophysical data using a web-based geographic information system that allows cotton growers, farm managers, consultants, extension staff, researchers, state and federal government agency personnel and policy analysts access to digital biophysical data. This aims to provide information critical to the agricultural industry with recent projects focused on the salinity threat posed to the cotton industry via irrigation.
For details of the research area see http://www.terragis.bees.unsw.edu.au/

Prof. Martin van Kranendonk

I am involved in research on the early history of the Earth, how the crust of the Earth formed and how life flourished in evolving habitats. I am also engaged in tracking the rise of atmospheric oxygen on Earth around 2.5 billion years ago and how the biosphere responded to these changes. As co-director of the Australian Centre of Astrobiology, I oversee research on the evolution of life and the search for life on other planets. As chair of the Precambrian Subcommission of the International Commission of Stratigraphy, I am responsible for re-calibrating the geological time scale over 4 billion years of Earth.

Dr Adriana Vergés: Marine ecology in tropical-temperate transition zones

My research focuses on marine ecology and conservation. I'm particularly interested in the ecological impacts of climate change and the conservation of the world's algal forests and seagrass meadows, which are increasingly under threat. I have worked in tropical coral reefs and temperate ecosystems from around the world (Mediterranean Sea, Atlantic, Indian and Pacific oceans) with much of my research being experimental and taking place underwater.
For details of the research area see http://www.bees.unsw.edu.au/staff/adriana-verges

School of Chemistry

www.chemistry.unsw.edu.au

School Contact
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Assoc. Prof. Jon Beves: Supramolecular chemistry and molecular devices

Our research is focused on using weak, intermolecular interactions to direct the controlled assembly of group of molecules - just as Nature uses to control all the chemistry of life. By careful design transition metal ions are combined with organic ligands to synthesize large (= nanometre!) ordered structures via spontaneous self-assembly. These novel structures are capable of functions ranging from molecular sensing and catalysis, to performing molecular level work and acting as molecular machines.

Assoc. Prof. Alex Donald: Novel methodologies in mass spectrometry

Mass spectrometry is a core enabling technology that is used in many emerging and existing scientific fields for characterizing the components of complex mixtures, including the contents of cells. We are developing and applying experimental methods in mass spectrometry with an emphasis on problems in catalysis, biology, and other areas. Current focus is directed towards performing significant portions of the mass spectrometry experiment in the open laboratory in order to develop energy efficient methodologies for desalinating seawater, separating solvents, and accelerating chemical reactions. We are looking for students who are interested in developing a valuable mass spectrometry skill set.

Dr Albert Fahrenbach: Origin of Life Chemistry

The origin of life on Earth is an open challenge involving collaborations among many scientific disciplines wherein chemistry plays a central role. Our group is interested in understanding how the ancient chemistry taking place on early Earth eventually gave rise to biology. To do this, our group focuses on generating complex reaction networks that can generate important biomolecules like peptides and nucleotides. We are also interested in understanding how these types of molecules could have replicated themselves in the absence of advanced enzyme catalysts. For more details about our research, see fahrenbachresearch.com

Prof. Justin Gooding: Nanomedicine

Our research falls under the category of nanotechnology and specifically nanomedicine. Nanomedicine is believed to be the next frontier in medicine where nanoparticles are used as either diagnostic devices or vehicles for delivering drugs directly where need. We work on both these aspects of nanomedicine. As members of the Australian Centre for NanoMedicine, which is based at UNSW, we collaborate with researchers in both medicine and engineering as well as science. In particular we focus on how to give the nanoparticles the functionality that is required via using very well defined surface chemistry and we study the fates of these particles in biological fluids and in cells. In essence we are seeking to answer the big question, how do we design nanoparticles that go where we want in a biological system, when we want and give us the information we want?

For details of the research area see http://www.chem.unsw.edu.au/staffprofiles/gooding.html

Assoc. Prof. Jason Harper: Mechanistic and Physical Organic Chemistry

Our research falls broadly into the category of physical organic chemistry. However, the areas covered also include biological, bioorganic, synthetic, analytical and environmental chemistry and this demonstrates the range of areas that physical organic chemistry is applicable to. The breadth of topics also illustrates the interdisciplinary nature of the research and the significant scope for collaboration with groups in the more traditional areas of organic chemistry and biochemistry. We particularly focus on understanding organic processes in ionic liquids, determining reaction mechanisms and developing novel ways to follow reaction progress.
For more details see area see http://www.chem.unsw.edu.au/staffprofiles/harper.html

Assoc. Prof. Luke Hunter: Fluorine in Organic Chemistry

Fluorine is a small element that packs a big punch. When fluorine atoms are incorporated into organic molecules, they can have a dramatic impact on the substances' physical and chemical properties. In the Hunter group, we are particularly interested in using fluorine atoms to control molecular conformation (a kind of "molecular origami"). We produce novel bioactive molecules that are constrained into optimal 3D shapes, controlled by the precise positioning of fluorine atoms. These shape-controlled molecules are designed to have applications in the treatment of cancer, malaria, and disorders of the central nervous system.

Prof Scott Kable: Laser Chemistry and Spectroscopy

In my group we use lasers to initiate chemical reactions and laser-based spectroscopic methods to probe what happens. In broad terms, we discover new molecules this way, and undercover new pathways that molecules use to evolve from reactant to product. Topics that we are currently investigating include: i) identifying new pathways that lead to acid formation in the atmosphere; ii) discovering new radicals that play a role in combustion of fuels; iii) discovering new chemical mechanisms that violate existing theories of the chemical transition state. New projects are starting all the time. See my web page for a description of projects and some recent publications.

Dr Dong Jun (DJ) Kim: Advanced Energy Storage

Climate changes, depletion of fossil fuels, and global warming have encouraged scientific society to consider utilising energy from sustainable resources, including wind power and solar energy. Despite the fact that sustainable energy sources are highly abundant, the supply of sustainable resources fluctuates all the time. Recent advances in lithium-ion battery technology have enabled a power source ranging from portable electronic devices to electric vehicles. In the future, developing energy storage applications for renewable resources will become increasingly important.
Our research approach combines synthetic chemistry, electrochemistry, and materials science principles to develop advanced energy storage devices, in particular, rechargeable batteries. During the Talented Student Program (TSP), the student will participate in designing novel redox-active molecules and learn characterising electrochemical performance for the battery application. For more information–*kimdongjun.net*

Prof. Naresh Kumar: Design and synthesis of Novel Antimicrobial Agents

Bacterial infections are a growing problem in today's society. With the emergence of multi-drug resistance in common human pathogens, there is clearly an urgent need to develop novel classes of antimicrobials for the prevention and treatment of bacterial infection. It is now well established that bacteria communicate with each other via small diffusible signalling molecules and coordinate their activities such as biofilm formation, swarming and expression of virulence factors in a coordinated manner. Our research focuses on designing and synthesising novel antimicrobial agents that target the bacterial communication system. As well as developing strategies to deliver or generate coatings based on these novel molecules.

Dr. Martina Lessio: Computational Investigation of Interfaces and Molecules for Sustainability Applications

Our group uses computational chemistry tools to investigate a variety of phenomena, molecules, and interfaces that are relevant to sustainability applications. In particular, we are interested in catalysis, water remediation, and material conservation. Example of active projects in the group are: 1) Developing new ligands for toxic contaminants removal from water for solid substrates such as metal-organic frameworks; 2) Studying existing and new transition metal catalysts for converting CO_2 into useful products; 4) Developing new catalysts for plastic conversion to useful products; 3) Study of relevant material/solution interfaces for artwork and heritage conservation. Check out our group website for more information! https://sites.google.com/view/martina-lessio/home

Prof. Jonathan Morris: Organic and Medicinal Chemistry

Prof. Morris's research interests are focused on the development of natural products as biomedical agents. Natural products deliver novel leads for pharmaceuticals in a diverse array of therapeutic areas and offer an excellent starting point for medicinal chemistry programs. One of the bottlenecks in the development of natural products is the availability of the compound. A/Prof Morris's research programme is focused on developing strategies to prepare these valuable materials and generate analogs that have improved potency and selectivity. The group collaborates with medical research groups in the Lowy Cancer Centre, as well as ones based overseas.

Dr Nicole J Rijs: Molecular Structure and Function

In the Rijs Research Group, we envisage a world where building a brand new catalyst or an artificial enzyme is as simple as following an architectural plan for a house. At the moment this is difficult because we don't even fully understand the construction materials! Our research investigates the intrinsic properties of molecular building-blocks and their "constructed" aggregates, moving us towards the ability to draw up these molecular blueprints from scratch. We utilize a range of cutting edge technologies in our chemical analyses, including high resolution ion-mobility, advanced mass spectrometry, computational chemistry, combinatorial robotics and synthetic methods. We are interested in structure-function relationships, mechanism, theory underpinning chemical reactions and catalysis, chemical data crunching, and methodological development (for mass spectrometry and ion-mobility). https://www.chemistry.unsw.edu.au/staff/nicole-rijs

Assoc. Prof. Neeraj Sharma: Solid State Chemistry and Energy Materials

Our research looks at how we can make better devices for the energy sector by understanding and manipulating the atomic-scale arrangements (crystal structure) of the materials within these devices. For example, lithium-ion batteries are found in high-power portable electronic devices, but they struggle to provide more than a few hours of stored power for applications such as laptops and mobile phones. Furthermore, these batteries do not provide economically viable energy storage for emerging applications such as electric vehicles. Our research investigates materials that can overcome the storage limitations in these batteries, and develops new battery chemistries that can outclass lithium-ion technology.

Prof. Martina Stenzel: Polymer chemistry and nanomedicine

The delivery of drugs can be improved by packaging the drug into nanoparticles. Nanoparticles for drug delivery have typically sizes below 100 nm and can be prepared using various materials including polymers. In our group, we synthesize various polymers to create core-shell nanoparticles – the core holds the drug, mainly anti-cancer drugs, while the shell makes the particles soluble and determines the interaction with cells. We use a range of materials starting from synthetic polymers, which we combine with nature's building block such as polysaccharides, sugars, peptides and proteins to create hydrid particles. These particles are then loaded with various anti-cancer drugs. Our projects range from the delivery of metal-based drugs such as cisplatin to peptide drugs or DNA.

Prof. Pall Thordarson: Functional molecular machines and smart gels

Our work is concerned with using the latest advances in chemistry to create smart materials and devices for tomorrow's challenges. This includes creating novel light-driven molecular machines and materials for clean energy production and the use of self-assembly to create smart gels for applications in medicine including drug delivery and tissue engineering. Both topics are underpinned by our desire to understand how molecules interact with each other in complex chemical systems. For details of the research area see http://www.chem.unsw.edu.au/research/groups/thordarson/ .

Dr Scott A. Sulway: Synthetic Inorganic Chemistry - Lanthanide Coordination Complexes

Lanthanides are a commonly overlooked area of coordination chemistry – people often say "*But we know everything there is to know and how they react*"... This isn't so, lanthanide complexes are incredibly interesting and have a range of potential applications. Lanthanides have uses in catalytic cycles, luminescent devices & interesting magnetic properties that could be utilised in data storage devices or qubits in quantum computing. This is where the research in the Sulway group comes in, we are exploring the synthesis and characterisation of new lanthanide containing coordination compounds that could be used in the technology of the future.

Prof. Chuan Zhao: Clean Energy and Bionics

Clean, renewable energy has enormous implications for the future prosperity of humankind. As creatures, living better and longer has been our instinctive pursuit, and advanced biomedical technology is therefore always highly demanded. Electron transfer is one of the most fundamental processes in the energy and life systems. Research in our lab addresses problems in clean energy and the life sciences by using electrochemical technology, nanotechnology and biotechnology. Our research areas include solar water splitting, batteries, bionics, biosensors and drug delivery. For more details see http://www.chem.unsw.edu.au/research/groups/zhao/ .

Dr Laura McKemmish: Theoretical and Computational Modelling of Molecules

I am in the Chemistry department but do not perform research in a lab. Instead, my work is all done on a computer or in my head!

I consider myself to be a quantum chemist and molecular physicist. My expertise is in theoretical and computational modelling of molecules, particularly their spectroscopy. I love interdisciplinary work and combining interesting methods with interesting applications. My research groups focusing on performing new and innovative method development linked with interesting applications in a variety of different fields, with fundamental chemistry and physics a particular interest. One characteristic of my scientific research is to look at new ways of investigating and solving particular problems that are inspired by a unusual perspective, such as from the lens of a different field.

I use a wide variety of computational and data science tools and methodologies from chemistry, physics and beyond to learn about molecules, for example, their high temperature rovibronic spectroscopy and sensitivity to changes in the proton mass.

The systems I study have relevance in astrophysics, experimental ultracold molecular physics and in finding new theories of ultracold and study molecules found in hot Jupiters, cool stars, ultracold physics experiments and in discovering the fundamental laws of the universe.

For details of a range of projects see https://sites.google.com/view/laurakmckemmish/home

Dr Junming Ho: Computational Chemistry and Biomolecular Simulations

We develop and apply methods of computational chemistry to elucidate the mechanisms underlying many catalytic processes in synthesis and in biochemical systems. This enables us to design more effective catalysts or reactions that our experimental colleagues can test or implement in practical applications. Topics of particular interest include, but are not limited to homogeneous and heterogeneous catalysis, medicinal applications of supramolecular chemistry, and fundamental physical organic chemistry. We work closely with experimental groups, so there would also be opportunities for students to gain experience in both computational and experimental research. For details of research topics, see http://www.chemistry.unsw.edu.au/ho-group

Dr Anna Wang: Soft matter and biophysics

How did life start on Earth? We work at the intersection of physics, chemistry, materials science, to answer questions on how molecules *self-assemble* into more complex structures like cells. This research falls under the bigger umbrella of studying *soft matter* – as opposed to hard materials such as metal or ceramics. We use techniques such as microscopy and holography to watch things as they happen.

For more details, see our website http://www.annawanglab.com/

School of Materials Science and Engineering

www.materials.unsw.edu.au

School Contact
Dr Rakesh Joshi
E-mail: r.joshi@unsw.edu.au

Prof. Veena Sahajwalla: Innovative Recycling of Waste Materials as Resources

The Sahajwalla group is interested in new methods and procedures that will result in cleaner processes used in the resource and mineral industry. As the director of the SMART centre (www.smart.unsw.edu.au) Prof. Sahajwalla leads a dedicated team of scientists and students committed towards a greener and cleaner future. Particular emphasis is placed on industry partnerships. Achieving sustainability targets set by industry has created a need for commercially relevant and globally significant R&D. The SMaRT Centre works with industry partners to develop the fundamental and applied science underlying sustainable materials and technologies.

Assoc. Prof. Nagarajan Valanoor: Physics of nanostructured functional oxides

In my group we investigate the relationship between nanoscale form and function of oxide materials with very small dimensions. Effects ranging from piezoelectricity to photochemical effects to quantum confinement are of interest. We make these materials using a host of ultra-high and high-vacuum epitaxy techniques and study them using advanced probes such as Scanning Probe Microscopy, Transmission Electron Microscopy and in-situ phase mapping. Students are trained on platforms similar to those used in industries engaged in functional materials and electronics. Our work is published in a number of high-level journals such as Nature Materials, ACS Nano, Nano Letters etc.

Dr. Rakesh Joshi: Applications of Graphene

My group is involved in a variety of industry funded research projects on the applications of graphene; including Graphene oxide membranes, graphene based ionic /molecular sponges, hydrogen generation, water purification, gas separation, graphene supercapacitors and chemical vapor deposition (CVD) growth of graphene and 2D materials.

Dr. Kevin J Laws: Advanced Alloys & Metal Physics

My research team is involved in a vast range of industry and government funded research projects in the fields of advanced alloys, including but not limited to high-entropy and compositionally complex alloys, bulk metallic glasses and amorphous alloys. In the physical metallurgy laboratory at UNSW, we develop and manufacture our own research samples in-house. Along with the fundamental science behind designing, new alloys, you will receive hands-on experience in alloy charge preparation, melting and casting using our suite of electric arc & induction melting facilities, making and processing your own samples. You will be trained to use advanced characterisation and processing techniques such as superplastic forming (SPF), thermomechanical processing (TMP), differential scanning calorimetry (DSC), x-ray diffraction (XRD), scanning electron microscopy (SEM), tensile, compression and hardness testing.

Prof. Tom Wu: Hybrid Organic-Inorganic Materials

Our group focuses on exploring the synthesis and properties of novel materials, particularly hybrid halide perovskites, in the form of thin films, single crystals, nanomaterials and mixed-dimensional nanocomposites. We target at diverse electronic and energy applications including field effect transistors, non-volatile memories, solar cells and photodetectors.

Prof. Dewei Chu: Nanoionic Materials and Devices.

Our research interest is develop novel nanoionic materials for energy storage and conversion, as well as information storage and processing applications. For example, by engineering cation defects in nanoionic materials, artificial synapses which mimics short term and long term memories of human brains can be realized. We are also developing innovative printing technologies, such as ink-jet printing, slot-die printing of nanoionic thin film devices.

A/Prof. Jianqiang Zhang: High Temperature Materials

My group is working on high temperature materials performance in corrosive atmospheres for high temperature applications, e.g. power generation and chemical and petrochemical industries. The research is focused on reaction product characterisation based on microscopic analyses, e.g. x-ray diffraction, scanning electron microscopy, focused ion beam and transmission electron microscopy. The understanding of corrosion mechanism will lead to the development of new high temperature alloys.

Prof. Jan Seidel: Advanced Scanning Probe Microscopy of Functional Materials

We develop new concepts for investigating material properties at the nanoscale using scanning probe microscopy, these include piezoresponse force microscopy, conducting-AFM, scanning tunnelling microscopy and spectroscopy, Kelvin probe force microscopy, magnetic force microscopy and many more in various environments from UHV to ambient conditions, at low and high temperatures, under magnetic and electric fields, light illumination and controllable gas and humidity environments. We are interested in magnetic, multiferroic and ferroelectric materials, solar energy conversion using halide perovskites, non-volatile information storage, ferroelectric memories, resistance-switching memories and oxide semiconductors.

A/Prof. John Daniels: Electro-mechanical materials

In my group we investigate electro-mechanical materials. These are materials that directly transform mechanical and electrical energies. They are used widely in acoustic imaging systems such as ultrasound and sonar, as well as precision positioning applications utilised in a range of different industries. Our goal is to constantly improve the response and stability of these systems. We use novel synchrotron x-ray and neutron characterisation methods at both national and international facilities to provide the critical atomic structural details that reveal the functionality.

School of Medical Sciences, Faculty of Medicine


School Contacts

Assoc. Prof. Kate Poole & Dr. Vaishnavi Ananthanarayanan
E-mail: k.poole@unsw.edu.au, vaish@unsw.edu.au

SoMS projects for the Talented Students Program

Research is at the heart of the mission of the School of Medical Sciences and we are proud of our long history of excellence across a broad range of biomedical research disciplines. As a central element of the biomedical research precinct at UNSW, our School features a diverse array of research teams who utilise cutting edge experimental approaches to study human health and disease. These studies incorporate research into the underlying causes, physiological functions, pharmacological interventions and the development of innovative treatments and novel methods for the early detection of particular disease states. The research teams within the school also have a strong commitment to assisting the next generation of biomedical researchers to gain expertise through higher degree studies and are supported in their work by an integrated team of research support staff. Many of our researchers are recognised internationally as leaders in their field of research, and we have strong links with colleagues within UNSW, as well as leading research groups both nationally and internationally.

Learn more at: http://medicalsciences.med.unsw.edu.au

Dr Vaishnavi Ananthanarayanan

Intracellular organisation in health and disease

In our group, we study the processes of cellular transport and organisation - or how organelles get to and remain where they are needed in the cell- in the context of health as well as diseases such as neurodegeneration and cancer. Our main research themes are uncovering 1) how receptors at the cell surface are transported into and within the cell to control the signals required for the cell to survive and thrive, which are often misregulated in cancer development; and 2) how mitochondria, the energy generators of the cell, are maintained by attachment to microtubules, which is important in neuron survival in diseases such as Alzheimer's and Parkinson's. We use cutting edge light and electron microscopy to visualise cells at the highest possible resolution so we can precisely see how the transport and positioning of receptors and mitochondria contribute to cellular function and ultimately our health. If any of these processes or techniques appeal to you, we would love to hear from you!

Dr Scott Berry

Every cell type in the human body expresses a different set of genes. And every individual cell expresses those genes to different levels – depending on its size, shape and microenvironment. We are interested in the mechanisms used by cells to regulate gene-specific and global RNA abundance – ranging from epigenetic memory and cellular decision-making to global RNA metabolism in the context of cellular physiology. We use approaches from high-throughput microscopy to mathematical modelling and data science to generate a quantitative understanding of gene regulation in human cells.

A/Prof Maté Biro

Cancer immunotherapy is a revolutionising therapeutic approach that takes advantage of the behaviour of specialised immune cells to recognise and eliminate tumour cells. Its key players are killer T cells, a highly motile and target-specific sub-population of the adaptive immune system that has the ability to hunt down and kill cancer cells. Whilst cancer immunotherapy has proven successful in blood cancers, to date its efficacy against solid tumours remains limited. The *Cell motility and Mechanobiology* group use a multidisciplinary approach that combines immunology, biophysics, microscopy and cancer biology to harness and optimise the body's own T cells to enhance the infiltration and eradication of solid tumours.

A/Prof Ingvars Birznieks

Sensory neuroscience

Our senses define our existence and determine how we perceive the world in which we live. I have always been fascinated by the function of sensory organs and astonished by the versatility of clever solutions we see in nature around us. There are many things to discover – not just to increase our understanding of how the brain works, but to help people who have lost part of their sensory function due to illness or trauma. We can also borrow ideas from nature and use them to develop future technologies like robotic hands and hand prostheses which can feel.
Related links:
https://medicalsciences.med.unsw.edu.au/people/dr-ingvars-birznieks
https://www.youtube.com/watch?v=eZCIdbo67-s
https://www.neura.edu.au/staff/dr-ingvars-birznieks/

Dr Omid Faridani

Single-cell technology lab

We have two major lines of research:
Single-cell technology: We are interested in single-cell gene expression analysis to characterise the diversity of human cell types. The human body consists of more than 200 cell types that reside in complex tissue structures. Studying the gene expression of a tissue, as a whole, will give averaged information derived from various cells residing in that tissue. However, studying the same tissue in a single-cell resolution (cell by cell) will give more precise information of tissue's behaviour and function in health and disease. We are developing a number of technologies to study individual cells' gene expression (transcriptomics).

Precision oncology: We aim to give the right drug to the right cancer patient. Cancer is a complex disease with diverse genetic properties. The same cancer type (pancreatic cancer, for example) in two patients can have different characteristics and can respond to a drug differently. Therefore, it is necessary to understand each patient's tumour and prescribe a drug that works on their specific tumour. To this end, we are developing a unique tumour culture system to investigate the drug sensitivity for each tumour. Also, we are developing a microfluidic device to isolate circulating tumour cells from patients' blood. These tumour cells can reveal information from tumours in a minimally invasive way. Both technologies are designed to interrogate patients' tumour materials at cellular and molecular levels to find the weak point and select the most efficient drug.

Dr David Jacques & A/Prof Till Böcking

Structural Virology & Molecular Machines

Viruses are exquisite invaders of cells. By subverting or hijacking cellular processes, they can be considered nanocontainers capable of a level of molecular control over cells far more sophisticated than any human-made technology. The study of viruses not only informs disease treatment but also helps understand the cells they infect. In our labs, we are interested in the molecular interactions between viruses and cells. Using HIV as our model virus, we have projects focused on (i) how the virus uses molecular motors to move through the cell; (ii) how the virus engages host proteins to shield itself from recognition by the host; and (iii) how the virus can penetrate the nuclear pore complex to gain access to the nucleus and the host's DNA. We use cutting-edge fluorescence microscopy to monitor these processes in real-time, and combine these dynamic measurements with the molecular structures we can obtain from X-ray crystallography and cryo-electron microscopy.

Dr Nicole Jones

Neuropharmacology and brain injury

My main research interest is to try and find new drugs to treat acute brain injuries (such as a stroke or birth trauma). We try firstly to understand what happens to brain cells in response to injury and then used various approaches to try and minimise brain injury. Drugs with protective potential are routinely investigated in cell lines, brain tissue cultures and in vivo rat injury models as part of a search for new therapeutic strategies for acute brain injuries. Because lack of oxygen (tissue hypoxia) often occurs after a brain insult, we are interested in learning how hypoxia-inducible proteins (hypoxia-inducible factor-1 (HIF-1), erythropoietin, vascular endothelial growth factor, glucose transporters) are involved in injury and repair processes of the brain.

A/Prof Fabio Luciani

Immunogenomics and Single Cell Technologies for Human Diseases

Our group investigate immune responses against pathogens infection and also how modern immunotherapies harness the basic mechanisms of our immune system to develop new therapies for the treatment of cancer. Our group focuses on immune-genomics and single-cell technologies. We have developed a "Systems biology" approach where we perform experimental and computational research utilising cutting edge methods such as single-cell transcriptomics and machine learning. In our lab, we have Honours, PhD and Postdocs, and our philosophy is to learn together in an interdisciplinary and happy environment.

A/Prof Kate Poole

Cellular sensing of physical stimuli

My research team investigates how physical forces can influence human health and disease. The sensing of and discrimination between different physical inputs is critical in the function of many cells and tissues in multicellular organisms; an acute response to mechanical stimuli underpins our senses of touch and hearing, integrated sensing of changing mechanical loads is fundamental for maintaining cartilage and the vasculature, and in the development of some cancers, tumour cells can probe the mechanical properties of their surroundings by applying forces at cell-matrix contact points. We are working to identify the force sensing molecules that enable cells to sense these inputs, and investigating how they influence cancer cell migration and invasion. We are also studying how cells respond to microgravity, where the gravitational vector has been disrupted. We seek to identify how cells are influenced by microgravity and which force-sensing molecules are involved in adaptations to changes in gravity, in humans.

Dr Emma Sierecki and A/Prof Yann Gambin

Single-molecule diagnostic of cardiac amyloidosis

Cardiac amyloidosis, or "stiff heart syndrome", is caused by the unfolding and aggregation of a protein, either transthyretin (TTR, causing ATTR) or immunoglobulin light chain amyloid (causing AL). TTR is a small protein found in plasma and unfolding of the protein induces aggregation/amyloid formation, with the resulting aggregates depositing on the cardiac muscle leading to heart failure. To date, there is no simple test for cardiac amyloidosis, and the disease remains underdiagnosed causing delays in treatment.

The goal of this project is to create a blood test that can rapidly detect amyloidosis and differentiate between ATTR and AL.

The detection of amyloids in patients' samples is possible as amyloids have the ability to multiply in specific assay conditions. The very recent development of such *in vitro* seeding amplification assays has provided a long-awaited breakthrough in our ability to detect other amyloid-linked diseases, such as Alzheimer's or Parkinson's disease, at the molecular level and at an early stage.

Our laboratory recently established *a single-molecule assay for the diagnostic of Parkinson's disease*. We showed that single-molecule counting, using our custom-developed 3D-printed microscope, can detect aggregates in cerebrospinal fluid of patients with Parkinson's disease, with exceptional sensitivity and ease of use.

The current project will build on the tools and experience acquired in the Parkinson's disease field, and introduce students to protein science, microscopy, assay development and data analysis.

A/Prof Nicola J Smith & Dr Angela Finch

Drug discovery at orphan G protein-coupled receptors

G protein-coupled receptors (GPCRs) are the most successfully 'drugged' proteins in the human body and include receptors for adrenaline, serotonin, dopamine and angiotensin. Our work in the Molecular Pharmacology of Drug Design laboratory is focused on understanding a group within the broader GPCR family called orphan receptors – these are GPCRs where we are yet to work out the identity of their natural hormone or transmitter. Instead, we must be guided by their associations with human disease, gene knockout animal models and expression in specific tissues in the body. In our lab we use a variety of cell-based techniques to try to unlock the pharmacology of these orphan receptors and attempt to discover both new drugs for the receptors and also their native ligands.

A/Prof Shane Thomas and Prof Kerry Anne Rye

The **Cardiometabolic Disease Research Group** is co-led by Prof. Kerry-Anne Rye and A/Prof. Shane Thomas and based in the School of Medical Sciences on the 4th floor of the Wallace Wurth Building. The research group currently consists of 4 post-doctoral scientists, 3 PhD students and 4 honours students. The group has two main research themes:

Heart disease:
We are developing new anti-inflammatory therapies that prevent the development of atherosclerotic lesions, which can rupture and stop blood from getting to the heart, causing a heart attack. We are also asking whether these anti-inflammatory therapies can heal the tissue damage that is caused by a heart attack.

In particular, we are complexing a new class of nanoparticles with clinically viable peptides and small molecule drugs to suppress inflammation in the heart and blood vessels. We envisage that these new nanotherapeutics will reduce the risk of having a heart attack and improve recovery after a heart attack. The research involves biochemistry, molecular biology, pharmacology, vascular biology, and pre-clinical models of cardiovascular disease.

Type 1 diabetes:
Type 1 diabetes is an autoimmune disease in which insulin-producing cells in the pancreas are destroyed by activated T-cells and glucose can no longer be removed from blood. There is no cure for this disease, with the only treatment being regulation of blood glucose levels by multiple insulin injections every day. However, these injections can reduce blood glucose levels to an extent that is potentially lethal.

We have identified a peptide with the capacity to generate new insulin-producing cells in the pancreas and stop T-cell activation and expansion, thus decreasing, and possibly removing, the dependence of patients with type 1 diabetes on insulin injections. Further development of this project towards clinical translation will involve multiple skill sets including molecular biology, pharmacology, development of oral delivery peptides, and the use of pre-clinical models of type 1 diabetes.

A/Prof Richard Vickery
Our experience of the world around us depends on our sensory receptors that translate signals from our environment into the language of the brain. My group is focused on decoding this language, called the neural code. We do this using human behavioural experiments and real-time electrophysiological recording combined with carefully controlled stimulation. Most of our work is in the sense of touch which has the benefit that most of the receptors are reasonably easily accessible. We use this knowledge to inform the design of prosthetic hands that can convey feeling to their users, as well as to look for early diagnostic tests for conditions such as peripheral neuropathy that can arise from diabetes.

School of Physics

www.physics.unsw.edu.au

School Contact

Assoc. Prof. Sarah Martell
E-mail: s.martell@unsw.edu.au

Prof Michael Ashley

I'm an astronomer working with instrumentation and computing in fields such as astronomy from Antarctica and wide-field infrared surveys of the sky. My recent work has involved understanding some newly discovered issues with Hawaii 2RG infrared detectors, similar to the ones used in the James Webb Space Telescope. My group is currently designing the support electronics for a new infrared camera for a telescope to be situated in Antarctica in collaboration with China. I am also working on a project to design a wind turbine for the unusual conditions on the Antarctic plateau, to provide power for future astronomical telescopes.

A/Prof. Julian Berengut

The study of the superheavy elements (nuclear charge $Z > 100$) is an important multidisciplinary area of research involving nuclear physics, atomic physics, and chemistry. Calculations of the atomic spectra are needed for planning and interpreting measurements; these involve understanding the role of quantum electrodynamic and many-body effects. Our group has developed high precision computer codes for atomic calculations. A student should use these codes to perform calculations of atomic properties to help guide experimental efforts.
A strong interest in theoretical physics and numerical calculations is essential for this project.

Prof Sarah Brough

I observe the stars that make up the most massive galaxies in our Universe. Galaxies grow over time so these massive galaxies are the apotheosis of all galaxy development. I use some of the world's best telescopes to find out when their stars formed and how they move within the galaxies to understand in detail how those galaxies formed and change over time.
Webpage: https://www.physics.unsw.edu.au/staff/sarah-brough

Prof Susan Coppersmith

My research group studies problems in theoretical condensed matter physics, with a major focus on understanding the physics to enable the construction and effective use of quantum computers.

Prof Victor Flambaum

We are looking for methods to detect Dark matter and Dark energy in the laboratory and for manifestations of them in astrophysical phenomena such as Big Bang nucleosynthesis and neutron stars (pulsars). Another direction of our research is testing the Grand Unification Theories by searching for effects of violation of the fundamental symmetries in atomic phenomena which are predicted by these theories. We also develop methods and computer codes for high precision atomic calculations.

Dr Caroline Foster

My team studies the transformation of galaxies across cosmic time. The appearance and internal motions of stars in galaxies have undergone substantial changes in the past ~9 billion years. Using 3D spectroscopy data from the MAGPI survey and simulations data, we research and aim to identify the main physical drivers of this transformation by targeting the Universe's Middle-Ages (i.e. the cosmic epoch ~4 billion years ago).

Prof Alex Hamilton

My group works in experimental condensed matter physics. We have two main activities: (i) advanced semiconductor nanostructure devices that use holes instead of electrons for quantum electronics and quantum computing (ii) new materials that are only 1 atom thick for ultra-low power electronics (made using sticky tape!).

Dr Joris Keizer

The Precision Qubit Processor Program led by Professor Michelle Y. Simmons has the ultimate goal of developing a scalable, phosphorus in silicon, quantum processor. Professor Simmons's group leads the field internationally in making precision atomic electronic devices in silicon for both conventional and quantum computing. Using a combination of scanning tunneling microscopy and molecular beam epitaxy phosphorus dopant atoms are controllably placed in Si devices with atomic precision. This has led to the development of the narrowest conducting wires in silicon, the development of the smallest precision transistors, the first two qubit gate between atom qubits in silicon and more complex architectures towards error correction. The Program is currently developing all the functional elements for an error corrected scalable spin-based quantum computer, including techniques for multiplexed parallel qubit addressability, 3D atomic precision patterning, fast gate-based read-out, and both error detection and correction. For more information please visit:
https://www.cqc2t.org/precision-qubit-processors-program/

Christine Lindstrom

I am a Lecturer in the School of Physics at UNSW Sydney, where I am the head of research in the Physics Education Research for Evidence Centred Teaching (PERfECT@UNSW) group. I am passionate about using student active teaching methods in my physics courses, and my research focuses on student understanding of astronomical scale, and improving physics teaching in higher education in a variety of ways. If you are interested in a project in Physics Education Research, please contact me (c.lindstrom@unsw.edu.au) to discuss ideas.
www.perfect.physics.unsw.edu.au

A/Prof Sarah Martell

My research group studies the structure and history of the Milky Way using data from large survey projects that observe hundreds of thousands of stars. We use data science techniques to find the oldest and most unusual stars, then study their chemical compositions and orbits to understand what role they play in the Galaxy.

Prof Dane McCamey

We measure the influence of spin on the optoelectronic property of molecules, materials and devices. Our experimental capabilities range from fabrication of organic electronic devices through to electrical and optical characterisation via electron spin resonance. We also spend time developing new spin resonance techniques. Our research has applications ranging from enhancing the efficiency of solar energy generation through to quantum sensing and information storage.

Prof Adam Micolich

I work on bioelectronics, which is a field devoted to interfacing electronic devices to biological systems. I am particularly interested in using nanoscale devices to work at the single protein limit towards the detection of mobile molecular motors in biocomputation devices and study of energy-converting rotary molecular motors such as ATP synthase at the single molecule level.

Dr Ben Montet

My research group studies the formation and evolution of nearby planetary systems. Using both ground- and space-based telescopes, we aim to understand how different stellar environments shape the formation and evolution of planetary systems. To accomplish this, our team leads the development of new data-driven methods to better find and characterise the small planetary signals in transit and radial velocity planet search data.
Online resources:
My website, My student's website, A lecture on how we find planets and what we will learn from future surveys (2017 Sagan Summer Workshop)

Prof. Richard Morris

The human body contains circa. 40 trillion cells, all working concert to sustain the miracle that is life. But can the behaviour of living systems--- such as cells, tissues & organs--- be understood with the same mathematical precision as, say, a fluid? I work alongside experimental biologists with precisely this question in mind. In particular, my work focuses on understanding living systems at a variety of spatio-temporal scales, from molecular-scale signaling, to cellular-scale force generation and locomotion, to shape and form in developing embryos and beyond.

A/Prof Rajib Rahman

I am a computational physicist who develops advanced simulation techniques to understand quantum materials and devices. My objective is to develop future electronics and computing technologies utilizing novel quantum phenomena in condensed matter. Design and optimization of silicon quantum computer hardware is one of my active areas of research.
Webpages: https://research.unsw.edu.au/people/associate-professor-rajib-rahman
https://sites.google.com/view/rajib-rahman/home

Dr Peter Reece

My research group is focused on the development of new concepts in optics and photonics, particularly in emerging areas of nano-scale photonics and novel hybrid optical materials, and their application to the disciplines of medicine and engineering. I offer a range of experimental projects including laser trapping of single nanoscale objects, photonic crystal biosensors, and ultrafast spectroscopy of semiconductor materials.

Prof Sven Rogge

In my group we carry out experimental research to understand the physics of how a qubit interacts with its environment to understand coupling mechanisms, decoherence pathways, and control with the aim to implement universal quantum computation and quantum simulation in silicon.

Dr Michael Schmidt

The Standard Model of particle physics describes nature with unprecedented precision. However, there is evidence for physics beyond the Standard Model: neutrino masses, dark matter, and the matter-antimatter asymmetry of the universe. My group investigates physics beyond the Standard Model including neutrino physics, the three-fold replication of matter, dark matter, and more recently cosmological phase transitions.
Webpage: https://www.unsw.edu.au/staff/michael-schmidt

Prof Michelle Simmons

We are building a prototype quantum computer processor using atom-based qubits in silicon. In my group we model, design, fabricate and test multi-qubit devices with a goal to demonstrate near term quantum algorithms taking a device from concept all the way through to realisation. Several projects are on offer from the fundamentals of qubit design and operation along with high frequency qubit control and testing at cryogenic temperatures. Projects will be hosted in the Centre of Excellence for Quantum Computation and Communication Technology headquartered at UNSW working alongside a start-up, Silicon Quantum Computing.
Webpages: https://www.cqc2t.org/precision-qubit-processors-program/
https://sqc.com.au/

Dr Oleg Tretiakov

I am a theoretical condensed-matter physicist working in the areas of nanomagnetism and spintronics. In particular, I focus on topics such as dynamics of skyrmions and other topological spin textures in ferro/antiferromagnets, spintronics with topological insulators, quantum phenomena in low-dimensional spin-orbit systems. The majority of my work either builds on observations made in recent experiments or predicts new phenomena that should be observable in the near future.
Webpage: https://sites.google.com/site/tretiakov/

A/Prof Kim-Vy Tran

My research group studies how galaxies form and evolve over cosmic time by combining observations from the most powerful space and ground-based telescopes. My team connects observations of galaxies in the distant universe to understand how galaxies like our own Milky Way formed.
Webpage: www.kimvytran.org

A/Prof Yvonne Wong

I am a theoretical physicist working at the interface of particle physics and cosmology. My research centres around investigating the cosmological consequences of fundamental physics theories beyond the standard model of particle physics.

School of Psychology

www.psy.unsw.edu.au

School Contact

Assoc. Prof. Joel Pearson
E-mail: jpearson@unsw.edu.au

Dr Lenny Vartanian: Body dissatisfaction, weight stigma and eating behavior

My work generally focuses on the psychology of eating and weight, and particular areas of interest include body dissatisfaction, dieting and eating behaviours, and obesity stigma.

Body image concerns are increasingly prevalent among women and men. One of the key predictors of body dissatisfaction is the extent to which individuals internalise societal standards of attractiveness (thinness for women, and muscularity for men). I am interested in identifying factors that predict who is likely to internalise the societal standards of attractiveness, as well as determining whether those factors can be modified as a means of reducing or preventing body dissatisfaction.

Negative attitudes towards obese people are widespread, and obese people experience discrimination in virtually every aspect of their lives. Weight-based discrimination is associated with a range of negative consequences for the stigmatised individuals. Research in this domain will focus both on developing a better understanding of what underlies people's negative attitudes towards obese individuals, and on examining the impact that weight-based discrimination has on obese individuals.

Unhealthy eating is a key public health issue, particularly because it can contribute to poor nutrition and weight gain. Although people's food intake is in part driven by how hungry they are and by how much they like the food they are eating, there are other powerful influences on the amount of food that people eat. These include social factors (*e.g.*, what other people are eating) and environmental factors (*e.g.*, how much food is available), which might influence people's food intake without their awareness. Research in this area will examine to what extent people are aware of the social and environmental influences on their food intake, and whether they can be made aware of these influences as a means of helping them improve their eating habits.

Prof Colin Clifford: Vision

The primary research focus of my laboratory is vision, how context affects our perception, and how our visual awareness might be related to the underlying neural processing. Potential projects include:

1) Gaze Perception: To an observer, the direction of your gaze reveals where you are looking and hence what you are looking at. This might be an object of shared attention or it might be the observer him or herself. The direction of your gaze is thus a strong social signal to your intentions and future actions. This project aims to understand the processes in our brains that enable us to know where someone else is looking. **Suggested reading**: Mareschal, I., Calder, A.J. & Clifford, C.W.G. (2013). Humans have an expectation that gaze is directed towards them. *Current Biology* **23**, 717-721.

2) Visual Feature Binding: The seeing part of the brain, visual cortex, can be subdivided into many regions. Breaking down vision like this leads to a problem. If different attributes of the visual scene are dealt with in different parts of visual cortex, how is it that we experience the world as coherently as we do? The question of how distributed neural processing gives rise to a unified perceptual representation of the world is often termed The Binding Problem. This project will explore the limits of perceptual binding in human vision. **Suggested reading:** Clifford, C.W.G. (2010). Dynamics of visual feature binding. In *Space & Time in Perception & Action*, R. Nijhawan & B. Khurana (eds.), Cambridge University Press, pp.199-215.

3) The Role of Spatial and Temporal Context in Perception: Vision is a dynamic process with adaptation as a fundamental property. Our visual systems are continually recalibrating themselves to the prevailing visual environment. Considering visual processing as an adaptive system in this way emphasizes that coding depends on context, and thus an understanding of contextual modulation is central to an understanding of visual coding. How any given region of an image is perceived depends strongly on the spatial and temporal context in which that region is presented. Spatial context is the structure of the surrounding image, while temporal context is represented implicitly in the adapted state of the observer's visual system. This project aims to use contextual manipulations to understand the coding of information in the human visual system.**Suggested reading:** Clifford, C.W.G. & Rhodes, G. (eds.) (2005). Fitting the Mind to the World: Adaptation and Aftereffects in High-Level Vision. Oxford: Oxford University Press.

A/Prof Tom Denson: social-personality

1) Why do men and boys LOVE violent video games so much? We have proposed the 'dominance-practice hypothesis' which is that males are attracted to violent video games because they allow players to practice displays of dominance and aggression. We are interested in examining preferences for violent video game play in response to two classic primate competitive situations: mating competition and physical strength competitions between males.

2) Angry rumination in groups as a determinant of intergroup aggression.

3) Reducing aggression by practicing self-control and cognitive training.

A list of all of my papers can be found at: http://www.psychexperiment.net/denson/pubs. Many were co-authored by former students.

Dr Chris Donkin: human cognition

See www2.psy.unsw.edu.au/Users/CDonkin.

1) Memory: The ability to store and retrieve information using memory is one of our most remarkable qualities. Some general questions worth pursuing might be: Is the capacity of short-term memory constrained to be a fixed number of whole items, or do we distribute a mnemonic resource amongst items? How does the potential for rehearsal influence access to short-term memory? Do verbal and visual short-term memory systems differ in fundamental ways?

2) Decision: People behave differently depending on whether you ask them to respond quickly or respond accurately. The most common explanation is that people simply collect more evidence before responding when asked to be more careful. An alternative idea I would like to explore is whether people simply guess more often when asked to go fast.

3) A Crisis of Confidence in Psychology: The reliability of a number of important results in psychology has recently been called into question. The problem arises because of a number of "dodgy" but common research practices. For example, no distinction is made between exploratory or confirmatory experiments (i.e., whether the researcher has outlined hypotheses, predictions, and analysis techniques before doing an experiment), evidence for a null hypothesis is impossible to accrue using standard statistics, and while conceptual replications are common, true replication is not.

Prof Brett Hayes: "high level" cognitive processes

1) How many types of reasoning are there? Psychological theories of human reasoning generally distinguish between deductive and inductive reasoning. Roughly speaking, deduction involves determining whether an inference necessarily follows from a given set of information (e.g., if we know that "All university students have high IQs" then it necessarily follows that "Psychology students have high IQs"). Induction on the other hand, involves assessing the plausibility of an inference (e.g., if we know that "Psychology students have high IQs" then it might seem plausible but by no means certain that other university students have this property). Recently, some researchers have challenged the "dual-process" account of reasoning, suggesting that both induction and deduction can be explained by a common set of psychological processes. This project examines single-process and dual-process models of reasoning using innovative techniques for comparing induction and deduction. There is also scope for projects examining the development of each form of reasoning. **Suggested Reading**: Heit, E., & Rotello, C. (2010). Relations between inductive reasoning and deductive reasoning, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*, 805-812.

2) The role of causal knowledge in intuitive probability judgments: People are often faced with situations that require intuitive judgments of probability (e.g., how far can I trust this person? how likely is it that my headaches are a sign of a serious illness?). This project examines how we can improve the accuracy of people's intuitive probability judgments by providing them with information about the causal mechanisms that that give rise to observed probabilities (e.g., different causal mechanisms that could lead to headaches). **Suggested Reading**: Krynski, T., & Tenenbaum, J. (2007). The role of causality in judgment under uncertainty. *Journal of Experimental Psychology: General, 136, 430-450.*

3) "As if thinking" in reasoning and judgment This project examines how people reason and make decisions about situations involving category uncertainty. For example, a doctor may see a patient with symptoms that are consistent with more than one diagnosis. In such situations optimal reasoning and decision-making involves taking into account all of the uncertain alternatives (other possible but less likely diagnoses). A wealth of evidence however, shows that when people make predictions about an uncertain situation they usually focus on just one likely alternative (e.g., the most likely diagnosis) and ignore other alternatives that are relevant to their prediction. This is a phenomenon we have termed "as if thinking". This project will involve designing experiments that specify the conditions under which people engage in as-if thinking and how this reasoning bias might be overcome. **Suggested reading**: Hayes, B. K. & Newell, B. R. (2009). Induction with uncertain categories: When do people consider the category alternatives? *Memory and Cognition, 37*, 730-743.

Prof Simon Killcross

1) Mechanisms of habit learning: Previous research indicates that, with continued training, lever pressing in rats makes a transition from being goal-directed (that is, influenced by the contingency between the instrumental response and reward, and the value of that outcome) to being habitual (whereby the response appears to be independent of current contingency and reward value). Disruptions of this transition process are thought to be, in part, contributors to drug addiction, and disorders of cognitive control such obsessive compulsive disorder and Tourette's syndrome. The proposed project will examine the psychological and neurochemical processes that dictate this transition. Nelson A & Killcross AS (2006) Amphetamine exposure enhances habit formation. Journal of Neuroscience, 26, 3805-3812.

2) Control of behavioural flexibility by the prefrontal cortex: A number of lines of evidence suggest that different subregions of the medial prefrontal cortex (mPFC) in the rat subserve distinct but complementary cognitive functions that attempt to achieve a trade-off between the control of behaviour by prior experience and the need to adapt to novel situations in a changing world. More formally, we have suggested that the prelimbic region of the mPFC acts to bring both simple cue-outcome associations and more complex behavioural patterns under the modulatory influence of contextual or other task relevant information; by contrast, the infralimbic mPFC exerts an inhibitory influence over the prelimbic region, biasing animals towards simple, prepotent or innate behavioural patterns. This project will examine tests of this hypothesis using a variety of behavioural procedures designed to assess the role of modulatory information in governing task performance. Rhodes SEV and Killcross AS (2007) Lesions of rat infralimbic cortex enhance renewal of extinguished appetitive Pavlovian responding. *European Journal of Neuroscience*, 25(8), 2498-2503.

3) The role of behavioural chains in goal-directed action: When animals produce an instrumental response for food, they do not produce a discrete action that leads to the immediate ingestion of food, but rather initiate a sequence of closely linked behaviours that ultimately result in the delivery of food. At a minimum, this chain might be leverpress -> magazine entry -> consumption. A variety of theorists have suggested that the nature of behavioural control that is present at different points in this chain varies as a function of, for example, proximity to final reward. This project will examine the development of such chains over the course of training and will attempt to establish the role of behavioural chains in performance and sensitivity to outcome value. Balleine, Bernard W.; Garner, Claire; Gonzalez, Felisa; Dickinson, Anthony (1995) Motivational control of heterogeneous instrumental chains. *Journal of Experimental Psychology: Animal Behavior Processes*, 21(3), 203-217.

Prof Gavan McNally: Behavioural and brain mechanisms for learning and motivation

1) Defining and manipulating the brain circuits for relapse and extinction of drug seeking

Relapse to drug-taking is the fundamental problem facing any treatment of drug addiction. 70-80% of drug-users seeking treatment will relapse to drug taking within 12 months of treatment. This project studies the neural and behavioural mechanisms for relapse to drug taking using animal models of cocaine addiction, methamphetamine addiction, and alcoholism. It also studies the brain mechanisms for extinction of drug seeking and attempts to use this knowledge to identify new ways of treating human drug users. **Suggested reading:** Millan, E.Z., Marchant, N.J., & McNally G.P. (2011). .Extinction of drug seeking. *Behavioural Brain Research*, **217**, 454-462. Conklin, C.A., & Tiffany, S.T. (2002). Applying extinction research and theory to cue-exposure addiction treatments. *Addiction*, 97, 155-67.

2) Defining and manipulating the brain circuits for prediction error in Pavlovian conditioning: Pavlovian fear conditioning has served as a useful model for studying the brain mechanisms of learning. Contemporary neural models characterise Pavlovian conditioning as detecting CS-US contiguity. By contrast, contemporary psychological models characterise Pavlovian conditioning, at least in part, as the learning of predictive relations. In other words, neuroscientists have largely failed to incorporate a role for the learning of predictive relations in their analyses of the brain mechanisms for fear conditioning. This project studies the brain mechanisms for predictive learning in Pavlovian fear conditioning, using optogenetic and pharmcogenomic control over defined cell populations in specific neural circuits. **Suggested reading**: *McNally, G.P., Johansen, J., & Blair, H.T. (2011).* Placing prediction into the fear circuit. *Trends in Neurosciences, 34, 283 - 292.*

3) Erasing drug memories: One of the more startling claims from contemporary research into the brain mechanisms for memory is that individual specific memories can be targeted and erased via simple behavioural manipulations. This project studies this process in an animal model of drug addiction. Drug associated cures exert a powerful control over craving and relapse to drug seeking. The project studies whether the memories of these cues can be erased and hence no longer drive drug seeking. **Suggested reading**: Xue, Y.X. et al. (2011). A memory retrieval-extinction procedure to prevent drug craving and relapse. *Science*, *336*, 241-245.

A/Prof Dr Joel Pearson: New methods to map the human brain

1) The neural dynamics and treatment of visual hallucinations: Using novel techniques to figure out what causes visual hallucinations and how to control them eg. Developing new treatments. Utilising controllable visual hallucinations to study consciousness in the normal population.

2) Fighting mental disorders with Mental Imagery: Many mental disorders are associated with uncontrollable mental imagery. We are working with new cutting-edge methods to measure the sensory strength of mental imagery and developing new methods to control its strength and vividness. We aim to reduce the strength of mental images as a symptom, but when imagery is used in treatments such as in cognitive behavioural therapy it is advantageous to have stronger and more vivid mental imagery.

3) Mapping the Human brain: Work on exciting cross-disciplinary projects focusing on innovative new ways to map the human brain using combinations of different neural imaging and modeling approaches. These cross-disciplinary projects will be loosely between the fields of neuroscience and mathematics/engineering/computer science or physics. Ranging from fundamental mechanistic work to applied clinical applications. For these projects students need to have a basis in Engineering, Physics, Maths, and Computer Science or a related field, and fluency in at least one computer programming language.

4) Decision-making: The study of decision-making spans such varied fields as neuroscience, psychology, economics, statistics, political science, and computer science. Despite this diversity of applications, most decisions share common elements including deliberation and commitment to an outcome. The lab is currently investigating how information outside of conscious awareness can change the decisions you make.

5) Does Intuition actually exist? (The scientific study of intuition): To answer this question, we utilise conservative, objective and reliable neuroscience techniques (i.e. noisy visual decisions) to study and even ask the question does intuition actually exist. We have ongoing projects using **novel empirical paradigms, physiological measures and computational decision models to show that unconscious emotional information can boost accuracy in concurrent emotion-free decision tasks**. Emotional signals, that subjects are never aware of, can be utilized to boost performance in simultaneous, non-emotional decisions. **These data and techniques show for the first time that 'intuition' does indeed exist, different unconscious emotions can boost concurrent non-emotional behaviour – a process of intuition**.

Dr Jenny Richmond: Developmental Psychology

1) I like that one better: Advertisers use evaluative conditioning to shift our preferences for products. For example, Nespresso manufacturers know that by pairing their product with George Clooney, some of the positive feelings toward the actor will rub off on the product and we will like the product better than if they paired it with an unattractive/unliked actor. Recent work in our lab has shown that much like adults, infants' preferences for initially neutral objects can also be shifted by pairing them with either positively-valenced or negatively-valenced stimuli. In this study we used an evaluative conditioning paradigm, pairing one object with happy facial expressions and another object with angry facial expressions and recording where babies were looking during conditioning using an eye tracker. When infants were given the choice between the two objects, most chose the object that had been paired with the happy face. This behavioural preference depended on the pattern of looking behaviour exhibited during conditioning. Infants who did not show a "face preference" during learning did not pick the positively-valenced stimulus at test. We are currently following up on this study to see whether this evaluative conditioning effect generalises to other affective stimuli (i.e. mums face vs. stranger face) and testing whether the face preference is a causal mechanism in this kind of learning.

2) Back to the future: Episodic memory allows us recollect past events, however, we can also draw on experience to imagine how future events might play out (Schacter & Addis, 2007). Recent work in our lab has focussed on exploring how the ability to imagine future events develops during childhood. We have recently shown that the ability to talk about future events is related to relational memory abilities (Richmond & Pan, 2013) and that the ability to make behavioural choices for the future is related to executive function. But do narrative and behavioural tasks tap the same kind of future thinking abilities? Is the ability to talk about future events related to the ability to make choices for the future? Our current work is testing this question in 3- to 5-year olds.

3) I know how you feel: Young infants very quickly become experts in processing faces; with relatively little experience they learn to discriminate between faces of different people and different emotional states. With experience, children learn to read how other people are feeling and understand others emotional states. These processes are impaired in autism spectrum disorders (ASD) and cause major issues in social functioning. Work in our lab uses EMG technology to measure the tiny changes in facial muscles that are produced when we see others express emotion. Current projects are looking at how these low-level affective reactions are related to empathy development and the kinds of social responsiveness abilities that are impaired in ASD during the preschool period.

For more details about the research areas of other staff in the School of Psychology please see the descriptions of the School's research expertise at
http://www.psy.unsw.edu.au/research