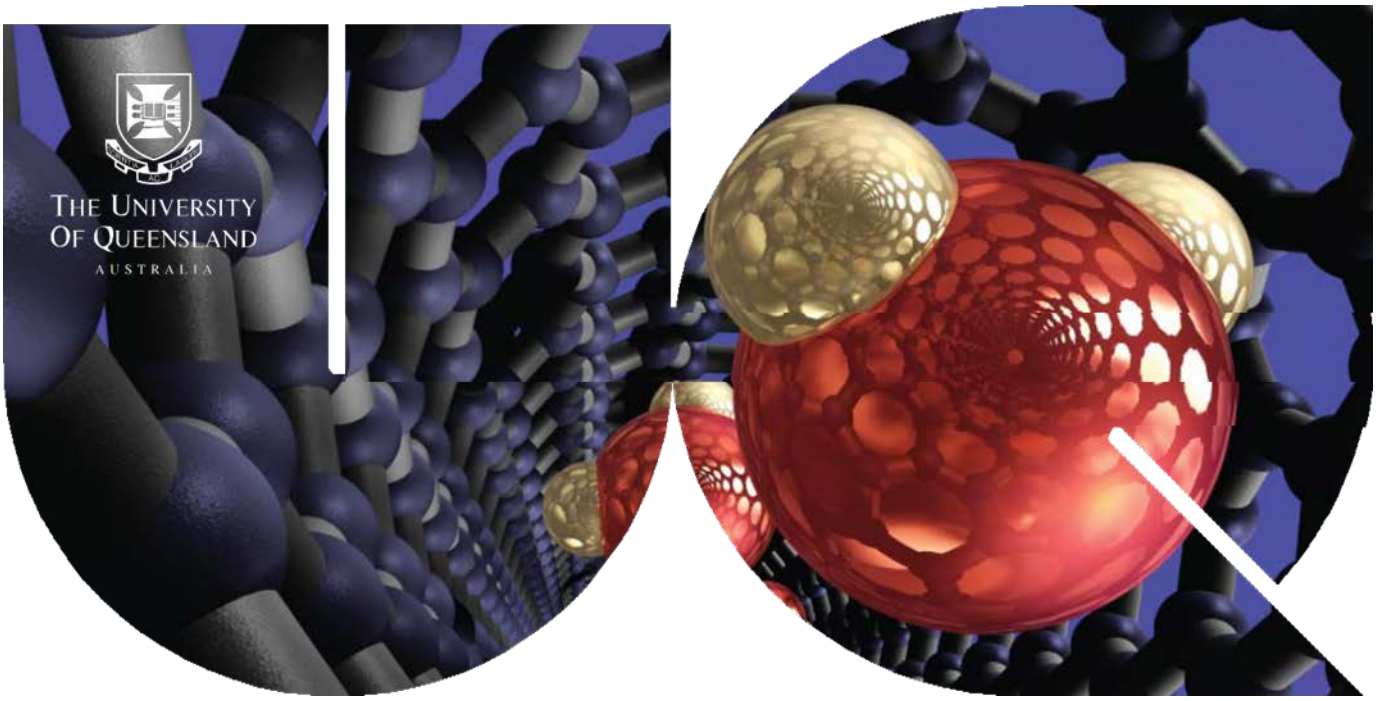

School of Chemistry & Molecular Biosciences

Faculty of Science

INTRODUCTION TO RESEARCH, HONOURS & MASTERS

Research Projects 2019

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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AFFILIATED INSTITUTIONS

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Advanced Water Management Centre - AWMC

Australian Institute for Bioengineering and Nanotechnology - AIBN

Centre for Advanced Imaging - CAI

Institute for Molecular Bioscience - IMB

Queensland Brain Institute - QBI

University of Queensland Centre for Clinical Research - UQCCR

University of Queensland Diamantina Institute - UQDI

Queensland Alliance for Agriculture and Food Innovation - QAAFI

EXTERNAL INSTITUTIONS

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Commonwealth Scientific and Industrial Research Organisation - CSIRO

QIMR Berghofer Medical Research Institute - QIMR

PROFESSOR PAUL YOUNG

HEAD OF SCHOOL

It is my great pleasure to provide a brief introduction to the School of Chemistry & Molecular Biosciences 2019 Research Projects Book. Within these pages you will find highlights of the many excellent research opportunities available to students wishing to undertake research projects within our School.

SCMB is a research-intensive School covering a diverse range of disciplines. The School is particularly known for its unique cross-disciplinary expertise in the chemical and molecular life sciences. The School is recognised nationally and internationally for its research quality and output including publications and patents, for its commercialisation of discoveries and for our successes in attracting research fellowships, grants, prizes and awards.

Becoming part of this dynamic research environment will be a highlight of your student experience.

Many of the group leaders you see in this book will be familiar to you; maybe you have met them when they have been lecturing or coordinating a course, or running a practical or PBL. These pages provide a window into the science that drives them, research that they won't normally talk about in their lectures. Most importantly, these are cutting-edge research programs that you can become a part of, either through the Introduction to Research course, an Honours year, or a Postgraduate Coursework degree.

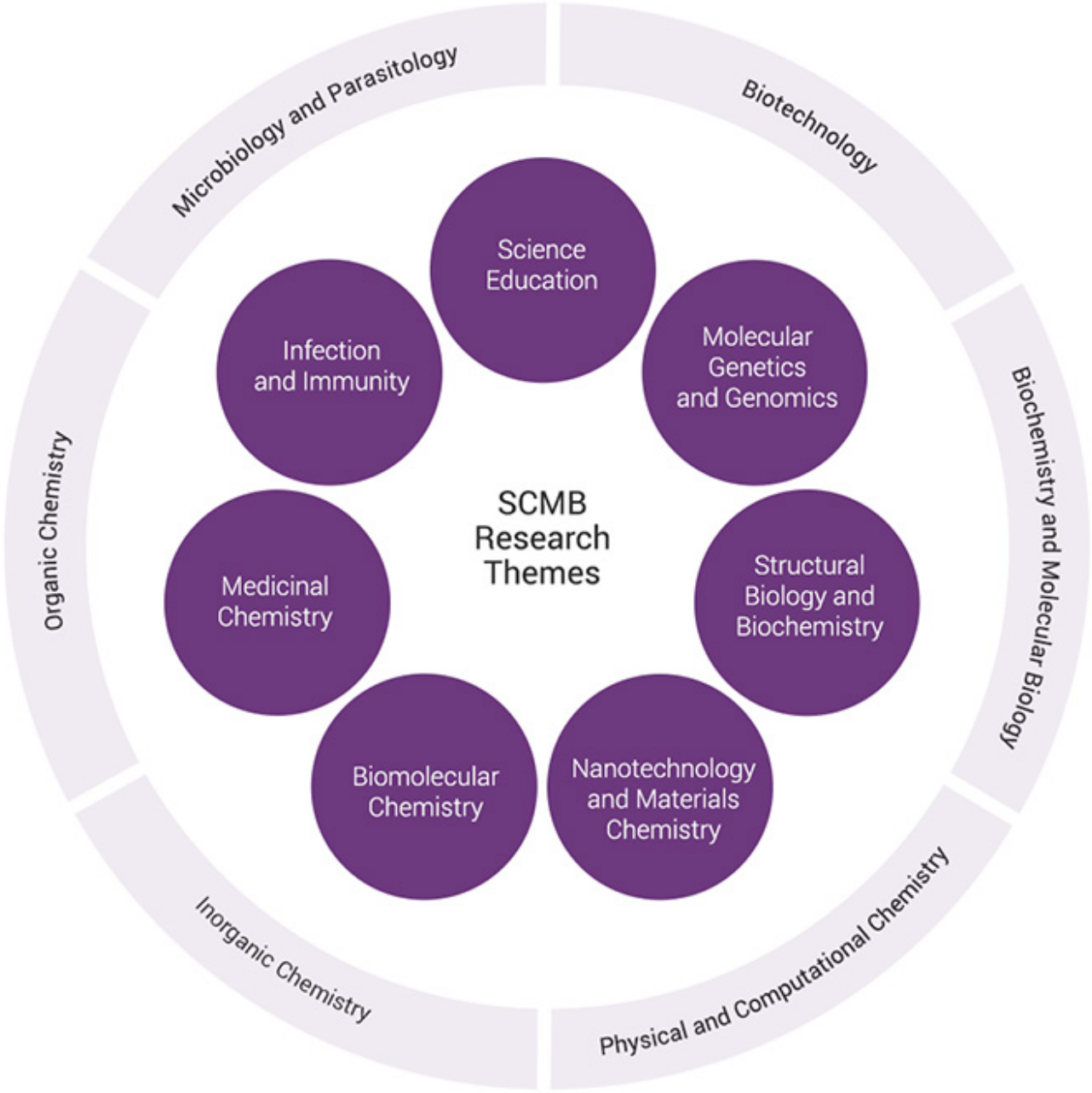
We believe a substantive research experience is a key part of an excellent science education. The lessons and experiences that come from undertaking a research project with one of our research groups include fostering creativity, learning how to balance individual and collaborative team work and developing problem-solving as well as critical thinking and communication skills. All of these skills will be invaluable to you regardless of your subsequent career path. If you are thinking of a research career, then undertaking a true research experience is your chance to take the next step and begin the transition from a student who is learning about science into being a scientist yourself.

We encourage you to review the exciting research opportunities available to you in SCMB and to talk to as many current students and staff as you can.

We do hope to see you as one of our research students in the future!

SCMB RESEARCH THEMES

The School of Chemistry & Molecular Biosciences is a diverse and powerful research grouping with unique expertise in the chemical and molecular life sciences. Research income exceeds $14 million per year and the School is recognised internationally for its research quality and output and for commercialisation of discoveries.



SCMB has seven identifiable research themes (inner circles) within a number of recognised discipline areas.

SCIENCE EDUCATION

Science Educators work to build new educational experiences. We also examine how well these new experiences work for students and academics; after all, “new” also needs to mean “better”.

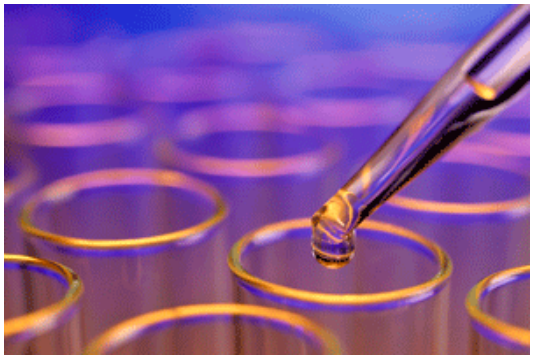
Our research projects use a combination of quantitative and qualitative methods to examine the development, implementation, stakeholder experience, and outcomes of educational activities. Our research students work directly with educators, employers, and other students at UQ and further afield; they conduct surveys and interviews, examine student outputs, and analyse feedback from multiple sources. In some cases they work directly on new and creative teaching media such as online learning tools, video productions, student magazines, radio programs, and podcasts.

As a science educator you have the opportunity to be part of the creative process and make a real difference for students!

Theme members:

Gwen Lawrie	Students' awareness of their own conceptual models in chemistry and their motivation to apply formative feedback in their learning
Justin Ridge	Research skills - how can students learn key research skills and how can we assess this. Teaching core biochemical, microbiological and molecular biology knowledge to students of the health professions
Susan Rowland **(Theme Leader)**	My group focuses in the development of professionalism in undergraduate students through authentic practice learning activities
Philip Sharpe	Laboratory-based learning in Chemistry – what are the barriers to student success in the laboratory and how do we provide situations that allow students to maximize their learning. Mathematical foundations for Chemistry study
Jack Wang	Integration and evaluation of undergraduate research experiences, and assessment/feedback practices in large undergraduate microbiology courses

BIOMOLECULAR CHEMISTRY



Research in the Biomolecular Chemistry theme includes the structure, reactions and synthesis of biologically important small molecules and chemical investigations of proteins and enzymes.

Members of the theme are brought together by their common approach to understanding the structures and mechanisms of biologically relevant organic and inorganic molecules at a molecular level which informs their role in nature and their potential applications.

Theme members:

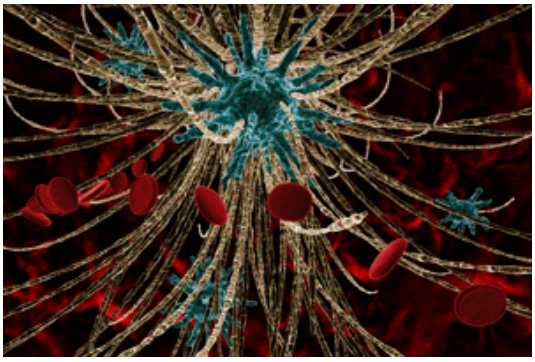
Paul Bernhardt	Inorganic Chemistry - Coordination chemistry
James De Voss	Biological and synthetic chemistry
Mary Garson	Organic Chemistry - Chemistry and bioactivity of natural products
Lisbeth Grondahl	Biomaterials for bone repair and regeneration
Elizabeth Krenske **(Theme Leader)**	Physical and computational chemistry; organic chemistry
Ross McGeary	Synthesis, methodology, and medicinal chemistry
Gary Schenk	Physical Chemistry - Structure, function, mechanism and pharmaceutical potential of metalloenzymes
Craig Williams	Organic Chemistry - Synthesis and isolation of complex natural products, method development, medicinal and physical organic chemistry

Affiliate theme members:

Mary Fletcher

Paul Alewood

INFECTION AND IMMUNITY



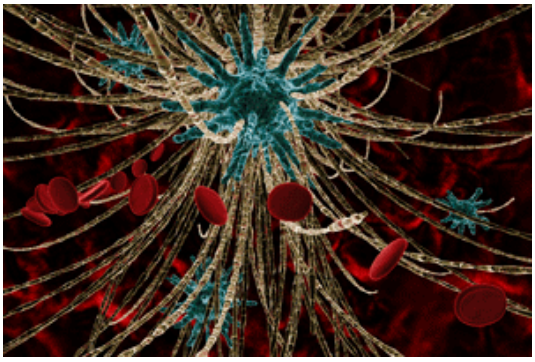
Research in the theme of Infection and Immunity at SCMB encompasses the study of microbial pathogens and the response to infection by their hosts. Specific areas of interest include molecular virology, bacterial pathogenesis, fungal pathogenesis, parasitology and innate immunity.

Members of the theme also represent a core group within the Australian Infectious Diseases Research Centre, a multidisciplinary network encompassing more than 80 research groups at The University of Queensland and the Queensland Institute of Medical Research.

Theme members:

Ross Barnard	Infectious diseases, molecular biology and biotechnology
Helen Farrell	Viral pathogenesis
James Fraser	Sex virulence and evolution in pathogenic fungi
Roy Hall	Structure and function of flavivirus proteins; ecology and epidemiology of arthropod-borne viruses
Ulrike Kappler	Microbial physiology and biochemistry of metalloenzymes
Stuart Kellie	Signalling molecules in macrophages and tumour cells
Alex Khromykh	Molecular mechanisms of flavivirus replication and virus-host interaction
Graham Leggatt	Immunotherapy of non-melanoma skin cancers
Alastair McEwan	Redox biology and bacterial pathogenesis
Mark Schembri	Bacterial Pathogenesis
Kate Stacey **(Theme Leader)**	Cellular response to foreign nucleic acids
Philip Stevenson	Viral pathogenesis and immunology
Mark Walker	Infectious diseases and vaccine development
Nick West	Tuberculosis microbiology and pathogenesis
Paul Young	Viral Diseases and their Control: Vaccines, Therapeutics and Diagnostics

INFECTION AND IMMUNITY



Affiliate theme members:

Matthew Cooper	Drugs and diagnostics for superbugs, viruses and cancer
Nick Davis-Poynter	Constitutive endocytosis, constitutive signalling and functional complementation
Ralf Dietzgen	Molecular virus-plant-insect interactions and virus biodiversity and evolution
Matt Sweet	Infection and innate immunity

MEDICINAL CHEMISTRY

Medicinal chemistry is a multidisciplinary science involving molecular design, chemical and enzymatic synthesis and bioassays followed by modifying compound properties for pharmaceutical applications.

Medicinal chemistry thus combines organic chemistry with biochemistry, physical chemistry, microbiology, pharmacology, structural biology, enzymology, computer modeling, molecular biology and *in vitro* and *in vivo* examinations.

Theme members:

Joanne Blanchfield	Drug development and delivery
Vito Ferro	Organic Chemistry - Glycoscience, drug discovery and biotechnology
Michael Monteiro	Living polymers
Avril Robertson	Drug discovery (inflammation, cancer, pathogenic fungi), medicinal chemistry
Istvan Toth **(Theme Leader)**	Novel drug delivery systems

Affiliate theme members:

Paul Alewood	Design and discovery of bioactive peptides and proteins in venomous animals
David Fairlie	Chemistry and human therapeutics

MOLECULAR GENETICS AND GENOMICS

Research in molecular genetics and genomics at the SCMB encompasses the application and analysis of targeted and high-throughput approaches to better understand all domains of life.

Vertebrates, plants, insects, microorganisms and microbial communities are subject to cutting-edge methodologies to elucidate evolution, ecology and function at the genetic and regulatory level.

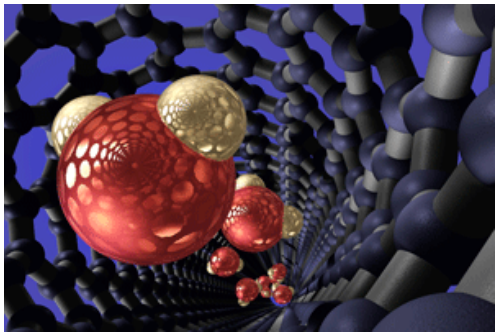
Theme members:

Stephen Barker	Evolutionary genetics and genomics of parasitic arthropods
Scott Beatson **(Theme Leader)**	Molecular pathogenomics
Mikael Boden	Bioinformatics (analysis, modelling and integration of biological data)
Bernie Carroll	Molecular genetics of gene expression and development
Marina Fortes	Genetics and reproductive biology in mammals
Phil Hugenholtz	Microbial ecology & evolution
Steve Reid	Insect Cell Technology and Biotechnology
Joe Rothnagel	Molecular genetics, Cell biology and Bioinformatics
Ann Trezise	Equine genetics
Gene Tyson	Molecular microbial ecology, diversity and evolution

Affiliate theme members:

Tim Bailey	Pattern recognition and modelling in computational biology
Rick Sturm	Melanogenics and skin cancer

NANOTECHNOLOGY AND MATERIALS CHEMISTRY



Organic, inorganic, physical, and computational chemistry underpin the SCMB Nanotechnology and Materials Chemistry theme.

The theme draws together expertise in synthesis (including self-assembly), characterisation (including spectroscopy, colloid and surface science) and computational modelling, and applications (optoelectronics, clean energy generation and storage, separation technologies, biomaterials, nanomedicine, molecular recognition) of organic, inorganic, and composite materials from small molecules to macromolecular structures including polymers, dendrimers, frameworks, gels, and nano-porous structures.

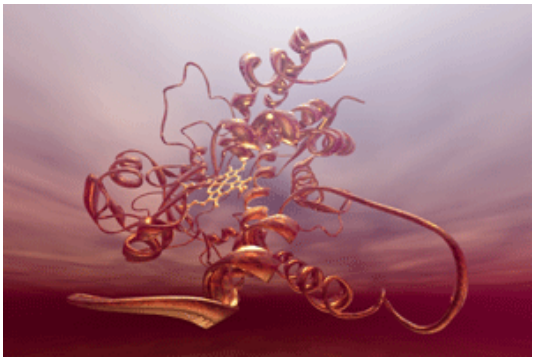
Theme members:

Debra Bernhardt	Materials chemistry application
Paul Burn **(Theme Leader)**	Organic opto-electronics
Jack Clegg	Metallo-supramolecular chemistry
Ian Gentle	Energy materials
Lawrence (Shih-Chun) Lo	Functional opto-electronic materials design, synthesis and characterisation
Evan Moore	Lanthanide metal ions properties
Mark Riley	Spectroscopic properties of new materials
Paul Shaw	Photophysics of organic semi-conductors
Anitha Sudheesh Kumar	Nano drug delivery systems for therapeutic proteins and anticancer drugs
Matt Trau	Nanoscience, Nanotechnology and Molecular Diagnostics

Affiliate theme members:

Annette Dexter	Design and use of peptides for industrial applications
Andrew Whittaker	Polymer chemistry, nanotechnology, photolithography, biomaterials science, magnetic resonance

STRUCTURAL BIOLOGY AND BIOCHEMISTRY



The Structural Biology and Biochemistry theme at SCMB focuses on understanding basic processes involved in cell regulation and disease at a molecular level.

Biophysical techniques such as x-ray crystallography and nuclear magnetic resonance spectroscopy are being used, together with computer simulations and modelling techniques, to understand at an atomic level how proteins and peptides interact with themselves and other cellular components such as lipids and sugars to form functional complexes. Biochemical and molecular biology approaches are being used to probe differences in protein expression, interactions or activity associated with different disease states.

Theme members:

Peter Dodd	Molecular mechanisms of neurological disease
Elizabeth Gillam **(Theme Leader)**	Biocatalysis and Molecular Toxicology
Luke Guddat	Protein structure and drug discovery
Bostjan Kobe	Structural biology of infection and immunity
Michael Landsberg	Structure and function of molecular machines
Alan Mark	Physical and Computational Chemistry - Simulation of biomolecular systems
Marloes Nitert Dekker	Metabolism and Microbiome in Pregnancy
Ben Schulz	Synthetic Systems Glycobiology
Simon Worrall	Mechanisms of drug-induced liver damage

Affiliate theme members:

Glenn King	Bugs and drugs
Jenny Martin	Antibiotic discovery, understanding insulin signalling, protein structure and drug design

INDUSTRY PROJECTS

Would you like to undertake part of your research project in a company outside UQ?

- Experience a commercial workplace
- Make contacts to help you with your career
- Receive support and guidance from UQ as well as your industry supervisor

Opportunities exist in these industries and more:

- biotechnology
- chemical
- pharmaceutical
- food processing

pathology

As a Biotechnology, Chemistry or Molecular Biosciences student, you may be able to undertake a research project or internship with companies with whom SCMB already has a working relationship. In addition, if there is a particular company you would like to work with, you are welcome to propose it to us.

SCMB students have been hosted for a variety of industry projects and internships at the following companies:

- Anteo Diagnostics
- Patheon Biologics
- Mars Petcare (Albury-Wodonga)
- Ellume
- Olayan (Saudi Arabia)
- TetraQ
- Sugar Research Australia
- Forensic Scientific Services, Qld Govt
- QFAB
- Cook Medical

'Honours in Industry' project is a win-win-win for a student, a company and for UQ

Qi Qi He decided in the third year of her BSc studies to do Honours as a way to obtain research and other skills valued by employers.

Interested in the synthesis of different kinds of new compounds related to carbohydrate chemistry, Qi Qi approached Associate Professor Vito Ferro of the School of Chemistry & Molecular Biosciences (SCMB) about a topic.

Using his industry contacts, Assoc Prof Ferro found a project for Qi Qi with Brisbane-based biopharmaceutical and drug discovery company, Alchemia Ltd, as part of SCMB's new 'Honours in Industry' program.

"We had encountered what looked like an interesting chemical reaction, but did not have the time to explore this due to other commercial projects," Alchemia's Vice-President, Discovery, Dr Wim Meutermans, said.

"It seemed an ideal honours project in terms of broad skill development (synthesis, purification, structure determination)".

Qi Qi was awarded a $2,000 Honours scholarship by SCMB and undertook her project under the supervision of both Assoc Prof Ferro at UQ and Dr Norbert Wimmer at Alchemia.

"My project involved solving a real problem of the decomposition of a promising compound in the compound library at Alchemia," said Qi Qi. "It was really interesting, and it gave me a chance to apply what I had learnt in my bachelor degree program.

"Working at Alchemia's plant exposed me to new research techniques and valuable practical skills that are specifically used in industry nowadays."

Qi Qi added that the experience gave her an insight into industrial culture and how to work on her own initiative and as part of a team. Dr Meutermans agreed that working on an industry real life problem gave Qi Qi a sense of direct applicability to it.

Dr Meutermans said that Qi Qi undertook to evaluate an unusual chemical rearrangement involving an undefined kinetic intermediate.

"Qi Qi successfully determined the structure, and it provided valuable information for our discovery efforts," said Dr Meutermans.

Qi Qi said that during her studies, she received "tremendous support" from her UQ and Alchemia supervisors.

"They helped me to plan what I should do to succeed to solve the problem in my Honours project. They also instructed me in the lab, sharing their knowledge of chemistry, assisting me with different kinds of research techniques and teaching me valuable practical skills."

Qi Qi graduated with First Class Honours and went on to do a PhD at SCMB under the supervision of Assoc Prof Ferro. Her honours research findings have been published in the international journal *Organic and Biomolecular Chemistry.*

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Integria Healthcare
Eight Mile Plains, Brisbane

Project Scope:
Analytical Chemistry as applied to the Pharmaceutical industry, with particular emphasis on complementary medicine

Project 1: Based in an analytical laboratory

Project 2: Based in a manufacturing facility

DR MARINA FORTES

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Molecular Genetics & Genomics

Inventia Genetics Technologies Pty Ltd
Herston, Brisbane

INVENTIA GENETIC TECHNOLOGIES

Project Scope:

Beef cattle production benefits from selective breeding, which is the practice of selecting animals according to their genetic merit. Cows with high genetic merit are often used as oocyte donors in assisted breeding programs. In these programs, oocyte collection is followed by in vitro fertilization (IVF) and embryo transfer so that each donor cow is able to have dozens of offspring in one year (instead of one). In partnership with Inventia Genetic Technologies (IGT), an Australian cattle breeding company, we aim to understand the requirements of the developing embryo to improve assisted breeding. Current IVF protocols were developed using *Bos indicus* breeds and may not be ideal for *Bos taurus* cattle. Our research aims to investigate the differences in *Bos taurus* and *Bos indicus* breeds during oocyte maturation and early embryo development. Specialised culture medias will ultimately reduce cellular stress and optimise cellular function, improving embryo quality and therefore pregnancy rates. The aim of this research is to optimise current IVF protocols used for oocyte maturation and embryo development to increase IVF success rates of beef cattle and to understand differences between *Bos taurus* and *Bos indicus* bovine breeds.

Summer project benefits student and Biotechnology company

Van Mai was inspired by a lecture to do an industry placement internship that led to her work being incorporated into presentations to customers by a successful Brisbane biotech company.

“Two scientists from Anteo Diagnostics gave a guest lecture in the second year *Issues in Biotechnology* course I was taking,” she said. “I found it very interesting and thought provoking.”

Course coordinator, Associate Professor Vito Ferro, mentioned to students that an eight-week internship at Anteo was available for a student taking the course *Biotechnology Industry Placement* over the summer semester. Van applied and was chosen.

After two weeks of on-site training about company policy, equipment use, experiment design and record-keeping, Van felt well-equipped to undertake six weeks in the company laboratory.

“I worked with one of Anteo’s signature products, Mix&Go, a high performance substance for surface coating,” said Van.
“The product enables fragile biomolecules to correctly orientate and attach to a wide range of surfaces.
“Specifically, I worked on optimising protocols for plate-based enzyme linked immunosorbent assays.”

Shaun Cooper of Anteo Diagnostics supervised Van’s project and said that Van was asked to use the underlying theory of Anteo’s novel ligand-metal coordination chemistry to determine its utility in improving sensitivity of an immunoassay in a format were low surface area traditionally limits performance.

“Van identified the performance differences of the product in high and low surface area plate formats,” he said.
“Her data demonstrated that sensitivity differences can be observed with the application of Mix&Go and that improvements are greater in the lower surface area format.
“Some of her data was incorporated into technology overview presentations given by the company’s chief scientific officer to prospective customers and partners.”

Van said that the work environment at Anteo was warm and welcoming and that the experience had taught her about the business side of scientific research, including policy, protocols and the importance of discussion and collaboration.

“It has also built my confidence,” she said.

Van is an international student who won a scholarship from the Vietnamese government to study in Australia. She was awarded Dean’s Commendations for high achievement in her undergraduate studies, worked as a peer tutor and charity volunteer, and is now completing her Honours year in materials chemistry.

She praised the quality of UQ’s teaching and learning, the range of courses, lab facilities and the beautiful St Lucia campus.

Anteo Diagnostics has hosted a number of UQ biotechnology students and is keen to host more.

“Students who undertake internships like Van’s gain not only general workplace skills, but also some insight into how Australian research contributes to commercial product realisation,” said Mr Cooper.
“Support for translational research is currently a topic of government policy debate, and projects like Van’s are a good example of the interface between research and commercialisation.

SCMB ACADEMIC STAFF

PROFESSOR STEPHEN BARKER

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Molecular Parasitology

My research is cross-disciplinary in that it contributes to 2 of the 7 research themes in our school: (i) Molecular Genetics & Genomics; and (ii) Infection & Immunity. I study parasites which are 1 of the 4 main groups of organisms that cause disease: the other 3 groups of organisms that cause disease are the viruses, bacteria and fungi.

My current research-focus is on the ticks of Australasia (Australia, New Zealand, New Guinea, and Islands of the western Pacific). Ticks cause disease in humans, our domestics animals, particularly dogs, and wildlife.

Phylogeny of ticks and their kin from entire transcriptomes. You would use entire transcriptomes (up to 225.8 megabases of cleaned, pair-end, sequence-reads per species) to infer phylogenies of ticks and their kin. A group of particular interest are the Australasian *Ixodes* and other “ancient” lineages of ticks in Australasia.

Create DNA diagnostic tests for the 71 species of ticks in Australia. This is the Australian contribution to an international project to DNA-barcode all life on earth, called BOLD (http://www.boldsystems.org). You would analyse cytochrome oxidase I sequences generated in the Barker lab and in the labs of our collaborators in the Chinese Academy of Agricultural Sciences, Xujiaping, and the Graduate School of Veterinary Medicine, Hokkaido University, Japan. You Will make DNA-based diagnostic guides for the identification of larval and nymphal ticks which are difficult to identify by their morphology.

Resolve by bioinformatics the Ixodida (tick) branches of the tree-of-life from entire mitochondrial genome sequences. This work is the Australian contribution to an international project to resolve the tree of life called the Tree of Life Web Project (http://tolweb.org).

Resolve by bioinformatics the climatic requirements of the ticks of Australia and PNG.

Techniques you would learn during your research project: microscopy, bioinformatics, creation of DNA diagnostic tests, public health concepts and strategies.

Useful Majors: Biomedical Science / Microbiology / Parasitology

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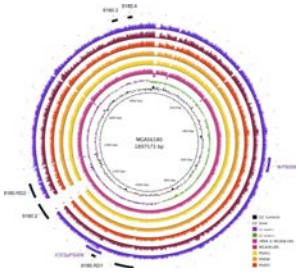
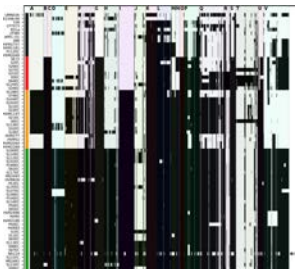
Microbial genomics

We aim to exploit next-generation DNA sequencing to better understand how medically important bacteria cause disease, become resistant to antibiotics and disseminate globally. Our major focus is the role of mobile genetic elements in the evolution of virulence and antimicrobial resistance amongst pathogens such as *Escherichia coli, Streptococcus pyogenes, Mycobacterium tuberculosis* and *Pseudomonas aeruginosa*. Our group develops new computational approaches for the rapid analysis of bacterial genome data from the latest sequencing technologies.



Project 1: Genomic investigation of antimicrobial resistance.

Carbapenem resistant Enterobacteriaceae (CRE) pose an urgent risk to global human health. CRE, which include organisms such as *Klebsiella pneumoniae* and *Escherichia coli,* are resistant to almost all currently available antibiotics. Almost 50% of patients who develop bloodstream infections with these organisms die from the infection. In this project we use Pacific Biosciences Single Molecule Real-Time (SMRT) sequencing to determine the complete genomes of CRE isolated from local hospitals. Comparative genomic analysis will enable us to recognise the genetic cause of antibiotic resistance and the relationship between isolates from an outbreak. As we outlined recently (Beatson SA, Walker MJ (2014) Science 345: 1454-1455), in contrast to short-read sequencing technologies commonly used in genomic studies, SMRT sequencing allows complex antimicrobial resistance elements to be properly characterised.



Project 2: Phylogenomic analysis of global pandemic *E. coli.*

Escherichia coli sequence type 131 (ST131) is a globally disseminated, multidrug resistant clone responsible for a high proportion of urinary tract and bloodstream infections. By sequencing the genomes of ST131 isolates from all over the world we were able to use phylogenomic analysis to investigate the rapid emergence and successful spread of this clone (Petty, Ben Zakour et al., PNAS, 2014). In this project we will analyse the genomes of other global pandemic multidrug resistant *E. coli* clones in order to understand of the role of mobile genetic elements and antibiotic resistance in their evolution.

Project 3: Novel methods to visualise bacterial genomic data.

We have previously developed easy-to-use software such as BRIG and Easyfig for visualising bacterial genome comparisons. We are seeking computationally focused students to develop novel web-based software for intuitive visualization and reporting of virulence and antimicrobial resistance gene profiles from genome data generated using Illumina or Nanopore technologies.

Techniques you learn in our group may include: Comparative genomic analysis, Phylogenomics, Bioinformatics, Python programming, Web programming; Joint projects that have both computational and "wet-lab" components may be arranged with other SCMB microbiology group leaders on request.

Useful Majors: Genetics / Microbiology / Bioinformatics / Biochemistry & Molecular Biology / Biomedical Science / Computational Science

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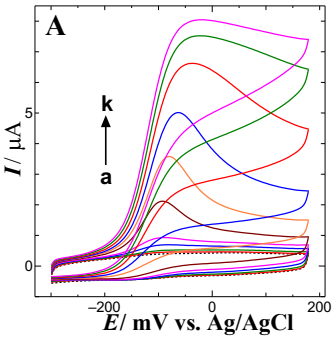
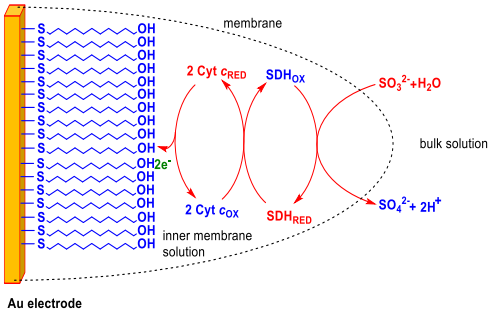
Biomolecular Chemistry

Coordination and Bioinorganic Chemistry

Our research efforts are concerned with electron transfer reactions and coordination chemistry of relevance to biology and catalysis. Students interested in any of these areas of research should contact Prof. Bernhardt for a more detailed project description.

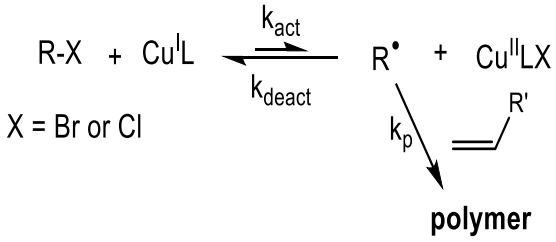


Enzyme Electrochemistry



Enzyme electrode biosensors are devices that comprise a redox active enzyme integrated with electronic circuitry to give real-time quantitative analysis of chemical compounds in biological fluids or the environment. The current that is generated by the oxidation or reduction of the substrate provides a quantitative measure of the substrate concentration. This project will involve the electrochemical investigation of metalloenzymes currently available within in our group.

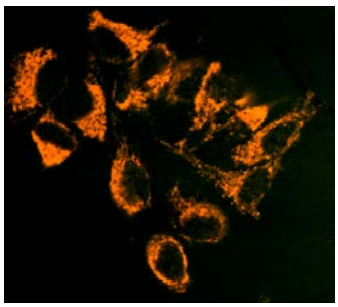
Copper complexes as catalysts for atom transfer radical reactions



Simple Cu(I) complexes (e.g. $[Cu(bipy)_2]^+$) are capable of generating organic radicals from alkyl halide precursors and have been used extensively in so called atom transfer radical polymerisation (ATRP). The mechanism by which the radical is produced remains controversial. This project will use spectroscopic and electrochemical methods to understand the reactivity of these simple but highly reactive compounds.

Imaging Metals in Cells Using Fluorescent Ligands

Within living cells transition metals may occur in various forms either tightly bound (to proteins) or weakly bound to small molecules. Identifying the cellular localisation and chemical form (oxidation state etc.) of these metals is an important goal. Due to its high sensitivity fluorescence is a popular technique for visualising molecules at low concentrations. This project will investigate the combination of the ideal metal binding properties with fluorescent tags such as fluorescein (a well characterised fluorophore) in order to develop ligands that respond as ON/OFF fluorescent switches when complexed to different metal ions within cells.



Techniques you learn in our group may include: electrochemistry, synthesis, spectroscopy, structure determination.

Useful Majors: Chemical Sciences / Chemistry / Biochemistry & Molecular Biology

PROFESSOR DEBRA BERNHARDT

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Theory and computation for new materials and fluids

My research group is interested in the study of matter using theoretical and computational methods that can ultimately be used to address a wide range of practical problems. Applications of interest include transport in nanopores, fluctuations in nanoscale systems, melting, solubility, separation of gases, lubrication, design of ionic liquids, design and assessment of materials for energy conversion and storage, carbon dioxide sequestration and catalysis. Our group has world leading expertise in various theoretical and computational methods ranging from quantum chemical calculations to the statistical mechanics of nonequilibrium systems, access to high performance computing facilities and an international team of collaborators. Possible projects include:

Transport in nanoporous systems

Nanoporous solids are used as adsorbents in pollution control, industrial separations, storage of fluids and catalysis. Simulations can be used to assist in the design of better materials, and to understand the fundamental nature of the adsorption and transport processes. One of the key factors determining flow of fluids through nanopores is their stick or slip behaviour near the walls. We have recently developed a new approach for studying this behaviour that should be more efficient for complex systems, and have projects where this approach can be applied.

Computational studies of ionic liquids

Ionic liquids have exceptional solvation properties and electrical conductivity, meaning they have a wide range of industrial applications. By combining different ions, ionic liquids can be designed to optimize their properties. However, the science of ionic liquids is new and therefore prediction of their properties is problematic. To address this, we are taking advantage of recent developments in nonequilibrium statistical mechanics to create efficient algorithms to determine key properties of ionic liquids.

Statistical mechanics of nonequilibrium fluids

Any system that is flowing, stirred, has a temperature gradient across it or is subject to an external field is in a nonequilibrium state. The properties of these systems are not well developed when the systems are far from equilibrium. In this project theory and computational methods will be used to expand our fundamental understanding of these systems.

Design of new materials for energy applications

New materials are required for solar energy applications, catalysis, adsorbents for pollutants, storage of fuels, new polymers, fuel cells etc. Quantum mechanics enables the properties of these materials to be predicted in an efficient and cost effective manner. Projects are available that will focus on the prediction of material properties using a range of computational quantum chemical methods.

Techniques you learn in our group may include: Molecular dynamics simulation, quantum chemical calculations, development of theories, modelling of experimental results.

Useful Majors: Bioinformatics / Biophysics / Chemical Sciences / Chemistry / Computational Science / Computer Science / Mathematics / Physics / Chemical Engineering / Chemical and Materials Engineering / Software Engineering

ASSOCIATE PROFESSOR JOANNE BLANCHFIELD

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Research Area

My research broadly concerns drug discovery, design and development. We search for potential new drugs in natural sources such as medicinal herbs and traditional remedies, we examine the mechanism of action of compounds with known biological activity such as the cancer preventative activity of bile pigments such as bilirubin and we use synthetic chemistry to design new molecules to mimic the structures on the surface of infectious organisms.

Our goals are to:

- Determine the compounds in herbal extracts that can cross the GI tract and thus are most likely to be the biologically active components
- Understand the action of biologically active compounds by determining their enzyme inhibitory activity or receptor selectivity or other biological activity
- Build scaffolds that can present the components of antigens to the immune system to elicited protective antibodies without having to use whole organisms in vaccines

Bioavailability of natural products from herbal extracts

Herbal remedies are a major source of medical treatment for much of the world's population. Unfortunately, little is known about the fate of the natural products in the extracts or which, if any, are biologically active. We are offering a project that uses a cellular model of the small intestine (Caco-2 cell monolayers) to investigate which natural products are likely to enter the blood stream after oral intake of some popular herbal remedies. We also look closely at what changes the compounds undergo during digestion and absorption.

How can waste products protect us from cancer

When red blood cells are broken down in the body, the heme is broken down to a series of waste products including bilirubin and biliverdin. These compounds are known as bile pigments. Previous work has established that these bile pigments can inhibit the mutagenesis caused by some important environmental carcinogens such as the polyaromatic compounds in car exhaust and the toxins such as Aflatoxin. Our project aims to determine how this inhibition takes place, particularly looking at the inhibition of P450 enzymes known to activate the environmental mutagens.

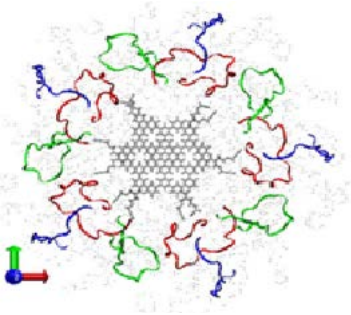

Fig: Energy minimised model of HPV discontinuous epitope displayed on a hexaphenylbenzene scaffold.

Synthesis of antigen mimics for synthetic vaccines

In collaboration with Dr Graham Leggatt (TRI) and Professor Paul Burn we are building fully synthetic constructs that display antigenic peptides or carbohydrates from HPV, HIV and Staphylococcus aureus. We are building a molecule that resembles the outside surface of the infectious agents so that whole organisms do not have to be used in vaccines.

Techniques you learn in our group may include: Natural products isolation, organic synthesis, HPLC, NMR, MS, cell culture techniques, assay development and analytical chemistry.

Useful Majors: Chemical Sciences / Chemistry / Biochemistry & Molecular Biology

ASSOCIATE PROFESSOR MIKAEL BODÉN

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Bioinformatics

Biology is becoming an information science. Data are now available at scales that challenge our ability to analyse them. But greater scale gives statistical power to distinguish meaningful signals from noise or artifacts, to identify drivers and determinants of function and structure.

Our goals are to:

- manage the complexity of operations for analysing millions of sequence reads, thousands of genomes, and proteomes of thousands of dynamically regulated molecules
- enable the mixing of expertise with uncertain and incomplete data, typical of the next wave of biotechnology, across genomics, proteomics, and structural biology
- interpret "whole system" data, aimed at understanding of basis of disease and other scientifically relevant phenotypes, using statistics and machine learning
- develop methods that support a range of scientific applications, exemplified by:

Data integration to understand cellular control

While DNA is essentially the same in all our cells, the expression of genes is a complicated story. Factors that contribute to cellular differentiation include abundance of regulatory proteins and RNA, binding of molecules to DNA, transcripts and proteins, epigenetics and chromatin conformation, transposable and repetitive elements. Technologies probe genome states at scale, enabling us to collect and combine data to capture what cannot be seen in isolation: how multiple factors conspire to make cells tick, and what happens when something breaks. We aim to understand regulatory networks from data for different organisms, in development, in tissues of scientific interest.

Computer-guided protein engineering – and reconstructing ancestral biology

Enzymes are biological catalysts with untapped potential to improve the efficiency of chemical industries, lessen their environmental impact, and improve drug development. We use data analysis coupled with principles Nature has refined over millions of years to detect hidden relationships between protein sequence and structure to design new proteins fit-for-purpose.

Methods for predicting protein function

Proteins carry out complex functions and interact with one another, but are challenging to experiment with. We use machine learning to develop predictors of function, interaction and cellular location that streamline analyses of proteins, and reconstruct biological systems *in silico*. We aim to identify and explain complex biological roles in terms of easily observable features.

Techniques you learn in our group may include: Sequence analysis; Computational modelling; Statistical analysis and testing; Computer programming and algorithms; Machine learning; Probabilistic methods.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Computational Science / Genetics

PROFESSOR PAUL BURN FAA FRSC

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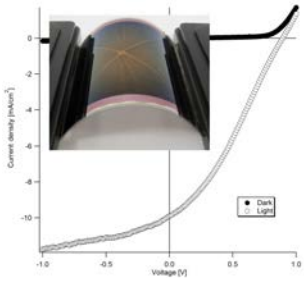
Nanotechnology & Materials Chemistry

Chemistry of Materials and Nanotechnology

The research mission of the Centre for Organic Photonics and Electronics (COPE) is to take **nanotechnology** from the "bench to the market". COPE contains state-of-the-art synthesis laboratories, a Class 1000 clean room, device fabrication facilities, and a suite of instrument rooms for the characterization of materials and opto-electronic devices. COPE has Honours research projects in all branches of Chemistry (organic, inorganic, materials, physical, and computation) giving a fantastic opportunity for you to develop your own interests and skills at the cutting edge of a technological area, e.g., **solar cells, flat panel displays and lighting, plastic electronics, explosives sensors, cameras and imaging, and synthetic vaccines**. Below is a snapshot of some of the projects on offer and I would be happy to discuss them with you.

Thin film solar cells



A key component of slowing and ultimately halting climate change is converting a proportion of the 1 kJ of solar energy that falls on each square metre of the Earth's surface per second of every daylight hour into electricity. Would you like to use your synthetic chemistry skills to create new nanomaterials (organic and inorganic, e.g., perovskites) that can be used in efficient, flexible, and light-weight solar cells? Do your interests lie in studying structure using neutron scattering or would you like to apply computation to develop an understanding of why some materials work well and some do not, leading to new design criteria?

Flat panel displays and lighting

Lighting and displays based on organic light-emitting diodes (OLEDs) have the potential advantages of cheap manufacturing, better power consumption, better colours, and ultimately being flexible. Imagine a TV screen that could roll up into your mobile phone! Would you like to apply your interest in synthetic chemistry to develop new emissive materials that can be incorporated into real OLEDs at COPE or apply physical chemistry techniques to understand how they degrade?

Sensors for explosives

We are developing in partnership with industry a handheld technology based on fluorescence quenching for the detection of explosives to replace canines. Are you an organic or physical chemist who would like to work in an interdisciplinary team developing and testing dendritic sensing materials?

Techniques you learn in our group may include: Synthetic chemistry [organic and organometallic, small molecule, dendrimers, polymers, and poly(dendrimers)]; characterisation techniques [chemistry (NMR, mass spectroscopy, IR, UV-visible etc), materials (GPC, DSC, TGA, electrochemistry, neutron scattering etc)]; photophysical (PLQY, PL spectra, time resolved PL measurements); computation; device fabrication and testing.

Useful Majors: Chemical Sciences / Chemistry / Computational Science

PROFESSOR BERNIE CARROLL

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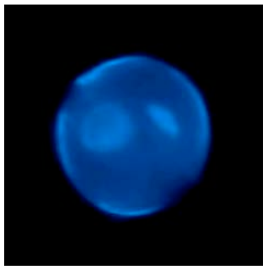
Research Area



We are using *Arabidopsis* as a eukaryotic model for studying the mechanisms of RNAi and epigenetic silencing. Gene silencing is a highly conserved process in plants and animals, and is of fundamental importance to developmental regulation of gene expression, defence against viruses, transposon silencing, adaptation to environments and genome evolution. Gene silencing is also of immense relevance to biotechnology.

Our goals are to:

- Understand components of gene silencing pathways in eukaryotes, including mechanisms of intercellular movement of gene silencing
- Define the importance of gene silencing pathways in eukaryotic development, reproductive biology, defense against pathogens, and adaptation to environmental change

Molecular basis of meiotic drive in pollen

Meiotic drive involves defective meiosis and results in preferential transmission of selfish chromosomes through to the next generation. We have recently identified the first example of meiotic drive in pollen of flowering plants (see above). This project aims to identify the gene responsible for the meiotic drive phenotype in pollen. Our data suggests that the meiotic drive phenotype may have an epigenetic basis. This project should shed new light on mechanisms of cell division (meiosis and mitosis) and sexual reproduction in both plants and animals.

Systemic RNAi and its relevance to defense & development

Remarkably, once RNAi is initiated, it spreads systemically throughout the plant to confer systemic resistance against homologous viruses. Using a GFP reporter (see left), we have identified *Arabidopsis* mutants that are defective in systemic RNAi, and many of these mutants also show epigenetic and/or developmental defects. This project will involve further characterization of these systemic RNAi mutants, including their interaction with plant viruses.

Techniques you learn in our group may include: Genetic analysis, genetic mapping and map-based gene cloning, plasmid construction and production of genetically modified plants (GM plants) including CRISPRs, micrografting of plants, plant pathogen assays, confocal microscopy, cell sorting, genetic diagnostics, genomics, bioinformatics.

Useful Majors: Genetics / Biochemistry & Molecular Biology / Bioinformatics / Microbiology

DR JACK CLEGG

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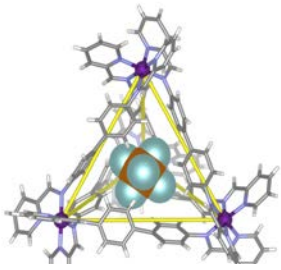
Nanotechnology & Materials Chemistry

Metallo-Supramolecular Chemistry and Metal-Organic Frameworks



We prepare new materials from both metallic and organic components for use in molecular separations. By using self-assembly the inherent physical and chemical properties of simple metallic and organic (ligand) components are brought together to form beautiful complex and functional architectures. In particular, we are interested in the design and synthesis of new materials with central cavities that are capable of selectively binding smaller molecules.

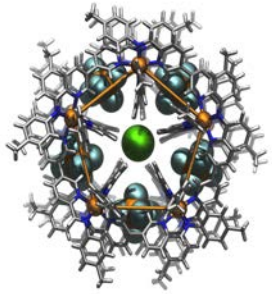
Our goals are to:

- Design and synthesise new materials
- Apply these materials to industrial problems
- Better understand self-assembly processes

Trapping Guest Molecules in Metal-Organic Frameworks

Metal-Organic Frameworks are a class of polymeric hybrid material formed from organic and metallic components. These materials have large surface areas and high porosity and are finding application in gas sequestration and separation technologies. Accordingly it is possible to trap a large variety of guest molecules inside them. In this project you will investigate the binding of different solvent molecules inside one of these frameworks to explore selectivity and potential separation applications.

New Metallo-Supramolecular Architectures



Careful consideration of the geometrical properties of metals and organic components allows for the construction of a variety of discrete "supermolecules" formed from the spontaneous aggregation of numerous predesigned components. These structures take numerous forms from two-dimensional architectures such as triangular and square architectures to elaborate and beautiful three-dimensional species such as tetrahedra and cubes. Changing the size, shape, properties and charge of the architecture allows for the selective encapsulation of different materials inside them.

Techniques you learn in our group may include: Organic Synthesis, Inorganic Synthesis, Crystal Engineering, Xray diffraction, NMR, IR, UV-Vis, Mass Spectrometry, and just about anything else you can imagine!

Useful Majors: Chemical Sciences / Chemistry

PROFESSOR JAMES DE VOSS

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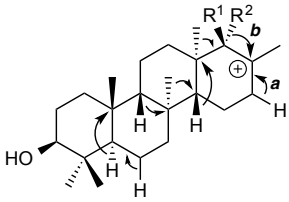
Biological and Synthetic Chemistry



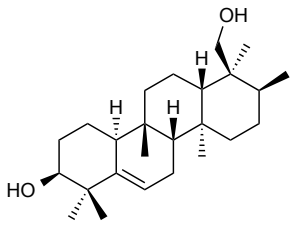
My group is concerned with *biological* and *synthetic* chemistry and in particular with the application of chemical principles to the understanding of biological processes. While some projects are purely synthetic in nature, most are a blend of the range of disciplines that make up modern bio-organic chemistry: molecular biology, protein purification and characterisation, synthesis and structure determination.

Our goals are to:

- Understand the mechanism of enzyme catalysed oxidations
- Discover the bioactive constituents of herbal medicines
- Synthesise herbal constituents and small molecule probes of enzyme mechanism

Cytochromes P450

The cytochromes P450 are a superfamily of oxidative haemoproteins that catalyse an amazing variety of oxidative transformations, ranging from simple alkene epoxidation all the way through to oxidative carbon carbon bond cleavage. P450s are of interest as they (i) are often unique enzymes in a biosyntheitc pathway and as such represent new targets for therapeutic agents or (ii) are extremely efficient biodegradative/biosynthetic catalysts that offer the potential of developing tailored oxidative catalysts for synthetic transformations. We are interested in understanding the mechanism of action of P450s that catalyse interesting and unusual biosynthetic and biodegradative reactions. This may eventually allow prediction of the types of reactions catalysed by P450s and their use in organic syntheses.



Phytochemical Characterisation of Constituents of Medicinally used Herbs

Whilst herbal medicines are widely used within the general community and have a long history of such use, their chemical constituents are often poorly characterised. This makes assessment of the true biological activity of many of these preparations extremely difficult. In collaboration with a local herbal medicine company (Integria) we have embarked upon a program of phytochemical characterisation of a number of therapeutically prescribed herbs with the aim of (i) determining the structure of their constituents and (ii) understanding the way in which these molecules are biosynthesised.

Techniques you learn in our group may include: Organic synthesis, enantiospecific synthesis, (enantioselective) chromatographic purification, structure determination (especially via nmr), site directed mutagenesis, protein expression and purification.

Useful Majors: Biochemistry & Molecular Biology / Biophysics / Chemical Sciences / Chemistry

DR MARLOES NITERT DEKKER

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Metabolism and Microbiome in Pregnancy

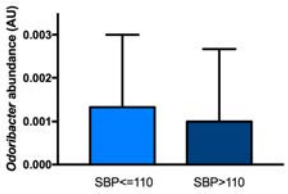
The focus of the Metabolism and Microbiome in Pregnancy lab is on understanding the role of the microbiome in shaping metabolic changes in pregnancy and pregnancy complications such as gestational diabetes mellitus and preeclampsia. The rate of pregnancy complications is increasing in line with the rise in overweight and obesity in women of childbearing age. Recently, it has become clear that the microbiome, *i.e.* the composite of microorganisms present on an organism, is an important regulator of many physiological processes including metabolism and immunity. The lab uses samples obtained from clinical studies to investigate the mechanisms by which the microbiome regulates metabolism in pregnancy.
Our goals are to:

- Identify how the gut, oral and placental microbiome change in pregnancy
- Understand how BMI, diet, medications and pregnancy complications alter the microbiome in pregnancy
- Find ways to manipulate the microbiome to improve pregnancy outcomes

Antibiotic resistance genes in the gut microbiome

In this project, we want to look at the expression of antibiotic resistance genes in the gut microbiome in pregnancy. It is unclear if the expression of these genes changes the composition of the microbiome and if it changes metabolic hormone levels or pregnancy outcomes. We want to analyse if antibiotic intake in pregnancy changes the expression of resistance genes and if this is related to metabolic changes in the pregnant woman.

SCFA production in the gut microbiome and blood pressure



We have shown that in early pregnancy, the abundance of *Odoribacter* in the gut microbiome is correlated with bacterial butyrate gene expression capacity and with lower blood pressure in host. In this project, we want to measure short-chain fatty acids (SCFA) levels in the circulation of pregnant women and compare these between women who developed gestational hypertension or preeclampsia and women who had normal blood pressure. The relationship with *Odoribacter* abundance later in pregnancy will also be investigated.

Techniques you learn in our group may include: real-time PCR, Western-blot, HPLC-MS, 16S rRNA sequencing, bio-informatics

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Genetics / Microbiology

ASSOCIATE PROFESSOR VITO FERRO

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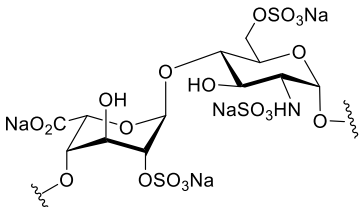
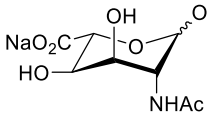
Carbohydrate and Medicinal Chemistry

My research interests encompass carbohydrate and medicinal chemistry/chemical biology, with a focus on the synthesis of compounds to probe and/or inhibit carbohydrate-protein interactions involved in disease processes. Of particular interest is heparan sulfate (HS) and the development of HS-mimetics as potential drugs for various other diseases. Available projects include, but are not limited to, the following:



Heparan Sulfate

A *radical* new approach to rare L-sugars



L-AltNAcA

Sugars with the L-configuration are relatively rare in nature but play important roles in many biological processes and thus are of great interest for the development of vaccines and other applications. However, they are generally not commercially available and are often difficult to synthesize. This projects aims to explore new, more direct synthetic routes to important L-sugars such L-iduronic acid and 2-acetamido-2-deoxy-L-altruronic acid (L-AltNAcA) via an approach that exploits free radical chemistry.

Synthesis of novel glycopolymers

Glycans are ubiquitous on cell surfaces and are important mediators of biological recognition events. Glycopolymers, i.e., synthetic polymers with pendant sugars, exhibit molecular recognition properties and have high affinities for proteins owing to their multivalency. This collaborative project with Assoc Prof Kris Thurect (CAI/AIBN) involves the synthesis of novel HS monomers and their conversion into various glycopolymers with tailored biological properties via RAFT polymerization.

Synthesis of pharmacological chaperones for lysosomal storage diseases

Lysosomal storage diseases (LSD) are caused by mutations in enzymes that degrade polysaccharides such as HS, resulting in the accumulation of undegraded substrate in the lysosomes of cells. Some patients may be treated with enzyme replacement therapy. Unfortunately, the replacement enzyme cannot cross the blood-brain barrier and thus cannot treat the neurological symptoms associated with severe cases. The aims of this project are to synthesize small molecules for the treatment of LSD which, unlike enzymes, are capable of crossing the blood-brain barrier and thus may offer relief of neurological symptoms. The compounds are designed to act as “chaperones” to protect the defective enzyme from degradation and restore enzyme activity to sufficient levels to alleviate symptoms.

Techniques you learn in our group may include: organic synthesis, NMR spectroscopy, mass spectrometry, flash chromatography, TLC, IR

Useful Majors: Chemical Sciences / Chemistry / Chemical Biotechnology / Drug Design and Development / Nanotechnology

DR MARINA FORTES

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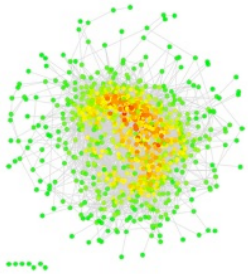
Genetics and genomics of mammalian reproduction



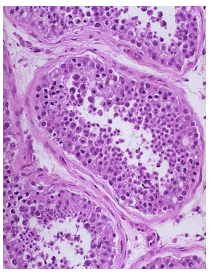
Understanding the physiology of mammalian reproduction has broad implications, from human fertility clinics to livestock productivity. In our group we use genetics and genomics as avenues to discover genes, gene networks and pathways associated with various aspects of mammalian reproduction, using livestock as a model.

Our goals are to:

- Identify mutations, genes and pathways associated with fertility
- Understand the genetic basis and inheritance of reproductive characteristics (aspects of sperm quality, for example)
- Create diagnostic assays (genotyping for fertility traits)

Genomics and gene expression underpinning fertility traits in Australian Brahman cattle

Brahman cattle are of particular importance for the beef industry in Queensland and northern Australia because of the breed's tropical adaptation. However, tropical adaptation comes with associated negative traits such as lower fertility and late puberty. This project has two aims: understanding the biological basis of late puberty in Brahman cattle and delivering a diagnostic tool, a DNA chip, specifically designed to assist selection for improvement in their fertility. Gene expression of key tissues will be measured in pre and post pubertal animals using next generation sequencing. This project is conducted in collaboration with the groups of Prof Stephen Moore (QAAFI), Dr Sigrid Lehnert (CSIRO) and Dr Toni Reverter (CSIRO).



RNA and ncRNA in testicular tissues

Normal sperm cell differentiation, termed spermatogenesis, requires re-organization of sperm DNA structure. The sperm head is much smaller than the nucleus of other cells and DNA must therefore adopt a highly condensed form in order to fit. This mechanism is hypothesized to be regulated by non-coding RNA (ncRNA). An essential role for ncRNA in regulation of spermatogenesis in mice has been demonstrated spermatogenesis (Yadav & Kotaja 2014). But, the impact of ncRNA on male fertility is poorly understood. This research will further investigate the role of ncRNA in spermatogenesis, profiling sperm ncRNA, RNA and protein content in testicular samples that represent three key stages of spermatogenesis.

Genetics of new sperm quality traits

Flow cytometric assays are replacing older methods used to define male fertility. Two emerging flow cytometric assays are the focus of this research: the sperm chromatin structure assay (SCSA) and the sperm protamine deficiency assay (SPDA, developed by our group). Sperm DNA damage measured by the SCSA is a known factor of male sub-fertility in mammals, including humans. We aim to investigate the relationship between protamine deficiency and sperm DNA damage, estimating for the first time the heritability of these sperm quality traits. This project is financed by Meat and Livestock Australia and is conduct in collaboration with Dr Gry Boe-Hansen and Dr Nana Satake (SVS).

Techniques you learn in our group may include: Quantitative Genetics, molecular genetics, bioinformatics, next generation sequencing, SNP genotyping, flow cytometry, analysis of sperm quality.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Computational Science / Genetics / Veterinary Science

ASSOCIATE PROFESSOR JAMES FRASER

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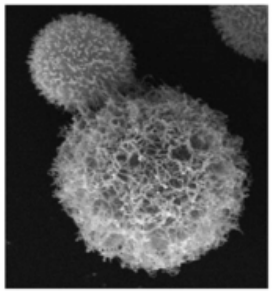
Fungal Pathogens of Humans


Cryptococcus neoformans, an encapsulated pathogenic yeast.

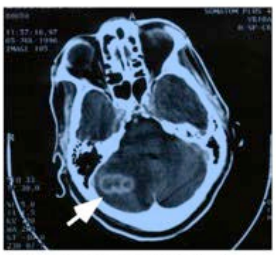
As immunosuppressed patient populations grow, the incidence of secondary infections from fungal pathogens has risen sharply to become a significant cause of death. Research in the Fungal Pathogenesis Laboratory focuses on *Cryptococcus neoformans*, the cause of one of the leading life-threatening infections in AIDS patients.

Our goals are to:

- Create new drugs for treating life-threatening fungal infections
- Identify how fungi evolve during infection to become more pathogenic
- Understand how primary metabolism and virulence are linked

Antifungal Development

Cryptococcosis is one of the top three killers of AIDS patients worldwide, in part due to the absence of an adequate array of antifungal drugs. We are addressing this need by pursuing the development of novel antimycotic agents active against *C. neoformans* and other fungal pathogens. Our current focus is on targets in the purine biosynthetic pathway, where we have been using mutagenesis, virulence models, crystallisation and high throughput screens to identify novel lead compounds upon which to base new therapeutic agents. This project is the focus of a collaboration with the groups of Prof. Bostjan Kobe (SCMB) and Prof. Matt Cooper (IMB).


CT scan of brain lesions (indicated) caused by *C. neoformans* infection.

Microevolution of a Pathogen during Infection of Humans

Even if a patient survives an infection by *C. neoformans*, they often suffer relapse infections that are even more deadly. We have shown that while in the human host the strains causing these recurrent infections have accumulated mutations that are associated with virulence, facilitating relapse. Using next-generation sequencing of the genomes of series of isolates from individual patients, we are developing a deeper understanding of this process. By combining our bioinformatic studies with molecular genetic techniques, we are revealing weaknesses in the pathogen that we hope to exploit in our antifungal development program.

Coregulation of Primary Metabolism & Virulence

In contrast to the nitrogen-rich environmental niche of *C. neoformans*, the human host is comparatively nitrogen-poor. In our investigations of how the pathogen responds to this dramatic change in nitrogen availability we have identified a transcription factor that coregulates both nitrogen metabolism and virulence. We are now investigating how this is achieved, and using this regulatory network to identify previously undiscovered virulence factors.

Techniques you learn in our group may include: Cloning, gene deletion, genomics, protein purification, crystallisation, eukaryotic virulence models, next-generation sequencing, antifungal testing, karyotyping

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Chemical Sciences / Chemistry / Computational Science / Genetics / Microbiology

PROFESSOR MARY GARSON

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Biomolecular Chemistry

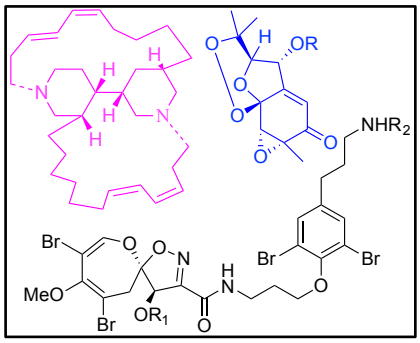
Marine Natural Products

The research in my group focuses on the biological chemistry of natural products from marine and terrestrial sources. One quarter of the world's drugs come from Nature, primarily from micro-organisms and from rainforest plants, but in recent years, attention has turned to the marine environment as an alternative source of novel bioactive metabolites.

Our goals are to:

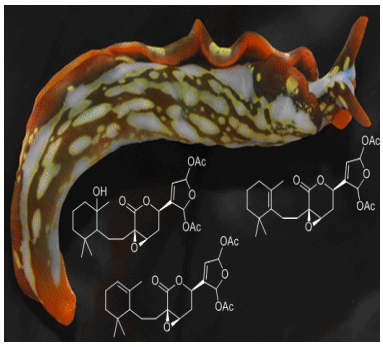
- Determine the structures & three dimensional shapes of bioactive marine natural products (terpenes, alkaloids, polyketides)
- Investigate the biochemical paths leading to their formation, and whether these involve associated microorganisms (biosynthesis, symbiosis)
- Understand the natural biological role of the metabolites (chemical ecology)

Bioactive Marine Natural Products



Samples are analysed by TLC, 2D NMR techniques and biological screening to identify organisms of interest. Modern techniques of organic chemistry and spectroscopy are then applied to work out the structures of the bioactive metabolites. Examples currently under study include structurally-complex antimalarial and antifungal alkaloids, and furanoterpenes.

Chemical Defence in Colourful Marine Molluscs



Nudibranchs are shell-less molluscs that display a striking colouration patterns and which contain toxic chemicals acquired from dietary sponges and stinging nematocysts as potential defences. Eastern Australia has nearly 400 different species of these colourful marine animals. This project will investigate the correlation between these chemical defences and visual warning signals in nudibranchs to better understand the evolution and maintenance of these traits in the marine environment, and will involve field site-specific intra- and interspecies chemical comparisons (with Dr Karen Cheney from Biological Sciences).

Chemistry of SE Asian Medicinal Plants

Through collaborations with colleagues from Indonesia and Thailand, we have access to a range of extracts of medicinal plants for chemical study. Recent work has included plants from West Timor (*Pandanus, Ochrosia* spp), Kalimantan (*Durio* spp.) and Java (*Fagaea* spp.), leading to the isolation of cytotoxic polyphenolics, lignans, and alkaloids.

Techniques you learn in our group may include: TLC, flash chromatography, NP and RP HPLC, high field NMR (1D & 2D techniques), GC & GC-MS, small scale chemical reactions, field-based bioassay methods

Useful Majors: Biomedical Science / Chemical Sciences / Chemistry

PROFESSOR IAN GENTLE

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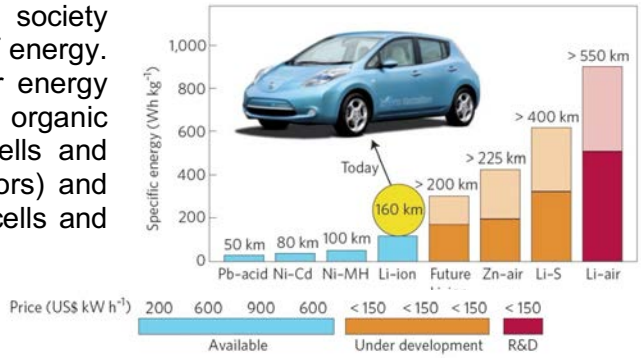
Nanotechnology & Materials Chemistry

Energy Materials

Some of the biggest technological challenges facing society today are related to the generation, use and storage of energy. Advanced materials will play an important role in our energy future. In our group we are investigating materials for organic optoelectronic devices (light emitting diodes, solar cells and sensors), energy storage (batteries and supercapacitors) and catalysts for electrochemical energy conversion (fuel cells and batteries).

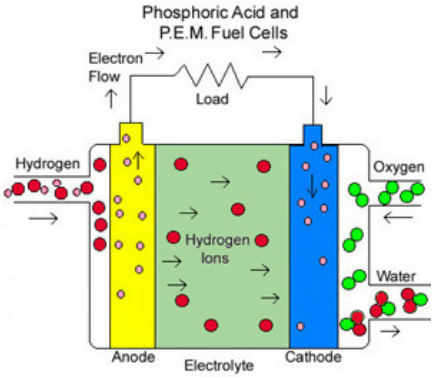


Our goals are to:

- Develop new materials for electronic devices
- Understand their behaviour using advanced characterization techniques
- Use this knowledge to design new materials and devices

Understanding interfaces in organic electronics

Over the past few years we have made good progress in the study of diffusion of organic materials in multilayer devices such as those found in organic light-emitting diodes and organic solar cells. It has now become clear that the interfaces between the organic materials and the inorganic electrodes can play a critical role in the performance and long-term stability of such devices. Using neutron reflectometry we have a unique method to study such interfaces, leading to insights that should allow us to engineer better devices with higher efficiencies and better durability.



Carbon materials for electrocatalysis

The reactions that occur in fuel cells and metal air batteries involve the reduction of oxygen to water. Because this reaction is sluggish a good catalyst is required and while noble metals such as platinum are good catalysts, they are expensive and scarce. Our goal is to design a carbon-based material to catalyse the oxygen reduction reaction in a similar way to platinum but at a much lower cost.

Carbon materials for energy storage

Electric vehicles are likely to play an important role in future transport solutions, particularly in cities. The major technological challenge facing widespread adoption of electric vehicles is the ability to store large amounts of energy in batteries that are light, durable, safe and low cost. We are researching carbon materials for use in lithium sulfur batteries, which offer the potential to store at least three times more energy than the current lithium ion technology and are cheap and easy to produce in large quantities.

Techniques you learn in our group may include: neutron reflectometry, film fabrication, electrochemical methods (CV, linear sweep voltammetry), battery fabrication and testing, electron microscopy, XPS.

Useful Majors: Chemical Sciences / Chemistry / Computational Science

PROFESSOR ELIZABETH GILLAM

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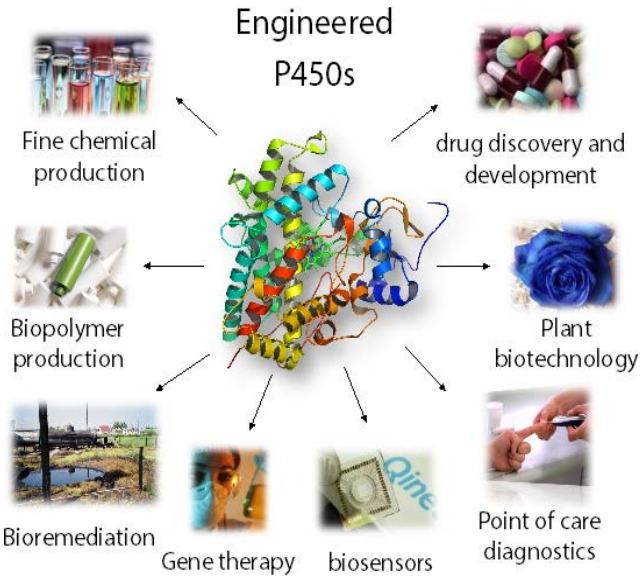
Enzyme Evolution/ Synthetic Biology

Cytochrome P450 enzymes can catalyse more than 60 different chemical transformations on an unprecedented variety of substrates, making them one of the most functionally versatile groups of biocatalysts known. An ancient family of enzymes distributed through all domains of life, they carry out diverse roles such as in the synthesis of hormones, the utilisation of carbon sources, the production of specialised lipids, and the clearance of foreign chemicals such as drugs. We are exploring the potential for P450s to be engineered for novel industrial applications by synthetic biology.



Our goals are to:

- Understand the catalytic versatility of P450s
- Determine what factors drive P450 evolution
- Create novel enzymes and systems that use P450s in clever ways for useful purposes.

Ancestral reconstruction of P450s, enzymes evolved to deal with the unknown

P450s metabolise ~ 95% of all drugs as well as innumerable environmental chemicals - an extraordinary range of substrates, many of which have not been present during evolution. We are studying how P450s have evolved to deal with such extreme diversity in their substrates by reconstructing ancestral precursors and evolutionary pathways. Results so far suggest the ancestors are extremely thermostable compared to modern enzymes, making them excellent candidates for use in industry, such as in modification of drug candidates or in biosensors.

Engineering P450s to increase food production in the third world

P450s catalyse many critical reactions in plants, such as in the biosynthesis of strigolactones, hormones with many potent effects in plants. We are using P450s to make strigolactones that can counteract the parasitic weeds which decimate food production in many parts of the third world.

Synthetic biology of P450s for clean, green chemistry in drug development, bioremediation and biosensors

We are engineering P450s that are more efficient, robust and specialized than naturally occurring enzymes for use in drug discovery and development, the synthesis of fine chemicals, and cleaning up the environment. Our approaches include using photosynthesis to power P450 reactions for clean, green biocatalysis in microalgae; immobilizing thermostable P450s in virus-like-particles as reusable, ‘designer’ reagents; and exploiting the spectral properties of P450s in biosensors.

Techniques you learn in our group may include: artificial evolution, protein engineering, high throughput screening, ancestral sequence reconstruction, fundamental methods of molecular cloning, genotyping, protein purification and metabolite analysis.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biophysics / Chemical Sciences / Biological Chemistry / Biotechnology / Genetics / Microbiology/ Biomedical Science

ASSOCIATE PROFESSOR LISBETH GRØNDAHL

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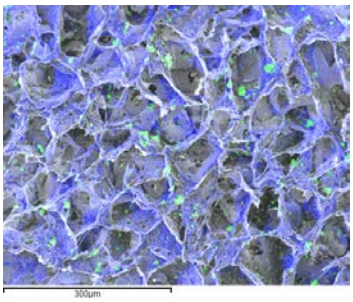
Research Area

The primary research area of the Grondahl Group is in materials design and evaluation. All projects builds on Physical and Materials Chemistry fundamentals.

Surface modification of polymeric materials

Polymeric materials including membranes are optimised with regards to their bulk properties but for many applications the surface properties are not ideal. Applications of surface-modified polymeric materials span from biomaterials science and tissue engineering to food science and water purification. This project will involve surface grafting of polymeric chains on polymeric substrates using free radical polymerisation. The modified materials will be evaluated with respect to surface chemistry, surface energy, surface roughness and viscoelastic properties were appropriate for the application. In addition, the modified materials will be tested for their performance in the intended application, eg. in vitro mineralisation, protein interactions, cell interactions.



Composite nano-materials for bone repair

Bone tissue engineering makes use of scaffolds for cell seeding. These scaffolds must have good mechanical integrity and bone-bonding ability. In order to achieve this, biocompatible polymers are combined with nano-sized filler particles. The function of the filler particles is two-fold: to enhance bone bonding ability and to enhance mechanical properties. However, to achieve this good dispersion as well as strong interfacial bonding with the polymer matrix is required. This project will use chemically modified hydroxyapatite nano-particels and study their dispersion both in solution and in polymer substrates. Evaluation of both in vitro mineralisation and mechanical properties will also form part of the project.

Protein delivery from polysaccharide systems

Delivery of protein drugs and nutraceuticals at an appropriate rate and with high bioactivity retained can be achieved by using a polysaccharide matrix material. Depending on the protein of interest and its intended application the polysaccharide matrix can be chemically modified to achieve a desired rate of release. Applications include delivery of growth factors to regenerate damaged tissue and incorporation of proteins with human benefit in food products. The project will involve the use of the polysaccharide alginate which will be modified with chemical moieties to modulate the intermolecular interactions with the protein thereby allowing for tailored rates of release. The chemically modified alginate will be evaluated using eg. NMR and FTIR while the intermolecular interactions between the protein and polysaccharide will be evaluated by eg. light scattering, and turbidity. Furthermore, the protein encapsulation efficiency and the release rate will be evaluated.

Techniques you learn in our group may include: XPS, FTIR, SEM, TEM, XRD, AFM.

Useful Majors: Chemical Sciences / Chemistry / Nanotechnology / Chemical Biotechnology

ASSOCIATE PROFESSOR LUKE GUDDAT

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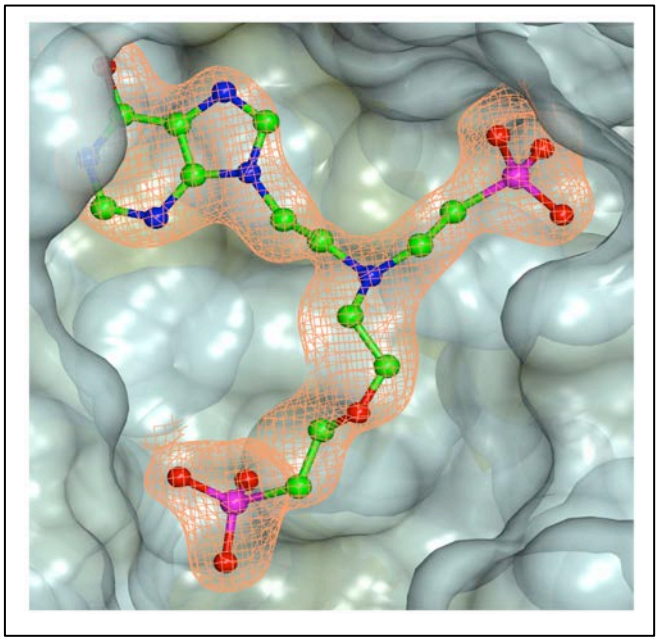
Research Focus: X-ray crystallography and Drug Design

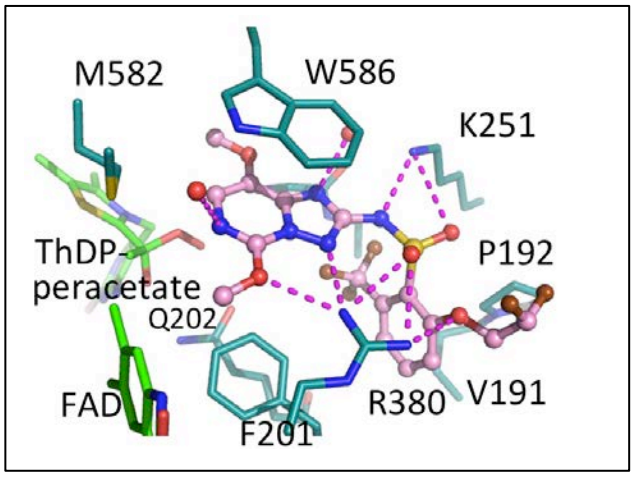


Our research is focused on understanding the structure, function and inhibition of enzymes that are essential to life. In particular, we are interested in studying enzymes involved in the synthesis of (i) RNA and DNA via the salvage pathway and (ii) the branched chain amino acids (BCAAs). These pathways are essential to the survival of many human pathogenic bacteria, parasites and fungi. For drug design this is a big advantage because humans and other animals either do not possess these pathways (*i.e.* BCAA pathway) or have alternative pathways (i.e. the *de novo* pathway for the biosynthesis of nucleoside monophosphates that are incorporated into RNA and DNA).

Our goals are to:

- Use X-ray crystallography to understand the structure and function of enzymes
- Use rational structure based drug design to develop potent enzyme inhibitors that can be tested as antimicrobial therapeutic drugs

Research Projects are available in a number of areas and can be tailored for honours, masters, masters by coursework and PhD students. Projects can range from protein expression, purification and characterization, to biological assays (e.g. testing for antimicrobial activity), to computer based drug design, chemical synthesis and X-ray crystallography. X-ray crystallography is the major technique used in this laboratory, but through collaborations with other research scientists (at UQ and overseas) we encourage multidisciplinary projects.



Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Chemical Sciences / Chemistry / Computational Science / Genetics / Microbiology / Parasitology

PROFESSOR ROY HALL

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Research Area

A major focus of our research is the discovery and characterisation of novel mosquito-borne viruses using new approaches and technologies developed in our lab. Analyses of new viruses to determine their modes of transmission, disease potential and taxonomic position are also key areas of study.

Our goals are to:

- Discover and genetically characterise novel mosquito-borne viruses
- Investigate mechanisms of their transmission and pathogenesis
- Produce research and diagnostic reagents for these novel viruses

Possible projects

Identification of novel viruses that infect humans and animals, and investigation of their modes of transmission and potential to produce disease.

Discovery and characterisation of novel viruses in mosquitoes, and investigation of their modes of transmission and effects on their insect host.

Techniques you learn in our group may include: Virus and cell culture (insect and vertebrate); immunoassays (ELISA, IFA, Western blot); RT-PCR and qRT-PCR; virus purification; animal inoculation and antibody production; virus gene cloning and expression; viral genome sequencing (Sanger and NGS), bioinformatics and viral phylogenetics.

Useful Majors: Microbiology / Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Genetics / Parasitology

PROFESSOR PHIL HUGENHOLTZ

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Microbiology & Genomics

As Director of the Australian Centre for Ecogenomics (ACE), a research centre within the School of Chemistry and Molecular Biosciences, Professor Hugenholtz's research includes the microbial ecology and evolution of host-associated ecosystems such as the koala and human microbiome, termite hindgut, and genomic mapping of the microbial tree of life. His group uses culture-independent molecular methods that he helped pioneer, to characterise microbial communities including marker gene and shotgun (metagenomic) approaches. Professor Hugenholtz is looking for motivated honours students to join his group on a number of exciting and cutting-edge projects.

Techniques you learn in our group may include: DNA extraction, next-generation library preparation, microbial community profiling, shotgun sequence analysis, microscopy, flow-activated cell sorting.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics/ Chemical Sciences / Chemistry / Computational Science / Genetics / Microbiology / Parasitology

ASSOCIATE PROFESSOR ULRIKE KAPPLER

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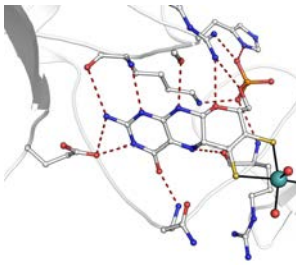
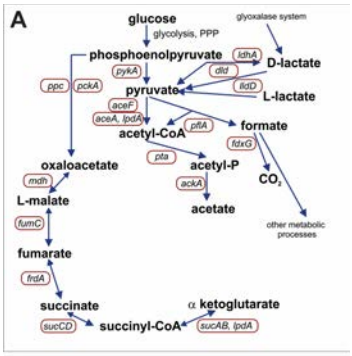
My Research Area



My interest is in bacterial physiology and how bacteria from various ecological niches, including host organisms, interact with their environment. A particular focus point are sulfur compounds and how they influence this process. Sulfur compounds have crucial roles in cellular function, but can also be toxic to cells (e.g. sulfide, sulfite) and affect key processes in the biosphere. Enzymes converting them have also been shown to affect virulence in several pathogens, which further highlights the importance of sulfur in cellular metabolism and cell-cell interactions.

The work in my group is very diverse and includes bacterial physiology, gene regulation, some genomic biology, proteomics as well as protein purification and characterization including different types of spectroscopy. Some areas in which we do work are set out below – please come an enquire about projects, there will always be additional options.

How do bacteria manipulate host cells? - Interactions between Haemophilus influenzae and the human host *H. influenzae* can cause respiratory tract infections of varying severity as well as invasive infections (septicaemia), but is unable to survive outside the human host, and therefore relies on being able to manipulate the host into 'allowing it to stay'. We are investigating how metabolites contribute to these interactions in a range of clinical isolates of *H. influenzae*, and are also investigating the role of individual enzyme systems in enhancing the survival of the bacteria.
Related projects: *Do metalloenzymes support virulence of human pathogens? Case study: Haemophilus influenzae Molybdenum enzymes; Friend or Foe? – Metabolic interactions between Streptococcus pneumoniae and H.influenzae; Alternatie sigma factors and H. influenzae virulence,*



Enzymes and their roles in bacterial physiology Metalloenzymes that can detoxify sulfur compounds are essential for cell survival, however, these enzymes are little studied, and even less is known about their role in the physiology of various bacteria. We have several current projects available looking to identify novel enzymes & pathways involved in sulfur detoxification in various species of bacteria, and we also study the proteins involved in the regulation of these enzymes.
Related projects: *Pathway discovery - How tetrathionate supports the growth of soil bacteria; Regulation of sulfite detoxification by alternative sigma factors; Novel sulfite oxidizing enzymes in marine bacterioplankton.*

Techniques you learn in our group may include: molecular microbiology, including genetic manipulation of bacteria, RNA techniques and physiological assessment of strains, protein purification and analysis, enzyme kinetics, systems biology techniques (mostly metabolomics & proteomics) basic phylogenetic analyses

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Chemical Sciences / Genetics / Microbiology

ASSOCIATE PROFESSOR STUART KELLIE

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Research Area

My interests lie in the cell biology and intracellular signalling processes in phagocytes and cancer cells. Phagocytes such as macrophages play a central role in both the innate and acquired immune response. Furthermore aberrant activation of these cells can lead to chronic inflammatory diseases. My interests are in identifying and functionally characterising macrophage signalling molecules that are associated with inflammation, and in intracellular signalling pathways in macrophages. I am particularly interested in the family of molecules known as tyrosine phosphatases and their role in regulating macrophage function. Current research is centred around the regulation of tyrosine phosphorylation in inflammatory and cancer cells.

Our goals are to:

- Understand the role of tyrosine phosphatases in the regulation of function in macrophages and cancer cells
- Generate tools that will allow us to investigate receptor-mediated intracellular signalling in those cells

Possible projects

- Determine the role of the tyrosine phosphatase PTPRJ in macrophages and breast cancer cells by characterising recombinant monoclonal antibodies
- Characterise the expression and function of novel isoforms of PTPRJ
- Test the effects of tyrosine phosphatase inhibitors on the generation of proinflammatory molecules and breast cancer cell proliferation

Techniques you learn in our group may include: Gene cloning; expression of novel genes in mammalian cells; quantitative PCR; cell culture; western blotting and other immunochemical techniques.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Genetics / Microbiology / Parasitology

ASSOCIATE PROFESSOR ALEXANDER KHROMYKH

NHMRC Senior Research Fellow

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Research Area

In our RNA Virology research group we study molecular mechanisms of virus RNA replication, virus-host interactions, and viral pathogenesis of mosquito-transmitted flaviviruses with the main focus on West Nile virus (WNV) and Zika virus (ZIKV).

Our goals are to:

- Identify viral and host determinants of WNV and ZIKV replication and virulence
- Understand mechanisms by which the identified virulence determinants influence outcome of infection
- Apply obtained knowledge to development of effective vaccines and antivirals

Viral and host proteins determining outcome of flavivirus infection

The projects aim to identify which viral and host proteins are responsible for determining outcomes of infection with WNV and ZIKV. The projects will employ recently-developed-in-our-group, state-of-the-art methodologies based on generation of large libraries of: (i) flaviviruses with all amino acid mutants in each codon of viral proteins; and (ii) recombinant flaviviruses producing siRNAs targeting entire host genomes. High throughput screening of these viral libraries *in vitro* and *in vivo* followed by deep sequencing of enriched virus populations and sophisticated bioinformatics will allow the identification of: (i) residues in viral proteins important for virus replication and pathogenicity, and (ii) host proteins restricting virus replication.

The role of viral noncoding RNAs in flavivirus-host interactions

Flaviviruses including WNV and ZIKV produce a number of non-coding RNAs from their 3' untranslated region, including subgenomic flavivirus RNA (sfRNA) and other small viral RNAs that play vital roles in virus replication and virus-host interactions. The projects aim to determine the role and mechanisms of action for viral noncoding RNAs in flavivirus-host interactions. The projects will employ RNAseq, bioinformatics, quantitative RT-PCR, RNA interference**,** small RNA detection, RNA-protein interactions, and proteomics to generate comprehensive networks of processes in infected cells regulated by viral noncoding RNAs.

Kunjin virus-based vaccine and cancer therapy vectors

We have previously developed and patented vaccine and cancer therapy vectors based on Kunjin virus replicons (self-replicating RNA). The projects aim at developing and evaluating the next generation vectors based on Kunjin DNA capable of generating single-round infectious viral particles.

Techniques you learn in our group may include: Molecular cloning, insect and mammalian cell culture, DNA and RNA transfections, RNA isolations, quantitative RT-PCR, generation of viral infectious cDNA clones and large libraries of mutant and recombinant flaviviruses, protein expression and detection, deep sequencing, RNA interference, small RNA detection and functional analyses, bioinformatics.

Useful Majors: Microbiology / Biochemistry & Molecular Biology / Bioinformatics / Genetics

PROFESSOR BOSTJAN KOBE

ARC Laureate Fellow

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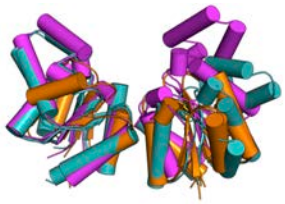
Structural biology of infection and immunity



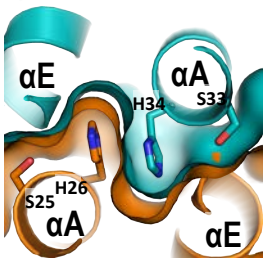
The group's research theme is protein structure and function, with an emphasis on understanding the structural basis of intra- and inter-molecular interactions formed by these macromolecules, and inferring function from structure. The biological focus is on proteins involved in infection and immunity. The primary technique used in the laboratory is X-ray crystallography, combined with a plethora of other molecular biology, structural, biophysical and computational techniques.

Our goals are to:

- Use structural and molecular information to understand the molecular and cellular functions of proteins
- Validate proteins as therapeutic targets or biotechnological products
- Design new therapeutics and biotechnological applications

Molecular and structural basis of bacterial, viral and fungal pathogenesis

Despite the availability of antibiotics for over 60 years and advances in anti-viral drug development, infectious diseases continue to cause global morbidity and ~20 million deaths per year. The aim of our project is to use structural biology to understand the processes of pathogenesis by different pathogens. The work has implications for developing anti-infectives and vaccines against bacteria (e.g. *Streptococcus pneumoniae*, *S. pyogenes*, *Neisseria gonorrhoeae*), viruses (e.g. dengue), and fungal pathogens (e.g. *Cryptococcus neoformans*). We are focusing on bacterial cell-surface and metal-transport proteins, viral envelope proteins and purine biosynthesis enzymes in fungi.



Molecular and structural basis of innate immunity

Innate immunity receptors detect pathogens and endogenous danger and initiate immune responses. In humans, innate immune pathways are associated with infectious, autoimmune, inflammatory, cardiovascular diseases and cancer. In plants, diseases account for 15% of crop losses, and plant immune receptors represent an environmentally safe strategy to protect crops. The aim of our project is to use structural biology to understand the molecular basis of innate innate immune responses. In the animal system, we are focusing on the proteins involved in signalling by Toll-like receptors. In the plant system, we are focussing on the interaction between pathogen effector proteins and plant "resistance" proteins that initiate immune responses.

Techniques you learn in our group may include: Recombinant protein expression and purification, X-ray crystallography and other structural biology methods, protein interaction analyses and biophysical characterization, molecular biology, bioinformatics and computational biology.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biophysics/ Microbiology / Biomedical Science

DR ELIZABETH KRENSKE

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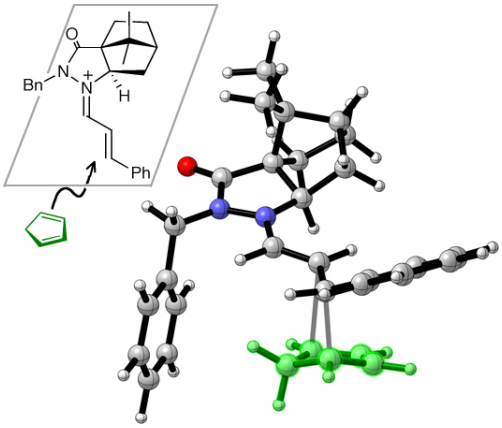
Molecular Modelling, Chemical Reactivity, and Drug Design

Our laboratory performs sophisticated computer simulations to study how molecules react. Molecular modelling provides atomic-level insights into many aspects of chemical reactivity – ranging from reactions that occur in a laboratory synthesis to the reactions that occur within the cells of our body. We apply modelling techniques to solve practical problems: for instance, how to design a drug that will interact with a specific therapeutic target, or how to make a laboratory synthesis more efficient.

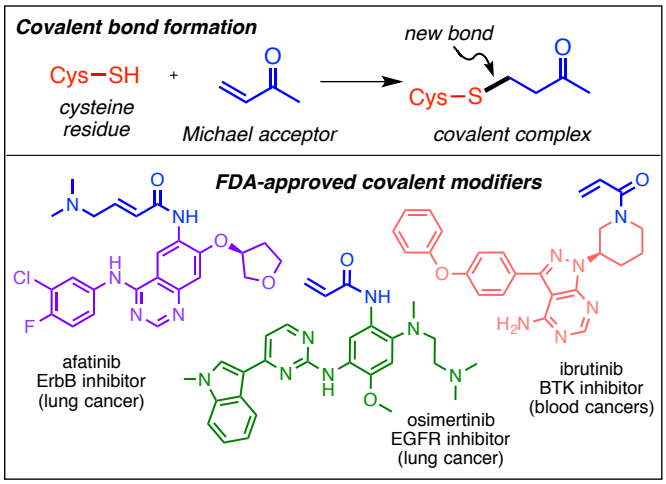
Designing New Catalysts



One area of current interest involves designing new types of catalysts to allow chemists to control the stereochemical outcomes of synthetic reactions. Stereocontrol is crucially important in the synthesis of pharmaceuticals. We perform transition-state modelling to obtain detailed pictures of bond-forming processes, revealing the exact interatomic interactions responsible for stereocontrol and reactivity. These insights help us to guide the development of new, more efficient chiral catalysts.

We frequently collaborate with leading synthetic chemists, both within SCMB and around the world. Projects are available that focus either entirely on computational research, or on a combination of experimental and computational work. Research projects in computer modelling add a new dimension to students' skillsets, complementing their laboratory training, and provide experience in working as part of a collaborative multi-disciplinary research team.

Exploring Drug–Target Interactions



We are engaged in research on covalent modifiers – an emerging class of drugs. Using molecular modelling and dynamics simulations, we study the interactions of these molecules with biomolecules. These simulations provide detailed fundamental insights about the factors that control drug–target binding. The aim of these *in silico* studies is to predict the activities and safety profiles of new examples of this important class of drugs, which have applications in cancer therapy.

Techniques employed by our group include: Molecular modelling including density functional theory (DFT), *ab Initio* calculations, molecular mechanics and dynamics, and transition state modelling. High-performance computing.

Useful Majors: Chemical Sciences / Chemistry / Computational Science

DR MICHAEL LANDSBERG

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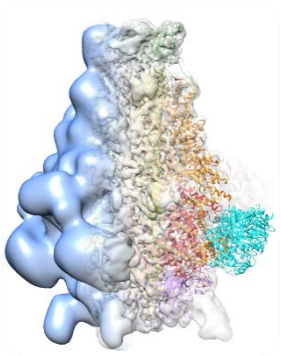
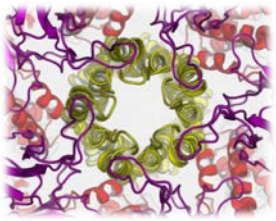
Structure and function of molecular machines



Our group is focused on understanding the structures and molecular mechanisms that underpin the functionality of important macromolecular machineries. The vast majority of proteins in our cells don't act in isolation; instead they form intricate networks of molecular interactions, many of which underpin the assembly of functional multi-subunit machines. The structure determination of large multi-protein complexes has been revolutionized by recent technological advances in electron cryo-microscopy (cryo-EM), a technique that is now poised to deliver unprecedented insights into many biological systems.

Our goals are to:

- Determine novel structures of protein complexes that are of fundamental biological importance, particularly in the context of microbial pathogenesis and disease.
- Use structural information to elucidate biological mechanisms, establish new insights into function, and identify new therapeutic strategies and biotech applications.



Structure and function of pore-forming toxins

Pore-forming toxins (PFTs) are hole-punching molecular machines that compromise the tightly regulated permeability of cellular lipid bilayer membranes. ABC toxins are a recently characterised family of PFTs that deliver potent cytotoxic enzymes to specifically targeted cells. Structural biology has begun to deliver insights into the molecular mechanisms employed by this family of toxins, but many questions remain unanswered. We are particularly interested in learning more about how ABC toxins recognise cell surfaces, as well as understanding in more detail the mechanism of toxin translocation and ultimately, their role in bacterial pathogenesis.

Viral protein structures and host factors involved in virus infection

We are also engaged in a number of research projects focused on understanding structures that are important in the context of virus infection. We use cryo-EM to determine the structure of "virus-like" capsid mimics that can be used as tools to understand mechanisms of virus infection, or for the delivery of therapeutic molecules. We also study host protein machineries that interact with viral proteins to facilitate infection by viruses such as HIV and Ebola.

Mega-enzymes and multifunctional protein complexes

Another area of research interest is mega-enzymes. We aim to determine structures of large proteins and complexes that combine multiple enzymatic modules into a single assembly.

Techniques you learn in our group may include: Molecular biology, protein expression and purification, cryo-EM, single particle image processing, structural modelling, bioinformatics.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biophysics / Chemistry / Computational Science / Microbiology

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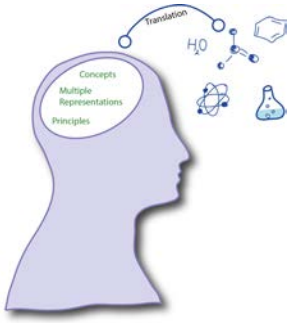
Chemistry Education Research

Chemistry education research, informed by models and theories, enables us to develop richer and more responsive learning environments to support student learning. Instructional design is based on knowing how students construct their understanding of chemistry concepts as well the factors that motivate and engage students in learning. Current projects available in my group include:

- the exploration of how multimodal external representations, used either in lectures or in online learning modules, can be integrated to construct student understanding of concepts and student behaviour in online learning environments.
- the investigation of effectiveness of online assessment strategies that aim to authentically capture student thinking.



Development and evaluation of multimodal resources.

Learning chemistry requires the development of internal mental models of concepts; hence instructors typically adopt multiple external representations (MERs) in their teaching. Often they may intentionally use MERs to provide complementary information, however more strategic scaffolding of learning can be achieved when MERs are integrated to promote students' construction of deeper understanding. The aim of this project is to translate specific combinations of external representations into alternative modalities, thereby widening access for student learning. Data will be collected to explore several aspects of learning, including students' visuospatial skills and cognitive load introduced through multimedia. Research students who undertake this project will gain deeper insights into pedagogies and practices in teaching chemistry, as well as the opportunity to create new tactile (involving 3D printing) and virtual resources. They will find that their own visual literacy is also increased as a result of focusing deeply on multiple representations of a key chemistry concept and how students engage with these.

Technology-enhanced collaborative explanation and learning.

This new project involves the investigation of online learning environments that support students to develop their reasoning and metacognitive skills through explanations and collaborative discussion. This research involves developing mechanisms for making explicit and evaluating students' thinking when they are faced with cognitive disequilibrium (an event that challenges their thinking), applying the educational framework of discourse analysis. The aim of the project is to design new authentic online assessment tasks with linked criteria that teachers can use efficiently in marking. Students who opt for this project will also have opportunity to design the stimulus resources, for example, videos of real phenomena in which what you see is not what you initially expect.

Techniques you learn in our group may include: Quantitative and qualitative research methods, including statistical analysis of psychometric data and interview skills. Information and communication technology skills and instructional design using new media and online tools.

Useful Majors: Chemical Sciences / Chemistry / Biochemistry & Molecular Biology / Psychological Sciences / B Education / B Science Dual program

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Infection & Immunity

Immunotherapy for non-melanoma skin cancer (NMSC)

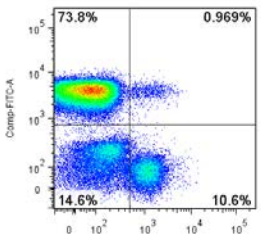
In Australia, approximately 2% of the population is diagnosed with a non-melanoma skin cancer each year. In Queensland, we are particularly susceptible given that sunlight is the causative agent for skin cancers and we lead an outdoor lifestyle. Our current research is focused on understanding the immune response against non-melanoma skin cancers and developing immunotherapies for treatment of these tumours. Currently, the most common treatment for NMSC is surgical removal which can be disfiguring to the patient. A subset of these cancers are also aggressive and move from the skin to form cancers at other sites in the body. It appears that the cancers develop the ability to avoid or inhibit our natural immune response and understanding this process is the central focus of my lab. We are also interested in the types of immune cells required to attack the cancer and how best to activate and maintain their activity over time.

Our goals are to:

- Promote CD8 T cell function in NMSC by reducing tumour-induced immunosuppression
- Study the development of CD8 T cell memory within precancerous and cancerous skin tissue

Immunotherapy of NMSC and their precursor lesions during lymphopenia

We have previously shown that precancerous skin lesions invoke an immunosuppressive local tumour environment through the actions of natural killer T cells (NKT). This project is focused on eliminating these suppressor cells through lymphodepleting drugs or irradiation followed by reconstitution of anti-tumour immunity. The project looks at different combinations of lymphodepleting regimes and the timing of immune cell transfer.



Memory CD8 T cell subsets in NMSC

Long-lived, memory T cells are a key goal of any vaccination strategy for cancer. This project studies the development of different memory CD8 T cell subsets within skin precancers and tumours including the recently described tissue-resident memory T cells. Both the function and longevity of these T cells are analysed to determine how we can enhance their anti-tumour efficacy.

Techniques you learn in our group may include: flow cytometry, ELISPOT, ELISA, tissue culture, T cell proliferation assays. immunofluorescence microscopy.

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Microbiology / Parasitology

DR SHIH-CHUN LO (LAWRENCE)

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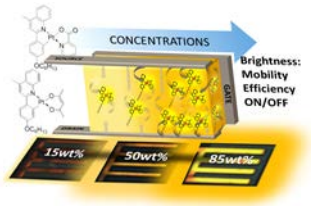
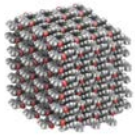
http://www.physics.uq.edu.au/cope/node/2

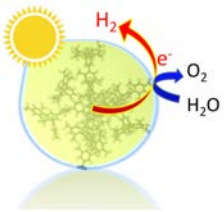
Research Area



Functional (nano)materials are playing the key role in advancing organic electronic and photonic applications, as well as biotechnology. In my research group, we focus on new materials design and synthesis with materials ranging from organic/organometallic small molecules, oligomers, dendrimers, and polymers, as well as inorganic nanocrystals, aiming to gain understanding of chemical structure-property relationships.

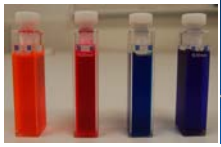


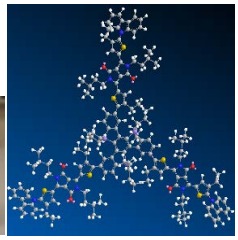
Advanced materials for clean energy generation



The search of renewable clean energy is of urgent need to meet with the increasing global energy demands and effectively converting solar energy into electricity or chemical energy is a promising approach. The programs involve design of advanced organic light absorption dyes via molecular engineering to get new insights into photophysical properties for improved performance in solar electricity production and also clean hydrogen fuel generation.

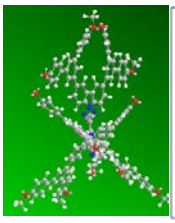
Luminescence materials for light-emitting displays, lasers & sensors

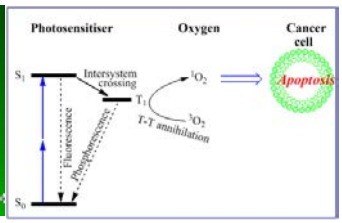




Highly luminescent organic chromophores have shown the promise for our next generation high-quality displays (*e.g.*, mobile phones and TVs). The aim of the program is to develop new efficient light-emitting chromophores for (transparent) light emitting displays, transistors, lasers, and bio-sensors on glass or flexible substrates utilising low-cost solution processing and printing methods.

Bio-nanomaterials for imaging and cancer treatment





Photodynamic therapy (PDT) has been developed to provide non-invasive (*cf.* conventional surgery) and less side effects (*cf.* chemotherapy) for cancer treatment. PDT can be accurately targeted, and repeatedly administered without total-dose limitations related with radiotherapy, resulting in little or no scarring after healing. We are developing new bio-compatible high-resolution 3D imaging agents and non-invasive PDT agents for deep tissue treatment under mild conditions.

Techniques you learn in our group may include: design, synthesis, purification and characterisation of functional (nano)materials; understanding their photophysical/electrochemical/ thermal properties; device fabrications and properties for applications like solar water-splitting, clean energy generation, organic light-emitting diodes, transparent light-emitting field-effect transistors, lasers, bio-sensing photodynamic therapy, and 3D imaging.

Useful Majors: Synthetic organic (organometallic) chemistry / Physical chemistry / Material chemistry / Sustainable energy / Nanotechnology / Biotechnology

PROFESSOR ALAN E. MARK

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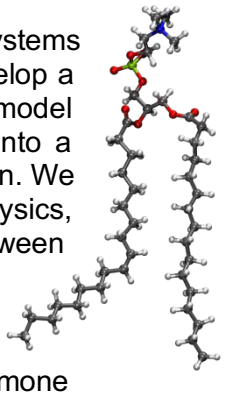
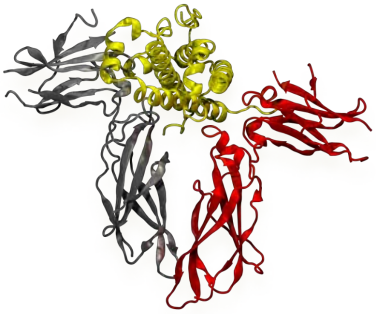
Structural & Molecular Biology

Molecular Dynamics



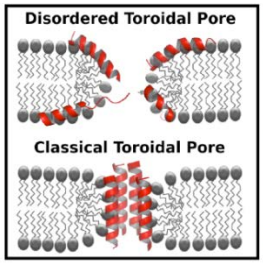
Our group uses computers to model the dynamic behaviour of biomolecular systems such as proteins, carbohydrates, nucleic acids and lipids. In particular we develop a range of software and interatomic interaction parameters and use these to model processes such as how a protein or peptide spontaneously self-assembles into a functional complex or how a potential drug molecule may bind to its target protein. We look for students with backgrounds in structural biology, physical chemistry, physics, pharmacology or computational science interested in working at the interface between these disciplines. Example projects include:



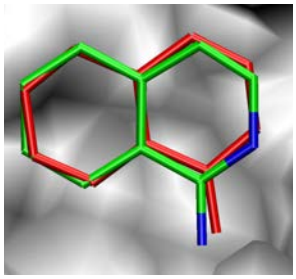
The activation of cytokine receptors

Cell surface receptors such as the growth hormone receptor and the epidermal growth factor receptor play critical roles in cell regulation. Simulation techniques will be used to characterize the conformational changes within the extracellular and transmembrane domains that accompany the binding of the cytokine (growth hormone, erythropoietin, prolactin or epidermal growth factor) to its receptor thereby shedding light on the mechanism of action of cytokine receptors in general.

Membrane protein assembly



The self-assembly of membrane peptides and proteins into functional complexes is fundamental to cell survival. We are investigating a range of peptides that spontaneously self-assemble within membranes inducing pore formation, membrane fusion, or even cell death. On a larger scale we are studying how proteins of enveloped viruses such as Dengue and Ebola drive the fusion of the viral and cell membranes. This is a key step in the entry of the virus into cells and a prime target for therapeutic intervention.



Molecular Interactions parameters

The automated topology builder (https://atb.uq.edu.au/) provides parameters for use in drug design and X-ray structure refinement. Our aim is to improve the parameterization of novel molecules and validate these against experimental solvation free energies. The work involves quantum chemical calculations, programming in python and mysql, matrix algebra, atomistic simulations and free energy calculations.

The group also works on a variety of other problems. These include peptide folding and assembly; the mechanism of action of pore-forming antimicrobial peptides; the nucleation and growth of amyloid fibrils; and the mechanism of action of glycopeptide antibiotics.

Useful Majors: Biochemistry & Molecular Biology / Biophysics / Chemical Sciences / Chemistry / Computational Science / Physics / Maths

PROFESSOR ALASTAIR MCEWAN

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Metal Ions in Infectious Diseases

Six first-row *d*-block metal ions – Mn, Fe, Co, Ni, Cu, and Zn – are essential micronutrients and are important in host-pathogen interactions; in some cases the human host prevents acquisition of these metal ions by invading bacterial pathogens (starvation) but there is also evidence that metal ion intoxication by Zn and Cu is also a key antimicrobial strategy at the host-pathogen interface.

Our goals are to:

- ✓ Identify and characterise mechanisms of metal ion metabolism in pathogenic bacteria, and their role in virulence.
- ✓ Study the biochemistry of proteins involved in the handling of transition metal ions
- ✓ Develop metal-based drugs as new therapeutics against bacterial infections.

Cu and Zn defenses in *Haemophilus influenzae* (with Dr Cheryl-lynn Ong)

Haemophilus influenzae is a leading cause of infections in the respiratory tract (COPD) and middle ear (otitis media). Our group and others have shown that Cu and Zn have a role in defense against bacterial pathogen (*J Biol. Chem.* PMID 26055706). This pathogen possesses an operon that may encode a pathway for Cu detoxification and an operon for Zn detoxification, both of which has never been characterised. In this project, you will use techniques in molecular biology, microbiology, biofilms, and cell culture to delete these two operons and determine the effects of this deletion in the ability of this bacterium to tolerate Cu and Zn exposure, to form biofilms, and to invade and survive within host macrophages and neutrophils.

Using metals to combat pneumococcal biofilms (with Dr Cheryl-lynn Ong)

Streptococcus pneumoniae (or pneumococcus) is a major human pathogen responsible for a range of diseases from middle ear infections, to pneumonia, meningitis and bacteraemia. The ability to form biofilms is critical for initial colonisation of the host. Furthermore, cells within the biofilms are protected from host innate immune system, antibiotics and other antimicrobials. As a result, pneumococcus can be difficult to treat and results in recurrent infections. This pathogen has been shown to require the use of Fe and Zn to form strong biofilms. In this project, you will use techniques in molecular biology, biofilms, and cell culture methods to test biofilm formation of various clinical isolates in the presence and absence of different metals and chelating compounds. This project has the potential to identify alternative antimicrobials that can abrogate pneumococcal biofilms.

Techniques you learn in our group may include: Basically everything that encompasses the fields of microbiology, biochemistry, molecular biology, cell biology and a bit of chemistry.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Basic Chemistry / Genetics / Microbiology

ASSOCIATE PROFESSOR ROSS MCGEARY

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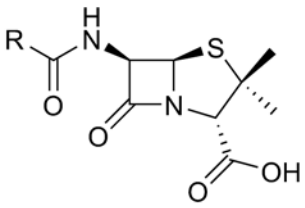
Organic and Medicinal Chemistry



Our group studies biological/medicinal chemistry and new synthetic methodologies. We also collaborate with colleagues both within the School, and in other universities. Several projects are available for Honours students and PhD students, and these group members will gain skills in synthetic organic chemistry, computer-aided inhibitor design, structure elucidation, and bioassays. I encourage you to contact me to discuss potential projects. New projects emerge from time to time, and further information can be found on my website (above).

Our goals are to:

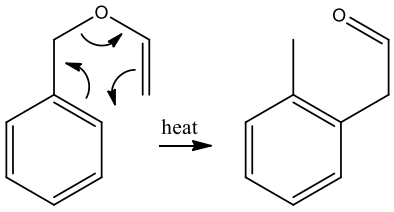
- Design new organic chemistry reactions
- Use organic chemistry to make molecules that are biologically active

Making New Molecules to Combat "Super-Bugs"

In recent years pathogenic bacteria have developed to ability to neutralise important β-lactam antibiotics such as the penicillins and carbapenems. This means that bacterial infections that were once easily treated can now become life-threatening. The World Health Organization (WHO) has described the rise of antimicrobial resistance a "global crisis". The bacteria are able to resist the β-lactam antibiotics by secreting an enzyme called metallo-beta-lactamase. Our research aims to develop potent inhibitors against this enzyme, as a first step towards developing new drugs to be used in the clinic. If the enzyme can be effectively inhibited, the bacteria will lose their resistance towards β-lactam antibiotics.

A New Type of Claisen Rearrangement

We have been studying a new type of Claisen rearrangement, which we have named the "Benzyl-Claisen rearrangement". This involves the thermal [3.3]-sigmatropic rearrangement of benzyl vinyl ethers, and we have been examining the scope and limitations of the reaction, using various differently functionalised substrates. This is purely a curiosity-driven project and it is being carried out in collaboration with Dr Elizabeth Krenske, a computational chemist in our School.



Other Medicinal Chemistry Projects

Our group collaborates with colleagues at this and other universities on multidisciplinary research projects focussed on medicinal chemistry. See the entries by A/Profs Schenk and Guddat for more details.

Techniques you learn in our group may include: Synthetic organic chemistry, spectroscopic techniques for structure elucidation, ab initio calculations, computer-aided inhibitor design, enzyme expression and assays.

Useful Majors: Chemistry / Chemical Sciences / Biomedical Science

PROFESSOR MICHAEL MONTEIRO

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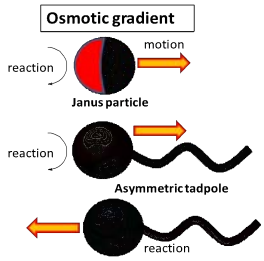
Research Area

Professor Monteiro has established an international reputation in the field of 'living' radical polymerization to create complex polymer architectures, including dendrimers, cyclic polymers and polymer nanostructures. His work focuses on building designer polymers for various biomedical applications, including vaccines, drug delivery and stem cells.

Our goals are to create new polymers with 'smart' and responsive behaviour for applications in biomedicine.



Designer Polymer Nanomotors

The aim of the project is to understand and then mimic the function of specialised, efficient and powerful biological molecular motors; this represents a grand challenge in the field of nanotechnology. Nature has recognised that controlling movement using molecular machines allows completion of complex tasks, such as active cargo transport, response and adaptation to environmental cues, regulation and transcription of RNA and DNA, cell fate and many more. Fuels (e.g. ATP) that drive biological motors and keep the system out-of-equilibrium are a key requirement for motion or motility. Directed motion for active transport has the distinct advantage that it overcomes the limitation of Brownian diffusion, providing nanoscale motors with faster and thus greater target-receptor selectivity, sampling of significantly larger volumes and decision options (i.e. logic functions).

My group devised an innovative method that utilises thermoresponsive polymers and *in situ* polymerization to make block copolymers. We were the first to create stable nanostructures directly in water at high weight fractions of polymer with multifunctional and orthogonal chemical groups on the surface through a one-step process. Thus formed block copolymers have a very low PDIs (<1.1), allowing reproducibility in forming the nanostructure. **Producing such nanostructures directly in water with surface chemical functionality will provide a facile method to covalently attach catalysts for fuel driven reactions. Further, producing these nanostructures at high weight fractions will allow scale-up for future applications.**

Techniques you learn in our group may include: Organic and Polymer Chemistry, Kinetics, Thermodynamics, Cell transfection in tumour sphere models.

Useful Majors: Chemistry / Chemical Sciences / Computational Science / Biochemistry & Molecular Biology / Biomedical Science / Biophysics /

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Nanotechnology & Materials Chemistry

Lanthanide Chemistry

Our research is focused on exploiting the unique luminescent properties of the Lanthanide series of metal ions, which are increasing utilised in high-end technological applications. Their unusual properties can be traced to their electronic structures, which are characterised by the progressive filling of 4f atomic orbitals. Our current research projects relate to the development of organic lanthanide complexes for applications in several different areas, as summarised below.

Luminescent Imaging

Lanthanides have well known luminescence properties. Their Laporte forbidden emission bands are sharp and atom-like, due to the core nature of the 4f orbitals involved, and their emission is much longer lived (μsec to msec) compared to organic molecules (nsec). We are interested in developing complexes of Yb(III) and Nd(III), which show emission in the Near Infra-Red (NIR) region. These wavelengths allow for improved penetration into tissue, and emissive complexes can be used in NIR imaging and optical tomography.

Photodynamic Therapy

Due to their high atomic mass, lanthanides exert a strong influence on the efficiency of intersystem crossing (eg. excited singlet to triplet state conversion) by enhancing spin-orbit coupling. The long-lived triplet state of organic molecules can act as a photosensitiser leading to the formation of excited ($^1\Delta g$) singlet oxygen, which is a highly reactive molecule, and can damage cellular structures, forming the basis of photodynamic therapy (PDT). We are exploring the use of Ln(III) complexes to influence existing photosensitisers used for PDT, and developing new Ln(III) based compounds with enhanced efficacy.

Lanthanide Frameworks

Coordination Polymers (CP's) (or Metal Organic Frameworks – MOF's) are crystalline materials built from infinitely repeating units of (typically) rigid organic ligands interconnected by metal cations to form 1-, 2-, or 3 dimensional structures. Our research in this area involves the construction of CP/MOF's utilising Ln(III) metal cations (as opposed to more commonly used transition metals), in combination with organic ligands such as aromatic N-oxides. We are interested in the structural, magnetic, and luminescent properties of these materials, together with their applications in important industrial processes such as gas sorption, separation and storage.

Techniques you learn in our group may include: Organic and inorganic synthesis, coordination chemistry, spectroscopy (NMR, UVVis, Luminescence).

Useful Majors: Chemical Sciences / Chemistry

DR JUSTIN RIDGE

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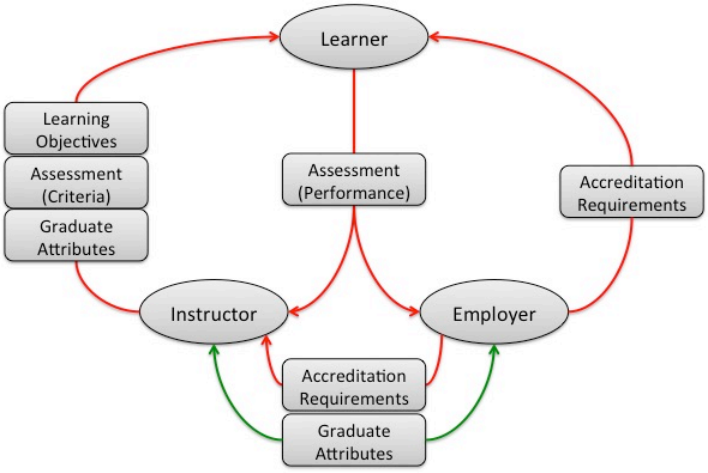
Science Education

My research focuses on the expectations of the key stakeholders (learners, instructors and employers) in the education of work-ready graduates. The basics of the relationships between the three stakeholder groups, and the means of communicating expectations, are shown below. There are three significant issues around these relationships: we do not fully understand the expectations of each group; we do not know if the expectations are being communicated effectively; and much of the communication is unidirectional (red arrows).

Our goals are to determine:

- What these expectations are for each of the stakeholders;
- How these expectations are communicated between stakeholders; and
- How we can seek to improve communication and manage expectations.



What skills should we teach (and how do we teach them)?

Students are often perceived to be poorly prepared to enter the research laboratory. To address this requires a multi-faceted approach to answer key questions: What skills do laboratory heads desire? Do students value the same skills? Are those skills being taught and assessed adequately? We hope to go on to: revise and improve learning objectives; and develop a research-skills portfolio for students. This project involves interviewing and surveying stakeholders to establish the rationale for change and the subsequent evaluation of changes we implement.

Engaging students in the learning design process

Academic staff go to considerable effort to create learning objectives that are aligned with graduate attributes, learning activities and assessment. However, students often fail to engage with, or understand learning objectives. This has negative impacts on student expectation and learning gains. This project will develop a series of workshop that will: improve student understanding of learning objectives and provide a mechanism for iterative and collaborative improvement of these objectives.

Techniques you learn in our group may include: Mixed-methods research including: design and implementation of surveys; quantitative and qualitative data analysis; ethnography; and grounded theory.

Useful Majors: All Science/Biomedical Science Majors; Education and other.

ASSOCIATE PROFESSOR MARK RILEY

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Nanotechnology & Materials Chemistry

Molecular Spectroscopy

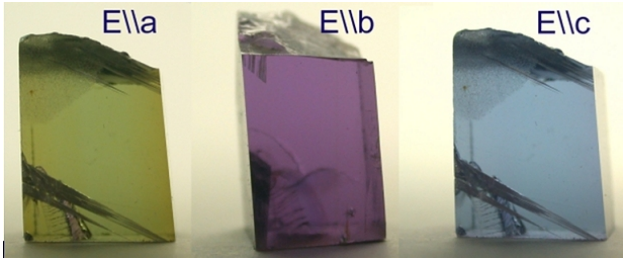
We have had a long standing interest in field of molecular spectroscopy and its use in determining the electronic structure and bonding in transition metal complexes and other materials. In particular we are interested in the molecular dynamics that results from the coupling of electronic and vibrational states and the cooperative effects that can result in the solid state from the magnetic/Jahn-Teller effects of unpaired spin/orbital systems.

Our goals are to:

- Create new materials that show interesting properties that could be used as molecular level devices, (switches and information storage)
- Understand how energy transfer occurs in metal centres

The study of the antiferromagnet CuB_2O_4

Crystals of copper meta-borate (CuB_2O_4) contains planar $Cu^{II}O_4$ species separated by BO_4 tetrahedra. It is an antiferromagnetic material below T_N = 20K and shows a number of remarkable properties. These include a claimed ability control of the crystal chirality by a magnetic field, the control of the magnetization direction by an electric field and the observation of a "Giant Optical Magneto-electric Effect". This latter effect results in the crystal having the intriguing ability to transmit light in one direction, but not in the opposite direction.

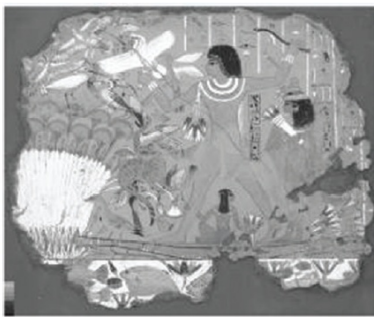


The optical properties of Tanzanite

Tanzanite is a rare gemstone that occurs only in a small area on the slopes of Mt Kilimanjaro. The blue/purple colour is thought to be due to trace amounts of V^{3+} replacing some of the Al^{3+} ions. The very different absorption of different polarisation of light makes it an ideal system for high resolution spectroscopic studies.

Luminescence and MCD of Egyptian Blue

Egyptian Blue ($CaCuSi_4O_{10}$) is a pigment that was first synthesized some 3500 years ago, and shows a remarkable and very unusual emission in the infra-red. The project will aim to understand the reason for this very efficient emission through time resolved fluorescence and low temperature magnetic circular dichroism (MCD) spectroscopic studies.



Techniques you learn in our group may include: Crystal growing, low temperature spectroscopy, electronic structure calculations, EPR, (M)CD, luminescence.

Useful Majors: Biophysics / Chemical Sciences / Chemistry / Computational Science

DR CHRISTIAN RINKE

ARC Future Fellow

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Microbial Genomics and Evolution

My main interests are genomics, ecology, and the phylogeny of uncultured microbes. Our group uses single-cell genomics, which is the separation and sequencing of single bacterial and archaeal cells, and metagenomics, which is the direct sequencing of environmental samples. Both methods are perfectly suited to explore uncultured microbes, also known as microbial dark matter.

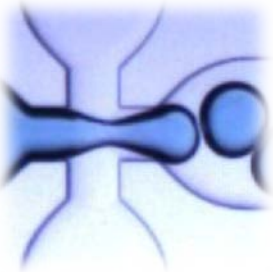
Our goals are to:

- Explore the metabolic potential of archaeal dark matter
- Improve microbial single-cell genomics
- Investigate the plastic degrading capabilities of host-microbe associations

Archaeal dark matter – exploration of the deep sea

Archaea are the third domain of life on our planet and thrive in a range of extreme environments, including deep sea hot vents and hyper saline pools. Archaeal diversity remains under-explored and we know little about the metabolic potential of these elusive microbes. We are exploring extreme habitats such as deep-sea sediments and hydrothermal vents to sequence DNA from single-cells and entire communities. We then reconstruct archaeal genomes and asses encoded functions. In particular we are interested in a group of Archaea which could be the missing link between prokaryotes and all eukaryotes, including us humans.

RV *Investigator* is Australia's marine research vessel.



Dissecting populations one cell at a time

Single-cell genomics enables us to sequence single-microbial cells and thus dissect microbial communities one cell at a time. We are constantly improving this cutting-edge technique to recover more complete genomes of uncultured bacteria and archaea.

Biodegradation of polystyrene

The durability of plastic products results in negative environmental impacts, for example nearly 269,000 tons of plastic debris is floating in our oceans. Polystyrene (incl. styrofoam) is among the four most common polymers and can be biodegraded by insects and their symbionts; however the key microorganisms and metabolic pathways involved in this process are poorly understood. We are using culture-independent techniques and bioinformatics to profile the community, reconstruct microbial genomes, and identify enzymes involved in styrene biodegradation.

Techniques you learn in our group may include: metagenomics, single-cell genomics, phylogeny, microbial ecology, and bioinformatics.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Computational Science / Genetics / Microbiology

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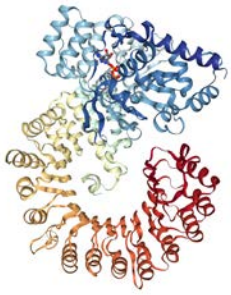
Research Area

The major focus of my research group is discovery and development of novel therapeutics for areas of unmet medical need. We are particularly interested in small molecule modulators of innate immune pathways to prevent or enhance inflammation. Other focus areas include cancer and infection, linking strongly to our interest in immune response. These multidisciplinary projects often include collaboration at local, national and/or international level.

Inflammasome inhibitors



NLRC4 protein
(PDB:4KXF)

Inflammasomes are multimeric protein complexes which form as part of the innate immune response. They act as platforms to process pro-inflammatory cytokines interleukin (IL) -1β and IL-18 to their active form and also trigger a pro-inflammatory cell death called pyroptosis.

Inflammasome dysregulation underlies an astounding array of disease states including Parkinson's Disease, asthma, cardiovascular diseases, autoimmune diseases (CAPS, Muckle Wells, NOMID) amongst many others. Therapeutic potential of inflammasome modulation has led to keen commercial and academic interest. NLRP3 inflammasome is the most well understood and a few inhibitory molecules are now entering clinical phase. Other inflammasomes, such as AIM2 and NLRC4, remain underexplored with no potent, selective inhibitors. We have multiple projects in this area.

Antifungal drug discovery

The pathogenic fungi Cryptococcus neoformans is a leading cause of death in HIV/AIDS patients. Infection usually occurs in immunocompromised patients after airborne basidiospores or desiccated yeast cells are inhaled resulting in pneumonia or, more frequently, dissemination to the central nervous system to manifest as meningoencephalitis. Without treatment, this disease is uniformly fatal. There are very few drugs available to treat pathogenic fungal infections. Current treatment is focussed on three available drugs: amphotericin B, flucytosine and fluconazole. Alarmingly, resistance to all three drugs has been observed and novel antifungal agents are urgently needed. We are working in collaboration with Assoc Prof Fraser and Prof Kobe to design and develop new antifungal drugs.

Techniques you learn in our group may include: medicinal chemistry, isotopic labelling, tests for drug-likeness, organic synthesis, chromatographic purification, structure determination.

Useful Majors: Chemical Biotechnology / Drug Design and Development / Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Chemical Sciences / Chemistry / Computational Science.

ASSOCIATE PROFESSOR JOE ROTHNAGEL

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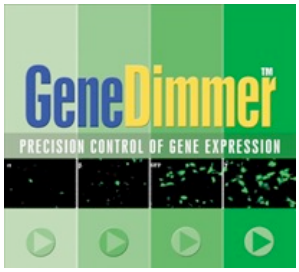
Molecular Genetics, Cell Biology and Bioinformatics



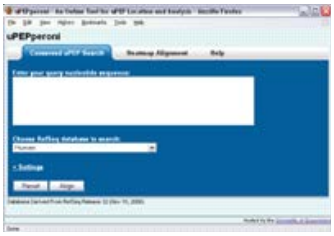
We study eukaryotic gene expression and use this information to develop novel tools for research and medical applications. This work has led to the development of *cis*-acting sequences, based on short upstream open reading frames (uORFs), which can be used to modulate gene expression; known as GeneDimmer™ and GeneBooster. This work has also led to an interest in the peptides encoded by these short ORFs.

Our goals are to:

- Characterise sequence variants in skin and hair genes
- Characterise the small peptides encoded by sORFs
- Develop nuclear-targeting tags

Gene expression in the skin

Our research is focused on the molecular mechanisms that regulate skin and hair development and epidermal differentiation in order to provide the basic knowledge needed for improving the treatment of inherited and acquired skin disorders such as eczema, psoriasis, cancer and wounds. Importantly, the skin serves as an important model for other epithelia such as the gut, oral cavity, breast and prostate so lessons learned in these projects are broadly applicable to other tissues.



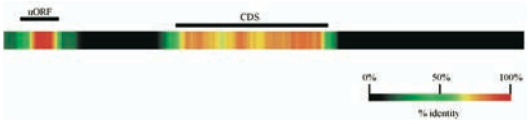
The uPEPperoni web site

You don't have enough genes buddy!

After a decade of intensive study, the complete sequence of the human and other mammalian genomes has been determined. Amazingly, the estimate of the number of protein-coding genes in humans is now thought to be less than 22,000. Yet most cells express a much higher number of distinct protein species. We propose that our proteome is also derived from the translation of small open reading frames (sORFs) present in a variety of transcripts including the 5' untranslated regions (5'UTRs), 3'UTRs of many eukaryotic mRNAs and on non-mRNA transcripts. These small peptides (sPEPs) may form the basis of a hitherto unknown regulatory network. These projects will involve a mix of bioinformatics, cell biology, and proteomics.

The development of organelle-specific tags for the delivery of gene medicines

We have identified a peptide sequence that localises to the nucleolus. We are developing a series of constructs that contain this peptide tag and are evaluating its use in delivering gene medicines to the nucleus. This methodology has the potential to increase the concentration of these genetic constructs in the nucleus thereby increasing their efficacy. We are also developing non-peptide aptamers of this sequence.



Techniques you learn in our group may include: bioinformatics, gene cloning and analysis, cell culture, transgenic plants, transgenic animals and expression analysis.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Genetics

ASSOCIATE PROFESSOR SUSAN ROWLAND

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Science Education

Science educators use the Scholarship of Teaching and Learning (SoTL) to deliver and evaluate high-quality learning experiences. Science Education is a well-established discipline in the USA, and an increasing number of Science Educators are now being employed in the Australian university system. My specific interest is nurturing our students' development of professional identity and expert status in science. My group pursues a range of projects that help students develop these qualities, collaborating extensively with other Science Educators in Australia and overseas. We evaluate our implementations using a mixture of qualitative and qualitative methods.

Our goals are to:

- Design, develop, and implement effective learning experiences for science students;
- Evaluate how participants in these experiences are affected by their experiences, with particular emphasis on students' development of professional identity and expert status;
- Document our results with the aim of improving educational practice in tertiary science.

The ALURE Project focuses on the development, implementation, and evaluation of Authentic Large-scale Undergraduate Research Experiences (ALUREs) for science students. We are investigating the experiences of both the students and the academic and technical implementers through interviews, reflections, and surveys. This project informs us about the design and delivery of the best-possible ALUREs for science students. We are also learning how to help new ALURE implementers navigate barriers to change, improve their educational practice, and influence the pedagogical climate in their institution.

The Free Energy Project connects working scientists to students through personal narrative. We work in the UQ JAC radio studio to build a collection of interviews with science graduates. My students take part in the planning and production of these interviews. We perform narrative and thematic analysis of the interviews themselves, and of student responses to the interviews. This project is giving us information about (i) the life stories of scientists and the factors that drive their careers and (ii) how undergraduate science students perceive and relate to working scientists.

SURJ@UQ is the undergraduate research journal written by and for UQ students. Susan Rowland is the editor in chief of the journal, and students who have an interest in the journal can help with writing, editing, and page production with a flexible time-frame. SURJ@UQ is an ideal opportunity for students to participate in the SCMB Student Internship Program by contributing to an issue.

Techniques you learn in our group may include: Mixed research methods including interview techniques, radio production, writing mentorship, survey design and delivery, narrative and text analysis using themes and categories, grounded theory, ethnography, phenomenology, basic statistical methods.

Useful Majors: All Science and Biomedical Science majors / Psychology / Education / Social Science / Arts

PROFESSOR MARK SCHEMBRI

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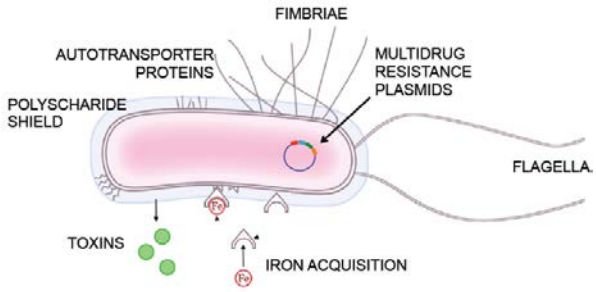
Molecular characterisation of multidrug resistant uropathogenic *E. coli*

Urinary tract infections (UTIs) are one of the most common infectious diseases of humans and a major cause of morbidity. Uropathogenic *E. coli* (UPEC) cause the majority (>80%) of UTIs and are a major contributor to global antibiotic resistance. Research in my lab aims to understand the virulence of multidrug resistant (MDR) UPEC, and to develop new approaches to treat and prevent UTI. The outcomes will address the enormous challenge of combating antibiotic resistance.

Our goals are to:

- Understand the virulence of MDR UPEC.
- Develop new methods to treat and prevent UTI.
- Characterize molecular mechanisms of adhesion, aggregation and biofilm formation utilized by MDR UPEC.



UPEC virulence factors

Molecular characterisation of UPEC clones

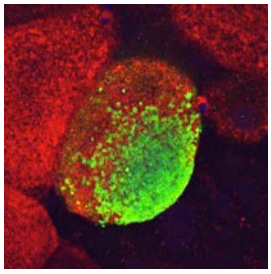
MDR UPEC strains from predominant clonal groups, including the globally disseminated MDR *E. coli* ST131 clone, exhibit important differences in virulence gene content and expression compared to other well-characterised non-resistant UPEC strains. We aim to understand the molecular mechanisms of MDR UPEC virulence using genomic, epigenetic and high throughput gene function analyses. We will study *E. coli* ST131 and other common MDR *E. coli* sequence types, including carbapenem-resistant strains and MDR strains of animal origin.

Development of new methods to treat and prevent UTI

New approaches are urgently needed to treat and prevent UTI caused by MDR UPEC. We aim to (i) identify and characterise novel UPEC vaccine targets, (ii) test novel anti-adhesive molecules for their ability to prevent UPEC adhesion and bladder colonisation, and (iii) develop the asymptomatic bacteriuria *E. coli* strain 83972 as a novel therapeutic agent for the prevention of UTI.

Molecular characterisation UPEC adhesins and biofilms

Aggregation and biofilm formation are critical mechanisms for bacterial resistance to host immune factors and antibiotics. Fimbriae and autotransporter proteins represent adhesins that contribute significantly to these phenotypes. Most UPEC strains produce multiple adhesins. We aim to study the regulation, function and structure of UPEC adhesins, and to determine their role in aggregation, biofilm formation, interaction with epithelial and immune cells, and colonization of the urinary tract.



UPEC intracellular biofilm

Techniques you learn in our group may include: PCR, cloning, SDS-PAGE, Western blotting, advanced genetic and proteomic techniques, cell culture, biofilm model systems, animal models.

Useful Majors: Microbiology / Biochemistry & Molecular Biology / Bioinformatics / Genetics

PROFESSOR GARY SCHENK

ARC Future Fellow

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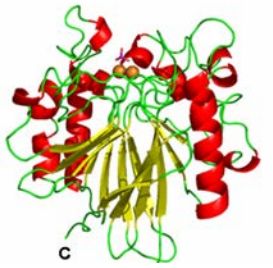
Research Area



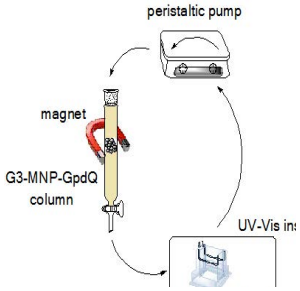
In a nutshell, I am a biophysical chemist working with a group of metal ion-dependent proteins (see figure on the right for an example) that are of interest in medicine (as drug targets) or agriculture (as herbicide targets or detoxifying agents). Using techniques that Darwin would view with envy our group evolves some of these proteins to tailor their properties according to our needs ("*in vitro* evolution").

My goals are to:

- figure out how metal ions promote catalytic reactions in biology
- try to stop these reactions in order to combat a medical problem (*e.g.* antibiotic resistance, tuberculosis, osteoporosis), or weeds (in agriculture) and
- use these reactions to detoxify the environment (bioremediation)

Metallo-β-lactamases: agents of doom that mediate antibiotic resistance

The emergence of antibiotic resistance is considered as one of the major threats to global health care. Metallo-β-lactamases (MBLs) are a particular concern, not only because they inactivate almost all of the commonly used antibiotics, but also because they evolve rapidly and no clinically useful inhibitor has yet been found. In this project we will investigate how MBLs work, and we will develop new strategies to stop them from working. Available projects focus either on the study of the biochemical properties of selected MBLs, or on the synthesis of inhibitors, which will ultimately be tested for their biological effects in collaboration with the Centre for Clinical Research at UQ.



Bioremediation: a clean alternative for pesticide degradation

Organophosphate-based pesticides have revolutionised agriculture in the 20th century, leading to a massive increase in both crop production and environmental pollution. No effective "green" solution to pesticide removal is currently available. However, some proteins have recently emerged that are highly efficient in breaking down those pesticides into harmless compounds. Here, students have the opportunity to use either these enzymes or suitable biomimetics to develop a device suitable for environmental detoxification (see illustration on the left).

KARI: a protein with an unusual chemistry but huge potential in biotechnology

Ever thought that you could combat a scary disease like tuberculosis and kill weeds at the same time? The enzyme KARI might allow you to do just that! It catalyses two sequential reactions (an isomerisation followed by a reduction) in the same active site. In this project students will have the opportunity to study the function of this unusual enzyme and develop inhibitors that may be suitable leads to develop both anti-tuberculosis drugs and novel herbicides.

Techniques you learn in our group may include: Numerous analytical and computational methods, recombinant gene technology, drug design and bioinformatics, in brief, almost everything! ☺

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Chemical Sciences / Chemistry / Computational Science / Microbiology

ASSOCIATE PROFESSOR BENJAMIN SCHULZ

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Synthetic Systems Glycobiology

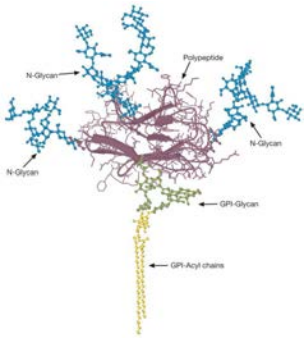
Glycosylation, the post-translational modification of proteins with sugars, is critical for fundamental biological processes as diverse as protein folding, regulating protein enzymatic activity and determining protein-protein interactions. Protein glycosylation is therefore a key regulator of development, cancer and infectious disease.

Our goals are to:

- Understand the mechanisms controlling glycosylation
- Engineer cell lines and bioprocesses for targeted protein post-translational modification
- Develop a toolkit for synthetic glycobiology

Glycoprotein Biopharmaceuticals

Many modern therapies for diseases including cancer, anemia, and hemophilia are glycoprotein biopharmaceuticals. These complex proteins can be produced in CHO cell culture, but are often deficient in key modifications, lowering their efficacy. This project is part of the ARC Training Centre for Biopharmaceutical Innovation, and will use cell-line engineering and bioprocess control to produce high levels of glycoprotein biopharmaceuticals with the desired modifications.



Synthetic Glycobiology

This project aims to understand and manipulate the regulation of the glycosylation machinery of Bakers' Yeast *Saccharomyces cerevisiae,* to engineer the specificity of glycoprotein biosynthesis to produce defined glycoprotein products, and to engineer glycoproteins so that they longer require glycosylation.

Beer-omics

Beer is delicious and wonderful. The process of making beer is similarly fascinating, combining malted grains, hops and yeast in an ancient bioprocess engineering process. However, the molecular details of many aspects of beer manufacture are surprisingly poorly understood. This project will use yeast genetics, proteomics, and glycoproteomics to study beer and wine biochemistry relevant to accurate monitoring and control of industrial production.

Techniques you learn in our group may include: Mass spectrometry, proteomics, glycomics, molecular biology, protein biochemistry, protein bioinformatics, yeast genetics, genome engineering.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Genetics / Microbiology

DR PHILIP SHARPE

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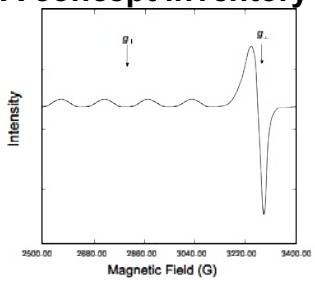
Research Area

My research area concentrates on how students learn in the Chemistry laboratory and how that learning can best be supported. Other interests are the area of "Green" chemistry and the development of ethically aware students.

Our goals are to:

- Acquire a deep understanding of how students learn Chemistry in the lab, in order to aid their learning.
- Improve the environmentally friendliness of undergraduate Chemistry experiments, while maintaining or enhancing educational benefits.

A concept inventory for EPR Spectroscopy



Electron Magnetic Resonance (EMR) Spectroscopy, also called electron paramagnetic (EPR) or electron spin resonance (ESR) spectroscopy, is a useful spectroscopic technique for chemists. However, the way that students learn EMR spectroscopy and common misconceptions has not been investigated in the Chemistry education literature. This project would involve surveying academics to investigate how EMR spectroscopy is taught and constructing a consensus expert concept map of the subject area, in order to develop a student concept inventory. This will aid in defining the best teaching approaches in this area. For example, does prior knowledge of NMR spectroscopy hinder or help students? This project is suited to an Honours or Ph.D. level student.

Understanding variability in cobalt ion concentration measurements in the presence of alkali earths

Recent attempts at characterising cobalt nitrito complexes have resulted in lower than expected concentrations using atomic absorption emission spectrometry (AAS). This may be due to the presence of Ba^{2+} and Sr^{2+} ions in the compounds. In this analytical project, you would synthesise the cobalt-nitrito compounds and investigate their composition by AAS, in the presence of varying amounts of the counterions. ICP-OES would be used for comparison. This project is suited to an undergraduate project student.

"Greening" undergraduate Chemistry experiments

Creation of interesting, robust, "greener" experiments for the Chemistry teaching laboratories and testing their educational effectiveness against traditional experiments. This is suited to undergraduate project students.

Techniques you learn in our group may include: Mixed methods research design, including conducting guided interviews, survey design, use of coding software, quantitative and qualitative data analysis.

Useful Majors: Chemical Sciences / Chemistry

DR KIRSTY SHORT

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Chronic medical conditions & severe influenza virus infections

Influenza A virus typically causes an acute and self-limiting infection characterised by symptoms such as muscle ache, fever and a dry cough. However, in patients with one or more underlying medical conditions, influenza A virus can cause severe, and even fatal, disease. This interaction between chronic medical conditions and severe influenza was particularly evident after the 2009 H1N1 influenza pandemic. Specifically, this pandemic highlighted that people with diabetes, asthma and obesity suffered from more severe influenza than people with no underlying medical condition. Our research seeks to identify the role of host impairments in the anti-viral response (asthma), chronic inflammation (obesity) and hyperglycaemia/glycaemic variability (diabetes) plays in the pathogenesis of influenza virus.

Ongoing projects involve:

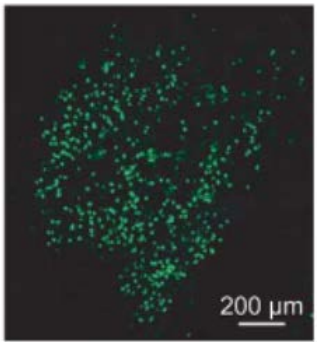
- Defining the role of obesity and asthma in the emergence of influenza virus variants
- Investigating the ability of asthma to facilitate influenza virus reassortment
- Identifying the role of obesity in driving the extra-respiratory complications (cardiac and neurological) complications of influenza
- Assessing the ability of influenza vaccination to prevent the microvascular complications of diabetes
- Determining the role of diabetic glycaemic variability in severe influenza virus infections

The role of endothelial cells in avian influenza

Birds are the natural reservoirs of influenza virus. However, amongst different avian species there are marked differences in influenza virus pathogenesis. In particular, whilst highly pathogenic influenza viruses target the endothelial cells that line the blood vessels in chickens, the endothelial cells of wild bird species are rarely infected. This project involves the culture of primary avian endothelial cells and next-generation sequencing to identify the species-dependent differences in the pathogenesis of avian influenza.

Fluorescent imaging of influenza virus

Fluorescent influenza A viruses offer new opportunities to study influenza virus replication, tropism and pathogenesis. To date, several influenza A reporter viruses have been described, each with their own pros and cons. This project involves optimising a novel strategy for creating virulent, replication competent fluorescent influenza viruses that can be ultimately used to study *in vivo* viral transmission.



Fluorescent influenza virus in the lungs of infected mice

Techniques you may learn in our group include: Virus growth and cell culture, primary cell culture (human, mouse and avian), murine infections, FACS, immunofluorescence, confocal microscopy, *in vivo* imaging, influenza virus deep sequencing, RNA Seq, Sanger sequencing, high-resolution melt analysis, qPCR, *in vivo* imaging (Carestream), *in vitro* co-culture models, PCR mutagenesis, cloning, immunohistochemistry and high-resolution imaging.

Useful Majors: Microbiology / Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Computational Science / Genetics

ASSOCIATE PROFESSOR KATE STACEY

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Pathogen recognition by innate immune cells

How are molecules or organisms determined to be foreign by the immune system? This is the most fundamental question in immunology. The last decade has seen an explosion of information on the recognition of "pathogen-associated molecular patterns" (PAMPs). These are characteristic conserved microbial molecules that activate innate immune cells through receptors such as toll-like receptors (TLR) or inflammasome initiators. This innate immune cell activation is essential for generation of subsequent T and B cell responses. PAMP recognition is thus a key to self/non-self discrimination, and has enormous importance in response to infection, and also in pathologies such as autoimmune disease, and in manipulation of immunity by vaccination. Our lab works on PAMP recognition, particularly immune stimulation by foreign DNA as well as viral molecules.

Our goals are to:

- Characterise molecular interactions important in inflammasome formation
- Establish whether innate immune imbalance contributes to autoimmunity
- Identify innate immune pathways activated by dengue virus

Cytosolic DNA as a danger signal activating the inflammasome

Inflammasomes are large protein complexes that are platforms for the activation of caspase enzymes. Inflammasome-mediated caspase-1 activation leads to cell death, an effective defence against intracellular infection, and production of inflammatory protein interleukin-1β, which is the major cause of fever. This can be initiated by DNA in the cytosol, an indication of infection. We are characterising protein interactions involved in inflammasome formation, and following the process by time-lapse microscopy of live cells.

Inflammasome function in autoimmunity

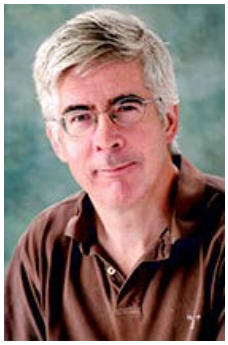
Autoimmune disease occurs when there is a failure in the distinction between self and foreign molecules by T and B cells. The human autoimmune disease lupus involves formation of antibodies against self molecules and their deposition as immune complexes in tissues. We propose that imbalances in innate immune pathways can contribute. We have found profound inflammasome deficiencies in a mouse model of lupus, and will now investigate the relevance of this to human lupus.

Innate immune recognition of dengue virus

The mosquito-borne dengue virus is an increasing problem in tropical and subtropical areas, and can cause life-threatening haemorrhagic disease. We are characterising activation of TLR and inflammasome pathways by dengue infection. This is providing information on the changes that lead to vascular leak and severe disease, and opening routes for therapies.

Techniques you learn in our group may include: Flow cytometry, western blotting, live cell imaging, ELISA, cell culture, fluorescence microscopy, molecular biology, real time PCR, mass spectrometry.

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Chemistry/ Microbiology



DR PHILIP STEVENSON

ARC Future Fellow

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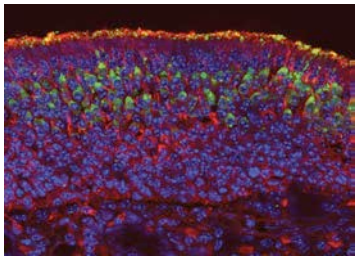
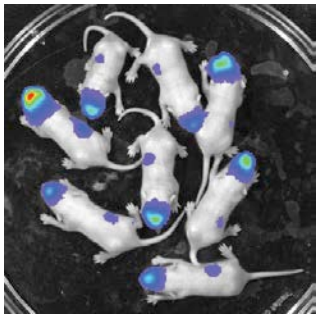
Research Area

The 8 known human herpesviruses establish chronic infections across all demographics. Each of us carries typically 4 or 5. Examples are Herpes simplex virus type 1 (cold sores, keratitis, encephalitis), Human cytomegalovirus (fetal damage, disease in transplant recipients) and Epstein-Barr virus (glandular fever, lymphomas, carcinomas). Each is complex, with more than 80 genes. Therapies are limited. We use murine infection models to understand basic principles of pathogenesis, host response and viral evasion, and so develop new means of infection control. A recent finding has been that several different herpesviruses enter new hosts by infecting olfactory neurons, providing a new potential vaccine target.

Possible Projects:

- Tracking how herpesviruses use olfactory neurons to cross mucosal barriers into new hosts.
- Tracking how infection spreads subsequently to systemic sites.
- Defining how host immune cells recognize epithelial infection and how they might prevent its spread.





Techniques:

In addition to basic virology and molecular biology, we use a wide range of reporter systems to track infection, including epifluorescent and confocal microscopy of virus-expressed fluorochromes, cre-lox recombination, and viral luciferase expression. We also use a range of immunological assays and interventions to understand host responses.

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Microbiology

PROFESSOR ISTVAN TOTH

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Medicinal Chemistry

Drug and Peptide Delivery

We aim to improve the delivery of promising drug leads by overcoming their poor bioavailability and *in vivo* stability. We use lipids and carbohydrates to create delivery platforms or vaccine candidates with optimal hydrophobicity, cell targeting and, when relevant, immunogenicity.

Delivery platforms for peptides

Although many peptides are promising drug leads their poor bioavailability and stability limit their clinical use. This project aims to develop a novel carrier system, the Lipidic Amino Acid (LAA) system, for the oral delivery of vaccines by exploiting the particulate-forming properties of LAA to form micro-particulate oral antigens. The amphipathic structure of LAA can be used to form micelles in aqueous environments when conjugated to hydrophilic compounds (lactic, glycolic, and gluconic acids). Preliminary experiments with a limited number of LAAs have demonstrated their ability to form vesicles alone or in the presence of cholesterol (unpublished observations). It is anticipated that vesicle size, stability, drug loading, permeability, lipophilicity, antigenicity, *in vivo* behaviour, etc. will depend on the LAA composition of the liposomes.

Our goals are to:

- Develop a practical delivery system for peptide drugs and antigens.
- Design and develop vaccine candidates combining the adjuvant, carrier and antigen in a single molecule.

Non-viral carriers for gene delivery

Gene therapy has the potential to cure a variety of diseases including cancer and muscular dystrophy. One of the biggest challenges preventing its use in the clinic is poor delivery into target cells. We aim to build novel peptide-based oligonucleotide carriers for gene therapy. The advantage of using peptides instead of virus particles is that they are less toxic and less immunogenic. These delivery molecules also include components that will help them overcome the barriers that prevent oligonucleotides from reaching the correct destination in the cell.

Our goals are to:

- Design and synthesise libraries of peptide-based molecules for gene delivery.
- Test the synthesised molecules for their oligonucleotide binding, stability and cell uptake.

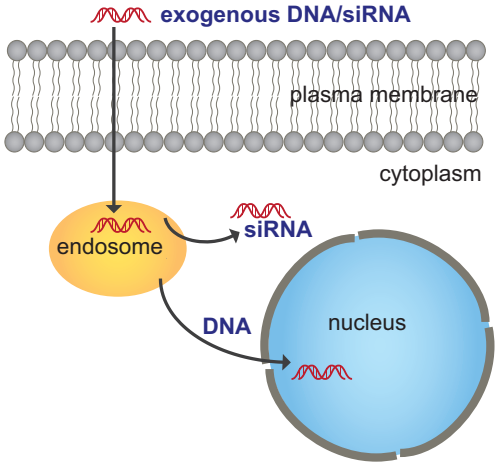

Figure 1: Barriers associated with gene delivery

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Chemical Sciences / Chemistry

PROFESSOR MATT TRAU

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Centre for Personalised Nanomedicine

Our Centre has a focus on developing miniaturised, inexpensive, flexible and robust “plug-and-play” molecular reading systems and diagnostic devices which can be deployed to detect and characterize different diseases. Students working in the Centre will have the opportunity to create nanoscaled biosensors for applications in cancer, infectious disease and point-of-care devices; as well as work on applied clinical genomics projects that utilize current next-generation sequencers. Successful applicants can expect to gain experience with a variety of fundamental molecular biology applications, as well be introduced to cutting edge cancer genomics and next-generation sequencing technologies. Students will also be given the opportunity to work with leading clinical researchers to test these devices in clinical settings, and to participate in a lab culture that promotes independent thought and research.

Projects

Link to current projects: https://aibn.uq.edu.au/trau#qt-trau_group_page_tabs-foundation-tabs-1

Translating epigenetic biomarkers into a pan-cancer diagnostic

Alterations in DNA methylation are a common phenotype in cancer and provide novel options for diagnosis and classification. The overall aim of this project is to expand the scope of our breast cancer biomarkers and assess their clinical utility in the detection and diagnosis of other cancers to design a universal blood-based pan-cancer diagnostic assay for early detection of disease.

A new interfacial bio-sensing approach for detecting aberrant protein phosphorylation in cancer

Protein phosphorylation is one of the most prominent post-translational modifications for protein regulation. This ubiquitous mechanism, however, is susceptible to alteration by the emergence and progression of cancer. In this project, we are developing simple, yet accurate, electrochemical and colorimetric tests that can detect aberrant protein phosphorylation.

DNA microdevices for Cancer Detection

Aberrant methylation in the genome can deregulate the gene expression pathways leading to cancer. This project aims to develop a novel multiplex micro-device for directly detecting the genomic methylation biomarkers with the mechanism of interfacial adsorption between DNA and metal surfaces.

SERS Microfluidic Assay for Cancer diagnostics

Microfluidics integrated with Surface Enhanced Raman Scattering (SERS) is a powerful platform for point-of-care diagnostic applications. In this project, we use SERS microfluidics as a diagnostic tool to detect different molecular biomarkers (i.e., cells, proteins, etc.) in biological and clinical samples.

Trapping and Observing Biomolecular Complexes near Nanopores

The aim of this project is to produce a generic platform technology that is capable of in-situ characterisation of nano-scaled objects to further understand and exploit the fundamental scientific principles of an integrated nanopore/optical system.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Chemical Sciences / Chemistry / Computational Science / Genetics / Microbiology / Parasitology

PROFESSOR GENE TYSON

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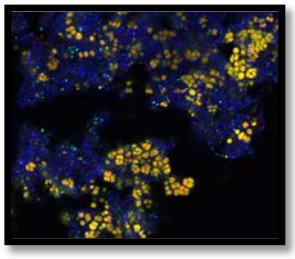
Microbiology of Natural and Engineered Environments

Professor Tyson's research applies molecular approaches (metagenomics, metatranscriptomics and single-cell genomics) to understand the structure and function of microbial communities in natural and engineered environments. He is continuing his pioneering endeavours in the omic technologies by leading efforts to recover population genomes from environments of varying complexity which provide insight into the metabolic capabilities of these microorganisms.

Melting permafrost - dissecting methane flux at the leading edge of global change

Microbial communities in northern wetlands are central to understanding current and future global carbon cycle. As permafrost thaws, methane emissions from northern wetlands are likely to cause positive feedback to atmospheric warming. In this project, high-throughput sequencing of microbial communities combined with biogeochemical isotope measurements will allow the functionality of these communities to be understood.



Methane-driven denitrification

A simple consortium consisting of archaea and bacteria are thought to be responsible for anaerobic oxidation of methane coupled to denitrification. Quantitative measurements of single cell ecophysiology will be combined with genomic, transcriptomic and proteomic analyses to investigate these interspecies consortia.

Understanding Marine Microbial Processes

Behavioural interactions and biogeochemical transformations of microbes is critical to the functioning of our oceans. This project aims to address key questions in microbial ecology at the biologically relevant microscale using a novel combination of environmentally-deployed microfluidic devices and single cell and population level omic approaches. We anticipate that this new approach, microfluidomics, will be generalizable to many environments and will be a major new tool in the omics arsenal.

Computational challenges of genome-centric microbial ecology

Microbial ecology is undergoing revolutionary change as improvements in computational and laboratory based methods make it possible to recover the genomes of hundreds to thousands of microbes from environmental samples. The procedures for generating these genomes can be markedly improved on a number of fronts. Further, interpreting these genomes in the context of their environment is a looming bottleneck for the field. In this project you will work with computational biologists and high performance computing to answer fundamental questions in microbial ecology.

Techniques you learn in our group may include: metagenomics, metatranscriptomics, bioinformatics, microbial ecology.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Computational Science / Genetics / Microbiology

DR KYLE UPTON

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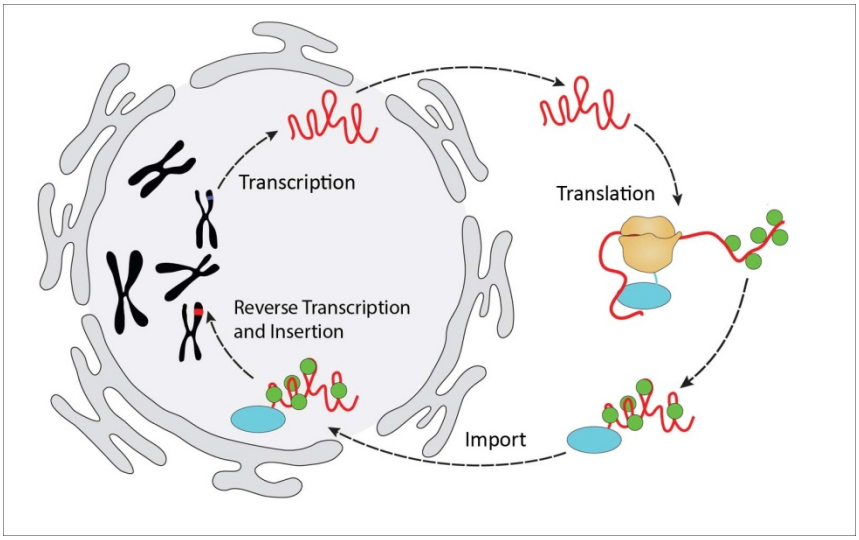
Molecular Genetics & Genomics

Mobile Genetic Elements in Breast and Ovarian Cancer

Mobile Genetic Elements (MGEs) in the human genome replicate through a copy and paste mechanism driven by proteins encoded within LINE-1 retrotransposons. MGEs make up almost half of the human genome, and often hypomethylated and transcriptionally activated in human epithelial cancers, including in breast and ovarian cancer. While mobilisation of these elements is a demonstrated source of mutagenesis, their dysregulation may have other important effects on cancer phenotype by affecting genome wide transcription and epigenetic states.

Our goals are to:

- Understand the factors controlling epigenetic regulation of MGEs
- Characterise the effects of LINE-1 reverse transcriptase on cancer cell biology.



Epigenetic Regulation of MGEs in cancer cells

A feature of many epithelial cancers is the loss of epigenetic repression (especially DNA methylation) controlling MGE expression. This project aims to characterize the factors which lead to this loss of repression, with a focus on the piRNA pathway. We are particularly interested in restoring epigenetic repression of MGEs, and determining the effects of restoring repression on LINE-1 mobilisation, and cellular function (morphology, proliferation and migration). piRNAs and associated pathway genes have the potential to provide important biomarkers for cancer diagnosis and treatment.

Effects of LINE-1 reverse transcriptase on cancer cell biology

The effects of LINE-1 reverse transcriptase on cancer cell biology are controversial and poorly studied. This project will involve over-expression and knockdown of LINE-1 reverse transcriptase in normal and cancer cell lines, and characterising the effects on cellular function (morphology, proliferation and migration). LINE-1 reverse transcriptase has the potential provide a novel therapeutic target in epithelial cancers.

Techniques you learn in our group may include: Bioinformatics, gene cloning and mutagenesis, mammalian cell culture and gene transfer, reporter gene assays, real-time PCR, Northern blotting, methylation specific DNA analysis, cell culture assays including cell proliferation and differentiation

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Genetics

PROFESSOR MARK WALKER

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Research Area

Prof. Mark Walker is an internationally renowned bacterial pathogenesis expert ranked #1 globally for publications on 'Streptococcus pyogenes' in the period 2013-2018 (Web of Science). He led efforts to investigate the current global scarlet fever outbreak and develop new vaccines against the pathogenic bacterium group A streptococcus, and the discovery of new antibiotic approaches. He is Director of the Australian Infectious Diseases Research Centre (AID), leading over 100 infectious diseases research groups. Prof. Walker was elected a Fellow of the American Academy for Microbiology in 2013. He has published more than 160 research papers and was awarded over $21 million from the Australian NHMRC in the past 5 years. Prof. Walker developed the comprehensive model for understanding the molecular transition from benign human infection to GAS invasive disease (Nature Medicine, 2007). His research on the ongoing scarlet fever outbreak in Hong Kong and China (>300,000 cases; Nature Genetics, 2015) resulted in a change of clinical practice. Prof. Walker's non-human primate vaccination and challenge model for GAS vaccine development was awarded the 2014 NHMRC Development Grant Achievement Award.

Our goals are to:

- Understand mechanisms of disease pathogenesis,
- Utilise genomic technologies to investigate outbreaks
- Develop a safe and efficacious vaccine.

Group A streptococcus pathogenesis and vaccine development

Group A streptococcus (GAS; Streptococcus pyogenes) is a strictly human pathogen of global significance that ranks among the top 10 infectious disease killers. GAS causes mild human infections such as pharyngitis and impetigo, and serious infections including necrotising fasciitis and streptococcal toxic shock-like syndrome. Furthermore, repeated GAS infections may trigger autoimmune diseases including acute post-streptococcal glomerulonephritis, acute rheumatic fever and rheumatic heart disease. Combined, these diseases account for over half a million deaths per year. Resistance of GAS to antibiotics is an increasing concern. The spread of antibiotic resistance determinants in the GAS population provides fresh impetus for the development of a safe commercial human vaccine. Numerous factors need careful consideration when developing GAS vaccines including the conservation and serotype coverage of antigens, the geographical distribution of serotypes, the use of antigens devoid of autoimmune epitopes, the selection of human approved adjuvants and the design and validity of experimental animal models. Future global eradication of GAS disease may be achieved by preparations that optimally address each of these factors.

Walker's research group, in conjunction with a global collaborative research network (UQ, QIMR Berghofer, UCSD, Emory University, Wellcome Trust Sanger Centre, University of Hong Kong, Helmholtz HZI, Griffith Glycomics, University of Wollongong) has made leading contributions to the fields of genomic epidemiology, GAS pathogenesis, innate immunity and vaccine development. His research team will continue to investigate infectious disease outbreaks on a local and global scale, characterise key host-pathogen interactions to reveal new targets for intervention, and test experimental vaccine formulations in non-human primate trials.

Techniques you learn in our group may include: Microbiology, molecular biology, cell biology, tissue culture, bacterial genomics, bioinformatics

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Microbiology

DR JACK WANG

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Research into Science Education

I am a Teaching-focused academic in Microbiology, and my research revolves around innovative strategies and technologies in Science Education. This type of research is not associated with extensive laboratory work, and therefore will not prepare you for a career as a laboratory scientist. It instead relies upon interacting with large networks of people – namely the students, academics, and administrators in Higher Education – to extract trends and develop new technology in teaching and learning. These projects may be useful for you if you are interested in careers in educational development and learning design in both public and private sectors:

Blending Online and Face-to Face learning in Science Education

Continually increasing class sizes in Higher Education (E.g. >1000 in many first year UQ courses) have highlighted the necessity of innovative delivery of learning experiences. Blending the Face-to-Face on-campus learning at UQ with interactive online resources can improve flexibility in learning modes available to students and provide instructors with additional teaching tools to maximise student engagement. This project will involve creating screencasts, videos, animations, and podcasts to enrich the blended learning experience at UQ, and evaluating their effectiveness through a rigorous mixed-methods strategy. This includes surveying and interviewing students and instructors across a number of Higher Education courses to map out the effective features of online and face-to-face learning activities, which will contribute to Teaching and Learning policy in Higher Education.

Digital literacy in students and instructors: using Learning Analytics to investigate student attrition and retention

The field of Learning Analytics is rapidly expanding in Higher Education, where correlations between student learning patterns and their academic outcomes are being actively investigated. This project will investigate the learning analytics data generated by Blackboard, and highlight learning patterns that can potentially serve as pre-emptive indicators of student attrition, including gaps in digital literacy and technological competency.

Techniques you learn in our group may include: Survey design and analysis, focus group interviews, generating and analysing video and multimedia content, coding and thematic analyses of qualitative and quantitative data, communicating with a variety of audiences.

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Genetics / Microbiology

Key references:

1. Wang, J.T.H. et al., (2015). Do you kiss your mother with that mouth? An authentic large-scale undergraduate research experience in mapping the human oral microbiome. Journal of Microbiology and Biology Education 16(1): 50-60 (http://www.asmscience.org/content/journal/jmbe/10.1128/jmbe.v16i1.816)
2. Wang, J.T.H. et al., (2013). *How much is too much assessment? Insight into Assessment-driven student learning gains in large-scale undergraduate microbiology courses*. Journal of Microbiology and Biology Education, 14(1): 12-24. (http://jmbe.asm.org/index.php/jmbe/article/view/449)
3. Wang, J.T.H. et al., (2012). *Immersing undergraduate students in the research experience*. Biochemistry and Molecular Biology Education 40(1): 37-45. (http://onlinelibrary.wiley.com/doi/10.1002/bmb.20572/abstract)

DR NICOLE WEBSTER

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Molecular Genetics & Genomics

Microbiology of Coral Reef Environments

Dr Webster's research merges experimental and field based ecological approaches with omic technologies to understand multiple facets of coral reef microbiology. Her research primarily focuses on determining how microorganisms contribute to reef ecosystem health and how microbial symbioses contribute to environmental acclimatisation and adaptation in reef invertebrates. Dr Webster holds a joint position at the Australian Institute of Marine Science.

Reef Invertebrate Symbioses in a Changing Climate

The vulnerability of marine invertebrates to environmental stress has traditionally been assessed by determining how the host animal responds to particular environmental factors. However, if we are to provide accurate predictions of the sensitivity and vulnerability of reef organisms we need to assess the stress response in both the host and its associated microbial community (holobiont). In this project we use experimental aquaria facilities to expose reef invertebrates to IPCC projected climate scenarios and employ a combination of microbial metagenomics and metatranscriptomics to assess the response of the symbiotic microbial community.

Microbial Contributions to Transgenerational Acclimatisation in Coral Reef Organisms

Significant declines in coral reef health and biological diversity are predicted for the coming decades unless coral reef organisms adapt or acclimatise to increasing levels of environmental pressure. This project examines how microorganisms contribute to acclimatisation and transgenerational adaptation of reef invertebrates. The project uses samples from an experimental reef mesocosm at the Australian Institute of Marine Science and applies 16S rRNA gene sequencing to determine how the microbiomes of different species respond to future climate change conditions. Specifically, we will determine if any shifts in the microbiome that facilitate host acclimatisation can be inherited by the next generation (thereby enabling transgenerational adaptation).

Techniques you learn in our group may include: 16S rRNA gene amplicon sequencing, metagenomics, metatranscriptomics, bioinformatics, microbial ecology

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Computational Science / Genetics / Microbiology

DR NICK WEST

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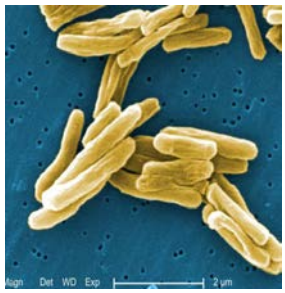
Tuberculosis (TB)



TB continues to kill more people in the world each year than any other bacterial pathogen and is also a major cause of HIV-related death. In the West Lab we study the pathogenesis of *Mycobacterium tuberculosis (Mtb)*, the bacterium responsible for TB. Our lab is fully equipped for the study of *Mtb*, from its microbiology, interaction with host cells, through to pre-clinical drug and vaccine trials; making us the only lab in Qld with such capabilities.

Our goals are to:

- Identify disease causing bacterial genes and gene products
- Develop new, potent anti-TB drugs
- Create novel efficacious vaccines
- Produce effective point-of-care diagnostics

The following are examples of the projects offered to students:

Characterisation of proteins essential for survival in the host.

We have identified a series of bacterial factors which are dispensable for growth in laboratory media but which are in-dispensable in the host. This project will define the role of three of these essential virulence determinants by modern molecular and proteomic approaches to characterise *when* and *where* they are expressed and to what end.

Essential gene regulation in *M. tuberculosis*.

Our genetic screening identified a series of transcriptional regulators essential to the bacterium *in vivo*. In this project you will clone, express and purify two novel regulators. To define the role of these regulators the influence of these mutations will be assessed by mammalian cellular infection studies and transcriptomic/ DNA binding analysis.

Next Generation Anti-TB Vaccine

We have identified proteins of *Mtb* which are only expressed during the latent phase of TB. These proteins would therefore not be expressed in the current vaccine, i.e., BCG. These proteins therefore represent attractive targets for inclusion as subunit vaccine antigens. You will assess these antigens as purified protein vaccines and also as inclusion in live recombinant vaccine strains.

Techniques you will learn in our group may include: Microbiological techniques. Gene cloning, protein and/or DNA vaccinations, immunological assays, macrophage cell culture and mycobacterial infection, PCR and molecular analysis. DNA binding assays and small molecule inhibition.

Useful Majors: Microbiology / Molecular Biology / Bioinformatics / Computational Science / Genetics

PROFESSOR CRAIG WILLIAMS

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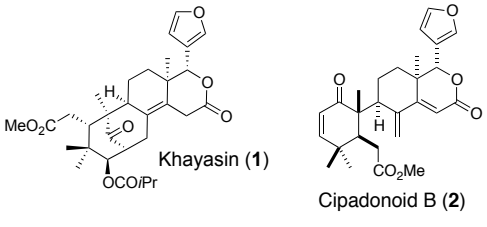
Research Area

Prof. Williams' research group focus and expertise is orientated around discovery and construction of complex biologically active natural products and drug like molecules. These projects have instilled high-level chemical competency within his group, which allow the group to tackle both simple and complex problems in associated areas, such as, modern and traditional synthetic methodology development, medicinal and physical/computational chemistry. Targets and areas of expertise cover diterpenes, diterpene alkaloids, alkaloids/opioids, tetranortriterpenes, polyketides, polycyclic hydrocarbons, saturated and unsaturated nitrogen, oxygen and sulfur containing heterocycles. The group also undertakes isolation and elucidation of natural products from the Australian desert and the Australian rainforest; the latter in collaboration with industry. New synthetic methodologies that have been discovered and developed to-date include silver based organometallics, photochemical transformations, new alcohol oxidation protocols, C-C bond forming reactions and application of green chemistry to named reactions.

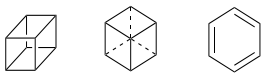
Anti-cancer, neurodegenerative disease and insect active limonoids

Recently we achieved the total syntheses of a number of the limonoid family members, such as, Khayasin **1** and Cipadonoid B **2**. The synthesised limonoids **1** and **2** are closely related to Gedunin **3**, another limonoid family member, which displays anti-cancer and neurodegenerative disease activity in Heat Shock protein 90 (Hsp90) models. We would now like to investigate the total synthesis of gedunin **3**, which has yet to be reported, and explore the gedunin **3** structure against Hsp90 using state of the art medicinal chemistry techniques (e.g. Fragment Based Drug Design).



Cubane Chemistry

Cubane **4**, when viewed from the corners (i.e. **5**) can be considered roughly the same size as a benzene ring (i.e. **6**). This is equally true when you take into consideration the π clouds of benzene, that is, cubane **4** is about the same "thickness". With this in mind the project would involve replacing the phenyl ring in a current drug or agrichemical molecule and comparing biological assay data. It would also be expected that cubane **4** has completely different P450 metabolism profiles, making it an exciting medicinal chemistry concept.



Local collaborators: Professors Parsons (QIMR); Smith (TetraQ); Gahan (SCMB); De Voss (SCMB); Guddat (SCMB); Walter (SBS); Hine (Business School); Krenske (SCMB); Young (SCMB)

Industry collaborators: EcoBiotics Ltd (Qld); CSIRO (Victoria), Bayer (Germany), Boron Molecular (Melb), DSTG (Adelaide).

Techniques on offer: Advanced organic synthesis and strategy design, Plant isolation chemistry, Medicinal chemistry, New reaction method development, Physical chemistry, NMR, MS, IR, X-Ray, and much more.

Useful Majors: Chemical Sciences / Chemistry / Computational Science / Biochemistry & Molecular Biology

DR SIMON WORRALL

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Structural & Molecular Biology

Mechanisms of Drug-Induced Tissue Injury

Liver, muscle, heart and brain injury have long been associated with the abuse and clinical use of drugs. My predominant research interest focuses on ethanol, the most commonly abused drug in Western societies. Ethanol is widely tolerated but induces a wide variety of tissue injury in a small number of individuals. Thus, my main research focus is the investigation of immunological and genetic phenomena associated with alcohol-induced tissue injury.

The metabolism of ethanol, a relatively benign substance, produces a series of highly reactive, more toxic, compounds that interact with cellular molecules to produce chemical modifications known as adducts. Such modifications generated by high levels of blood glucose in diabetics are now used as a measure of the blood glucose concentration over extended periods. Our aim is to discover analogous adducts which will allow clinicians to estimate blood alcohol concentrations over periods of weeks and months.

Protein Modification in the Alcoholic Brain

One of the major targets of alcohol toxicity is the brain, leading to a variety of forms of injury. We are concentrating on one form called alcoholic cerebellar degeneration to see whether adducts of alcohol metabolites can be used as a marker of the severity of injury.

Protein Modification in the Alcohol-exposed Foetus

Alcohol consumed by pregnant women can harm their unborn babies. Foetal alcohol spectrum disorder (FASD) refers to a group of conditions that can occur in a person whose mother drank alcohol during pregnancy. Problems that may occur in babies exposed to alcohol before birth include low birth weight, distinctive facial features, heart defects, behavioural problems and intellectual disability. We are looking for biomarkers that will indicate how much alcohol the foetus was exposed to in the uterus, and will also determine whether such modifications play a role in the pathological process occurring in these individuals.

Techniques you learn in our group may include: Protein purification, raising mono- and polyclonal antibodies, immunological techniques such as western blotting and ELISA, mass spectrometry; UV-visible and fluorescence spectroscopy.

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science Chemical Sciences / Chemistry

PROFESSOR PAUL R. YOUNG

Head of School

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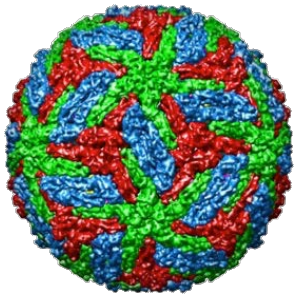
Viral Diseases and their Control

The Young lab employs molecular, cell and structural biology based approaches in the study of viral replication and pathogenesis. Key stages identified are in turn targeted for the development of improved diagnostics, vaccines and anti-viral therapeutic control strategies. Current studies are focused on two very different viruses; dengue virus, a serious mosquito-borne disease, and KoRV, a retrovirus of koalas that we have shown is currently invading the koala germline and is linked with high rates of cancer in this iconic species. In addition, the group is building a major translational vaccine program targeting viruses identified as potential emerging disease threats.



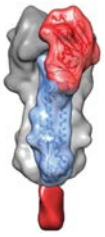
Dengue virus

Ongoing projects involve:

- Development of a generic recombinant protein platform technology, Molecular Clamp, that locks viral fusion proteins into a pre-fusion state as the basis of subunit vaccine candidates.
- Development of TLR4 antagonists as inhibitors of dengue virus induced pathology, based on our group's discovery that the secreted flavivirus protein NS1 is a TLR4 agonist.
- Needle-free, microarray patch delivery to the skin of a range of both established (inactivated polio, influenza, measles/rubella) and novel vaccines (dengue, Zika, Ebola, etc) with enhanced potency.
- The role that koala retrovirus (KoRV) genetic diversity plays in transmission, genome invasion and disease in wild koala populations.

Virus vaccines and therapeutics

Subunit vaccines are safer and can provide a targeted immune response to sites on viral proteins known to stimulate protection. Current focus within the laboratory is directed towards the production of recombinant subunit vaccine candidates for influenza, respiratory syncytial virus, Ebola, Lassa fever, dengue and many other medically significant viruses. Vaccine delivery to skin via novel micropatch arrays is being investigated with our industry partner, Vaxxas. We are also developing recombinant antibodies that bind to these proteins as immuno-therapeutics.



Influenza HAclamp

Understanding the molecular basis of viral pathogenesis

Elucidation of the molecular mechanisms governing viral replication and disease draws on many fields of biology, including cell biology, molecular biology, biochemistry and immunology. Understanding the life cycles of viruses and interaction with their host has the potential to reveal novel therapeutic targets. One such target we have identified through our studies is the role of the flavivirus protein NS1 as a TLR4 agonist. We are investigating small molecule and antibody inhibitors of NS1 activity as potent antivirals.

Techniques you learn in our group may include: Virus growth and cell culture, protein biochemistry, recombinant protein expression and purification, immunological techniques, immunofluorescence, confocal microscopy, high-resolution imaging and vaccine studies.

Useful Majors: Microbiology / Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Computational Science / Genetics

SCMB AFFILIATE STAFF

DR HELLE BIELEFELDT-OHMANN

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Research area

My main research focus is on the pathogenesis and pathobiology of viral infections in the natural hosts and appropriate animal models. Current studies are focused on arboviruses, mainly West Nile virus (WNV), dengue and Zika virus. We employ molecular biology, immunologic and conventional pathology methodologies to characterize disease processes and elucidate the pathogenesis of these infections.

Possible Hons, MSc, Intro to Research projects

Investigations of the pathobiology of WNV, DENV and ZIKV, using appropriate animal models**.** This includes studies of innate and adaptive immune responses and pathology.

Techniques: Virus and cell culture; serology; RT-PCR and qRT-PCR; animal inoculations and assessments for disease, tissue sampling, histopathology and immunohistochemistry.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Genetics / Microbiology

PROFESSOR ROBERT CAPON

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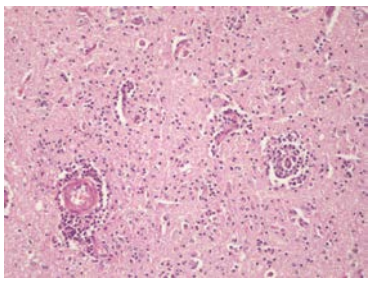
Biodiscovery: learning from nature

My research group focuses on the discovery and use of novel bioactive natural products from Australian marine and terrestrial biodiversity. These metabolites span all known biosynthetic classes and include many molecules that are new to science. Our research makes use of a range of sophisticated chemical technologies, and extends into the fields of microbiology, cell biology, pharmacology and biochemistry, supported by an extensive network of collaborators. Natural products uncovered during our investigations represent valuable new leads in the search for drugs in the fields of human and animal health and crop protection. They also have potential application as molecular probes to better interrogate, understand and manage living systems.

Possible research projects

- Marine biodiscovery
- Microbial biodiscovery
- Drug discovery: infectious diseases, cancer and pain
- Synthetic and medicinal chemistry
- Cane toad chemical ecology



Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Chemical Sciences / Chemistry / Microbiology

ASSOCIATE PROFESSOR RALF DIETZGEN

QUEENSLAND ALLIANCE FOR AGRICULTURE AND FOOD INNOVATION (QAAFI)

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Molecular plant-virus-vector interactions

Negative-sense RNA viruses belong to complex families of established and emerging viruses that infect plants and animals. My research interests are in the discovery and biodiversity of genes, proteins and regulatory RNAs in plants, viruses and vector insects, and their molecular interactions in agricultural systems. Increased knowledge of these interactions will enable improved crop performance and better pest and disease control. Special interests include the characterization of plant rhabdoviruses and tospoviruses, virus diagnosis, taxonomy and molecular evolution, RNA silencing pathways for pest and disease resistance, and genome-wide molecular genetic responses to RNA virus infection.

Possible themes

- Genome organization of novel plant rhabdoviruses
- Viral protein structure and functions
- RNA interference-mediated host defenses
- Plant-virus-insect molecular interactions

Projects can be tailored to suit Honours, Masters or Introduction to Research requirements.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Plant Biology / Genetics / Microbiology

PROFESSOR DAVID FAIRLIE

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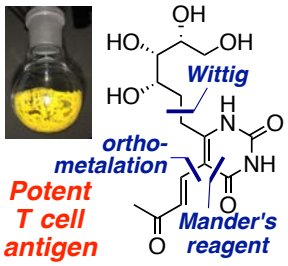
Organic/Medicinal Chemistry; Cell Biology and Immunity

Our *chemists* design (computer modelling), synthesize (solution & solid phase organic reactions) & determine (NMR) structures of new drug candidates. Our *biologists* study mechanisms of drug action in human cells & in rodent models of human disease. We seek to better understand life, ageing, disease & death. We invent new chemicals and chemical reactions, design new drugs, discover new mechanisms of immunity & disease, & identify new ways to treat inflammatory & metabolic diseases (diabetes, cardiovascular), cancers, viral infections & Alzheimer's disease.

Possible Hons/Post-Graduate Projects

• Organic synthesis • Medicinal chemistry • NMR solution structures
• Design of enzyme inhibitors and cell modulators as new drugs
• Downsize bioactive protein surfaces to potent small molecules
• Modulate proteins on innate immune cell surfaces as drug targets
• Regulate signalling pathways in cells • Study mechanisms of cancer, inflammation and immunity • Image drugs/proteins in cells and mice



Useful Majors: Chemistry / Chemical Sciences or Biochemistry / Cell Biology / Pharmacology / Immunology

DR MARY FLETCHER

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Research area

Our group focuses on the identification and analysis of natural toxins in a range of plants, fungi and agricultural products. Toxins of particular interest include toxins from pasture plants such as pyrrolizidine alkaloids and indospicine that can impact on animal health and also have the potential to form residues in agricultural products and pose a risk to consumers. Fungal mycotoxins pose a similar problem in cereal grains.

Research project:

The Risk of Pyrrolizidine Alkaloids in Queensland Honey. Pyrrolizidine alkaloids are natural toxins produced by flowering plants that are transferred through pollen to honey. These alkaloids which have been associated with acute and chronic liver damage (even death), and the contamination of honey represents a potential risk to human health. The Australian provisional tolerable daily intake of pyrrolizidine alkaloids is 1 µg/kg/day, but their presence in Queensland honeys has not previously been determined. This project in conjunction with Queensland Health will establish a validated LCMS analysis method for measurement of pyrrolizidine alkaloids in honey, and investigate both the identity and level of alkaloids present in honey market survey samples collected across Queensland.

Useful Majors: Chemical Sciences / Chemistry

PROFESSOR ROBERT G. GILBERT

CENTRE FOR NUTRITION AND FOOD SCIENCES
QUEENSLAND ALLIANCE FOR AGRICULTURE & FOOD INNOVATIONS (QAAFI)
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Biosynthesis-structure-property relations for complex branched polymers

Starch provides more than half the world population's calorific intake; glycogen is our body's glucose buffer. These are at first sight simple homopolymers of glucose, but their structure spans many levels of complexity, with features ranging from nm to mm. These structural features strongly influence nutritional value for humans, and how well glycogen is effective in controlling blood sugar (and hence propensity to diabetes). In synthetic polymer science and technology, the paradigm for understanding material properties, and producing materials with improved properties, is well established as synthesis controls structure controls properties. We are now doing the equivalent for starch and glycogen: one changes the genetics (biosynthesis) to try to obtain cereals with desirable properties—better digestibility for managing and reducing obesity, diabetes and colo-rectal cancers—and drug targets for diabetes through glycogen synthesis enzymes. This project will greatly expand current knowledge, through our unique experimental and theoretical tools, to examine the structure of these polymers and then to relate the structural features to both biosynthesis and to properties. **Possible Hons, MSc, Intro to Research projects:**

The actual project will be tuned to accommodate the student's interests and background.

Project 1: Genetics/structure relations: theoretical description

Project 2: Genetics/structure relations: experimental developments

Useful Majors: Chemistry, Mathematics, Physics, Biochemistry & Molecular Biology Biomedical Science / Biophysics Computational Science / Genetics / Microbiology

PROFESSOR BEN HANKAMER

INSTITUTE FOR MOLECULAR BIOSCIENCE (IMB)

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Bio-inspired design of solar fuel systems

Solar energy is the largest renewable energy source available (1300 ZJ yr^{-1}) to us and can supply global energy demands (0.5 ZJ yr^{-1}). Our team is focused on developing solar fuel technologies based on green algae that tap into this huge energy resource and use it to produce a range of fuels (e.g., hydrogen and oil-based fuels) as well as animal feeds and high value products. Light capture is the first step of renewable biofuel and bioproduct production. The natural photosynthetic machinery of plants has evolved to capture solar energy and store it in the form of chemical energy (fuel). Our lab is investigating the complex structure of the dynamic photosystems of microalgae through a multi-scale approach, using electron tomography (cellular structures), single particle analysis (macromolecular structures), and crystallographic data (atomic resolution structures). By merging these data sets, our aim is to produce a pseudo-atomic resolution model of these intricate and dynamic systems in their cellular context. This cellular 3D atlas will be used to guide and refine the design of higher efficiency algae-based and artificial solar energy systems for the future. In parallel our team is devolving and testing algae cell lines and production systems at the lab and pilot scale in conjunction with our advanced Solar Biofuels Research Centre (www.solarbiofuels.org/sbrc) for the production of renewable fuels, animal feeds, waste water treatment systems and high value product production applications.

Possible projects:

- Biochemical & Structural studies of photosynthetic membrane protein complexes
- Expression of high value products in algae Model guided design of microalgae production systems

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PROFESSOR GLENN KING

INSTITUTE FOR MOLECULAR BIOSCIENCE (IMB)

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Development of peptide-based drugs and insecticides

We harness venoms from arthropod predators such as spiders, centipedes and assassin bugs to develop peptide drugs to treat chronic pain, epilepsy and stroke. Stroke is the second leading cause of death worldwide, while chronic pain is a huge medical problem that affects 1 in 5 adults. We are also interested in development of eco-friendly insecticides to help safeguard Australia's crops and reduce the spread of insect-borne diseases. We have the largest collection of arthropod venoms in the world, a high-throughput pipeline for venoms-based drug discovery, protocols for rapid protein expression and structure determination, and links to key laboratories for testing the efficacy of lead molecules in animal models of pain, epilepsy and stroke.

Possible projects:

- Discovery and characterization of venom peptides targeted at ion channels involved in stroke, epilepsy or pain, and examination of their therapeutic potential in animal models of disease
- Discovery and characterization of novel insecticidal and nematicidal compounds
- Structural characterisation of the interaction between venom peptides and ion channel targets using complementary NMR spectroscopy, X-ray crystallography and cryo-EM approaches

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Chemical Sciences / Chemistry / Computational Science / Pharmacology

ASSOCIATE PROFESSOR MEHDI MOBLI

CENTRE FOR ADVANCED IMAGING (CAI)

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Structural biology & drug discovery

Our research group uses high-resolution NMR structures of peptides and proteins to identify and design molecules that can be developed into therapeutics. Currently the following projects are available:

(1) Structural and functional characterisation of disulfide-rich tandem-repeat peptides that target ion channels. We use a combination of recombinant protein expression in bacteria and protein splicing for production and NMR for structural characterisation. Functional testing is done through our collaborators inside and outside of UQ.

(2) Structural characterisation of the ligand binding domains of ion channels. In this project we use a combination of bacterial protein expression and cell-free protein expression to produce the allosteric, ligand-binding domain of various ion channels. Transmembrane domains are inserted into cyclised lipid-nanodiscs for structural characterisation and ligand screening.

(3) Advanced methods for data acquisition and signal processing in NMR. This is a computer based project that involves applying and developing methods that under sample multidimensional NMR data, and use and develop (non-Fourier) methods for spectral reconstruction from such sparse data. These methods are critical in improving throughput and quality of NMR data used in structural biology research.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Chemical Sciences / Chemistry / Genetics / Microbiology / Pharmacology

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PROFESSOR MARK MORRISON

UNIVERSITY OF QUEENSLAND DIAMANTINA INSTITUTE (UQDI)

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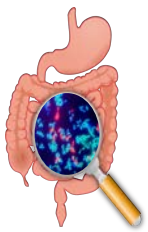
Research area

Our research focuses on “how what we eat becomes what we are” by examining the roles microbes play in health and gastrointestinal diseases like IBD, diabetes and cancer. We collaborate with clinicians, biomedical scientists, and other microbiologists to use microbiology and metagenomics to: i) characterise structural and/or functional changes in gut microbial communities; ii) isolate “new” bacteria from the human gut and; iii) use techniques in bacterial genetics, to better understand host-microbe interactions affecting health and disease.



Possible projects

Wanted alive not dead - isolation of “new” human gut bacteria: Use both culture- and genomics-based methods to isolate and characterize the most-wanted “not-yet-cultured” human microbes.

Bacterial mousetraps - the role of serpins in gut bacteria: Serpins act as “mousetraps”: when clipped by the target proteinase, they cause an irreversible inactivation of the enzyme. Using gut bacteria, characterise serpin expression, their target(s) and role in host-microbe interactions and gut homeostasis.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Biomedical Science / Biophysics / Chemical Sciences / Chemistry / Computational Science / Genetics / Microbiology

DR KATE SCHRODER

INSTITUTE FOR MOLECULAR BIOSCIENCE (IMB)

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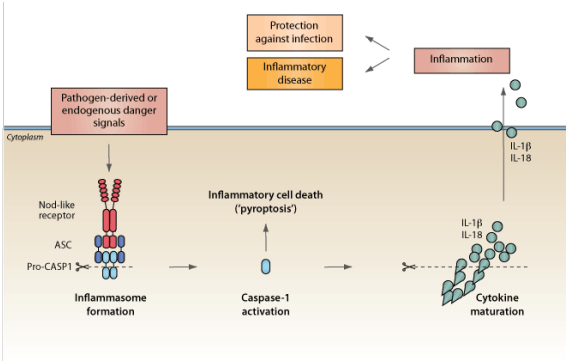
Inflammasomes in infection and inflammatory disease

The innate immune system is critical to defence against infection, but also drives unhealthy processes in inflammatory disease. An important emerging player in both of these settings is the 'inflammasome' pathway. Inflammasomes are molecular machines that trigger cytokine maturation and immune system activation in response to signals indicating cellular 'danger'. We research the molecular and cellular mechanisms by which inflammasomes initiate inflammation.



Possible projects

Lab research areas include novel inflammasomes, the molecular mechanisms of inflammasome assembly, and the cellular mediators of inflammasome-driven inflammation. We use a wide variety of molecular and cell biology techniques, in conjunction with animal models and human clinical samples, to investigate the biology of inflammasomes at the molecular, cellular and organismal levels.

Useful Majors: Biochemistry & Molecular Biology / Biomedical Science / Microbiology

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ASSOCIATE PROFESSOR RICK STURM

DERMATOLOGY RESEARCH CENTRE, UQ-SCHOOL OF MEDICINE
TRANSLATIONAL RESEARCH INSTITUTE (TRI)

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Melanocyte Biology and Pigmentation Genetics

A/P Sturm is a professional research scientist, trained as a molecular biologist, with over 30 years' experience using a combination of techniques to examine the genetic association and function of common gene polymorphisms in pigmentation and melanoma. The focus of his research is concerned with investigations of melanocyte biology and pigmentation genetics in relation to human skin cancer.

Possible projects

1. Genetics of human pigmentation traits including comparing individuals of high and low mole number, and looking at genes controlling mole morphology, freckling and eye colour.
2. Cell biology of human pigmentation, whereby the laboratory is growing primary cultures of human melanocytes alone or together with keratinocytes to assay function of genes and examine the UV induced tanning response.
3. Whole exome sequence and bioinformatic analysis of patients at high risk of melanoma and cell culture of melanocytic lesions.

Useful Majors: Biochemistry & Molecular Biology / Molecular Genetics / Cell Biology/Bioinformatics/ Biomedical Science

PROFESSOR MATT SWEET

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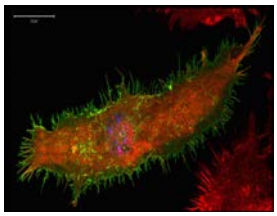
Research area

Our group studies the role of the innate immune system in infection and inflammation. We study mechanisms by which cells such as macrophages detect and respond to bacterial pathogens (e.g. Salmonella, uropathogenic E. coli) and how these pathogens overcome macrophage antimicrobial pathways. We also study signalling pathways downstream of pattern recognition receptors such as the Toll-like Receptors, and how this signalling contributes to dysregulated inflammatory responses in the context of acute and chronic inflammation-related diseases.

Possible Hons, MSc, Intro to Research projects



Toll-like receptor-inducible inflammatory pathways in innate immunity; Toll-like receptor-inducible antimicrobial pathways in macrophages; Histone deacetylases in inflammation and infection; Subversion of macrophage antimicrobial responses by the bacterial pathogens Salmonella and uropathogenic E. coli; Role of zinc trafficking in macrophage antimicrobial pathways; Role of innate immunity and inflammation in chronic liver disease. Techniques and approaches used span molecular and cellular biology, immunology and *in vivo* models of inflammation and infection.

Useful Majors: Biochemistry & Molecular Biology/Genetics/Microbiology Bioinformatics/Biomedical Science

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PROFESSOR ALA TABOR

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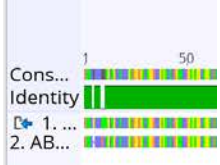
Research areas

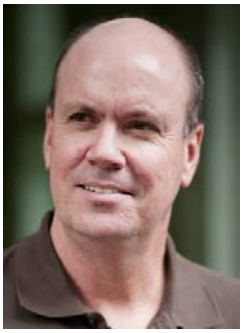
Bovine venereal diseases affect cattle in northern Australia causing decreased calf output and thus a reduction in breeding efficiencies. One of the main diseases is bovine campylobacteriosis. Our laboratory is developing novel diagnostic methods to differentiate *Campylobacter fetus* subspecies *venerealis* from other organisms. We are also examining the pathobiome of infected cattle to determine if this influences the development of bovine VD. Ticks and tick borne diseases affect humans, livestock and pets. The Tabor group has on-going research activities associated with vaccines, molecular assays and biomarkers.

Possible Hons, MSc, Intro to Research projects



Opportunities exist for comparative genomics, bovine host metagenomics, molecular diagnostic assay development, tick host biomarker studies including proteomics, miRNAomes, RNA-Seq and bioinformatics. The angle of the project can be negotiated to suit the candidate.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Microbiology



PROFESSOR ANDREW WHITTAKER

AUSTRALIAN INSTITUTE FOR BIOENGINEERING AND NANOTECHNOLOGY(AIBN)

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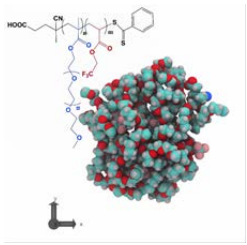
Polymer Chemistry

Our goal is to translate fundamental research findings and knowledge into products and health-care protocols. We use knowledge of physical and synthetic chemistry to design and synthesize novel materials for important applications. These are currently materials for photolithography and for medicine. The Whittaker Group consists of ~40 scientists working in a range of projects spanning fundamental physical chemistry to applied polymer chemistry. Our projects aim to impart detailed knowledge of important chemical systems, and provide training in modern scientific techniques.

Possible Hons, MSc, Intro to Research projects



Novel Biologically-Responsive MRI Agents: Polymers for imaging of diseased tissue; Nanofunctional Surfaces for Control of the Biological Interface: Novel surfaces to repel microbial colonies; Novel Polymers for Lithographic Applications: Materials for advanced manufacture of computer chips; more at http://www.uq.edu.au/polymer-chemistry/available-student-projects

Useful Majors: Biomedical Science / Biophysics / Chemical Sciences / Chemistry

RESEARCH FELLOWS

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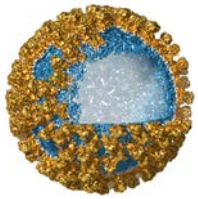
Viruses in Nanotechnology



Nature's original nanoparticles have evolved to protect and deliver sensitive cargo to precise subcellular locations. To do this the protein coat, or capsid, must assemble around a given cargo, retain integrity under a range of environmental conditions and interact selectively with its surroundings. The strength of some virus capsids, their structural fidelity and their biocompatibility, make them highly attractive for a number of applications in health and manufacturing.

Possible Hons, MSc, Intro to Research projects

Possible projects range from the biophysical characterisation of novel virus-like particles to developing new virus-based nanotechnologies. The ability of virus capsids to enter cells can be co-opted for the delivery of alternate cargos useful in cell engineering. In addition, designing particles to encapsidate enzymes can provide a stabilising scaffold to improve functional lifetime of biocatalysts. Techniques include protein expression and purification, directed evolution, electron microscopy, biophysical appraoches to monitor and evaluate self-assembly.

Useful Majors: Biochemistry & Molecular Biology / Biophysics / Chemical Sciences / Chemistry / Computational Science

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DR BEN WOODCROFT

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Environmental microbiology and informatics

Microbiology drives most ecosystem function on this planet, and yet we know comparatively little about how these tiny cells affect change. This is in large part due to their enormous diversity and the billions of years they have had to adapt, cooperate and modify their environment. These days, investigating these communities using computational techniques is an especially rewarding task. The volume and quality of meta-omic data available, while at times overwhelming, hides many interesting nuggets if you know how to look for them.

Possible Hons, MSc, Intro to Research projects

Topics suitable for project work are broad (and to some extent open to your ideas), but centre around developing new computational techniques that complement alternative wet-lab techniques and/or their application to the climate feedback of thawing permafrost, e.g. using metabolomics in concert with expression data to try to determine function in uncharacterised genes; new techniques for finding large viruses in metagenomic data; integrating bulk and single cell metagenomics to discern soil-particle-scale cooperation; mining public metagenome data; and relating microbial community composition to greenhouse gas emission in thawing permafrost.

Useful Majors: Biochemistry & Molecular Biology / Bioinformatics / Computational Science / Genetics / Microbiology

AFFILIATED INSTITUTIONS

Projects may also be available in the following UQ Centres and Institutes that have strong links with the School of Chemistry & Molecular Biosciences:

ADVANCED WATER MANAGEMENT CENTRE

Website: www.awmc.uq.edu.au
Contact: awmc@awmc.uq.edu.au

AUSTRALIAN INSTITUTE FOR BIOENGINEERING AND NANOTECHNOLOGY

Website: www.aibn.uq.edu.au/honours
Contact: rhd.aibn@uq.edu.au

CENTRE FOR ADVANCED IMAGING

Website: www.cai.uq.edu.au/honours-projects
Contact: honours@cai.uq.edu.au

INSTITUTE FOR MOLECULAR BIOSCIENCE

Website: www.imb.uq.edu.au
Contact: postgrad-office@imb.uq.edu.au

QUEENSLAND BRAIN INSTITUTE

Website: www.qbi.uq.edu.au/honours
Contact: qbistudents@uq.edu.au

UNIVERSITY OF QUEENSLAND CENTRE FOR CLINICAL RESEARCH

Website: www.uqccr.uq.edu.au
Contact: students@uqccr.uq.edu.au

UNIVERSITY OF QUEENSLAND DIAMANTINA INSTITUTE

Website: www.di.uq.edu.au
Contact: di.pgao@uq.edu.au

QUEENSLAND ALLIANCE FOR AGRICULTURE AND FOOD INNOVATION

Website: qaafi.uq.edu.au
Contact: qaafi_rhd@uq.edu.au

EXTERNAL INSTITUTIONS

CSIRO
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION

QUEENSLAND BIOSICENCES PRECINCT, UQ ST LUCIA CAMPUS

DR KEMAL KAZAN
CSIRO Plant Industry
Email: Kemal.kazan@csiro.au
And
PROFESSOR JOHN MANNERS
CSIRO Plant Industry
Email: john.manners@csiro.au

Potential Honours Project

- Fungal pathogen species *Fusarium* and interactions with both *Arabidopsis* and wheat

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QIMR BERGHOFER MEDICAL RESEARCH INSTITUTE

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