THE UNIVERSITY OF NEWCASTLE AUSTRALIA

FACULTY OF SCIENCE & INFORMATION TECHNOLOGY




HONOURS RESEARCH TOPICS

2012

HONOURS

CONTENTS:

School of Design, Communication & IT

School of Environmental & Life Sciences

School of Mathematical & Physical Sciences

School of Psychology

School of Design, Communication & Information Technology

COMMUNICATION

Public Relations
Public relations is both a professional practice and a subfield of communication with its own research and theory base. Public relations is relatively young as an academic field, having developed identifiable theory in only the last 30 years. The theoretical debates are far from settled and scholars from across the world, including scholars from this university, are contributing their research findings to further these debates in areas including the construction of meaning in contested spaces and the strategic management of communication. The field of public relations has developed into a theoretically based area of applied communication that has the potential to inform several areas of communication/mass communication and to offer theoretic and conceptual tools in many areas of communication industry practice. The advent of social media and new technologies potentially provides the field of public relations with huge challenges and opportunities, some of which are the focus of research being undertaken at the University of Newcastle. Projects are invited that explore aspects of the management of communication in public relations contexts, including from critical perspectives offered through discourse or semiotic approaches.

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Design, Information & Human Communication Group

Communication, media and consumption in the cultural sphere
This contemporary area of study focuses on current and future trends in communication theory/practice created by digital media and the web. With the development of digital media and the online environment, the traditional lines between media and marketing/advertising products are increasingly blurred. The merging of marketing and media content has given rise to fresh concepts such as convergence, transmedia narrative, interactive advertising and a range of new theoretical perspectives. As marketing transforms into entertainment and media increasingly involves promotion, this new media-marketing terrain significantly impacts on
-the role of both media and marketing in the cultural sphere,
-how media and marketing function as cultural producers/intermediaries and
-how we consume these cultural products.

This area of study adopts an interdisciplinary approach from marketing, consumer research, media and cultural studies to investigate new theoretical and practical aspects of this exciting new world of possibilities for communication, consumers and culture.

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Design, Information & Human Communication Group

Creative Practitioner Research
The research uses a Practitioner-Based Enquiry (PBE) approach in examining how form, format and an aesthetic style develops through the process of Media Practices. Any media project can be used for this research and theoretical approaches using Creativity are also suitable.

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Design, Information & Human Communication Group

Creativity and Innovation in Cultural Production
Creativity is not, according to the latest research, a process of self-discovery in a freely expressive romantic process. Nor is it simply confined to the arts. In fact the latest research is showing that creativity and innovation involves an agent who necessarily engages with the social and cultural structures that both limit and enable their creative activity. It is a basic human activity that works across both the arts and sciences. It is multifactorial in origin. One of the confluence models developed from the current body of research, the systems model of creativity, is being tested at this University in a number of areas. These include journalism, children's literature, songwriting, video and documentary making, website construction, sound and radio production and so on. Projects are invited that explore similar areas of creative concern via an application of the systems model. Methodologies include quantitative and qualitative forms (experiments, surveys, ethnographies and case studies) as well as practitioner-based enquiry (PBE).

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Design, Information & Human Communication Group

Poetics, Aesthetics and Ethics
Communication practices can be explored through a variety of creative and philosophical approaches. Poetics allows us to understand how we go about doing what it is we do. Poetics allows us to explore the how of what we do as we do it. The outcomes can be creative as well as philosophically novel. Aesthetics allows us to approach communication objects from the perspective of reception. What is the audience response, what do they perceive, how can media artists instruct intentions within objects? Ethics gets us to the why of things. Media objects always raise ethical issues. Media effects is one of the short cuts to this question of why.

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Design, Information & Human Communication Group

Journalism and Public Affairs
Research in the field of journalism encompasses a very broad area. For example, research can focus on journalists and their actions or journalism and society. Students can research and engage with texts or journalists or their audiences/readers/listeners. Honours research at UoN in journalism has included creative projects where students have combined an exegesis with a creative work. In 2009, one student undertaking journalism-related research created a radio series on "Coal and the Community", while another examined the impact of Web 2.0 technologies on the communication strategies of the major parties on the Australian political scene. Students interested in journalism related topics have a very open brief to develop a research question that will maintain their interest and academic staff work with them to focus that interest in a manner that will result in Honours research work that is focused, enjoyable and very achievable.

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Design, Information & Human Communication Group

How Religion, Media and Culture Intersect
Projects could take an inter-disciplinary approach in seeking to examine the intersection of these spheres in particular the mediatization of religion and culture.

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Design, Information & Human Communication Group

Current Honours' student projects include:

- Environmental activism in Newcastle – 1999 to 2009.
- Communication and coal in the Upper Hunter.
- Facebook Fogies: a uses and gratifications approach to 55-64 year olds on Facebook.
- The HPV school vaccination programme: an examination of the sources and nature of information provided to parents and their constructions of meaning about the product and the programme.
- "Soul Invaders": an exploration of heavy metal culture in Newcastle and Sydney.
- Disaster Porn.
- The future of news: examining the potential ramifications of online news for credibility.

DESIGN

Design in a World of Excess

At this moment in the world's history, economically advanced countries can be characterised as suffering from a condition of excess. They use more resources than less advanced economies; have greater choice in relation to how their citizens live their lives; have a surfeit of product choice; and in their media saturated world are inundated with a limitless volume of visual information and imagery. In such conditions of excess people become less concerned with consuming things and more concerned with the experiences they have. This has in turn led to the growth of the service sector economy where the key thing being sold is not a product to own but an experience to be had. For an industry such as design, that has largely been built on designing products for people to buy - and in the case of visual communication designing the messages to get people to buy these products - this poses the question 'what do we design?' In a conventional consumer driven logic visual communication has adapted by shifting its focus to designing messages to get people to buy these services. However at the cutting edge are multi disciplinary teams working in the fields of service sector design, customer experience design, interaction design, and experience design. Contested though these terms may be what they share is the belief that visual communication is central to conducting research into and telling the stories of the experiences people have and want to have of the world they live in. They see visual communication as more than just something that is tacked on at the end to make some product or service look nice so they can flog more stuff. It is about researching, visual story telling, and visualising data and information. Oddly enough it is the financial services sector in this country that is at the forefront of this work.

This project option would suit students who are interested in: working at the cutting edge of design research and application in corporate Australia; interested in people, their experiences and behaviour; the growing field of design for experience; and information visualisation. Though yet to be finalised these projects may run in collaboration with companies such as Vodafone, Westpac, BT Financial Group, and Second Road Thinking. Previous projects have been run with Westpac and Deluxe & Associates.

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Current Honours' student projects include:

- ***A Discussion of Over-The-Counter (OTC) Pharmaceutical Packaging: Is it driven by Legislation or Design Aesthetics?***
  The role of packaging design in today's society serves not only to contain, protect and promote the contents, but also to inform the potential consumer. The purpose of the study is to find out if designing within visual constraints inhibits creativity. The researcher aims to examine the visual trends and conventions used in the graphic design of OTC pharmaceutical packaging and investigate the role of labelling legislation in order to create a packaging solution that is both informative and appealing to the consumer.

- ***Graphic Design and Freeride Skis: An investigation into the graphic and cultural influence of snowboarding on skiing***
  This study aims to examine the influence of surf/skate/snowboard cultures on the evolution of freeride skiing, as well as investigate the graphic design process and visual elements of Freeride Skis.

- ***How the visual language of graphic design is used to read the film posters of filmmaker Christopher Nolan in the films Memento (2001), The Prestige (2006) and Inception (2010).***
  Investigating the semiotics and the language of film posters, this study aims to create a new design of film poster that targets the plot and genre while at the same time successfully advertising the films in question.

- ***Influences of the Avant Garde on magazine design***
  Magazines serve an important purpose as cultural artifacts, defined by social circumstances and shaped by technology. Within contemporary society, the magazine is changing as a direct result of the information age. New, avant-garde magazines are emerging and forming an independent publishing industry. The magazine acts as a mirror to both graphic design and society today. The aim of this study is to ultimately define what a magazine is in a post-modern context.

- ***Visual Communication Design***
  Graphic design is concerned with the visual environment. It is an intellectual, technical and creative activity. It is focused on all aspects of the production of images, from analysis and presentation to distribution and reception. Graphic design creates visual solutions to communication problems. It is an exciting area of research and study because of the increased importance of graphic design in the communication mix of an online world.

Research areas within the discipline include:

- Visual Communication Principles
- Concept Illustration and Visualisation
- Digital Media and Virtual Technologies
- Digital Illustration
- Stop Motion Animation and Animation
- Instructional Design
- Cognitive Load Theory

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NATURAL HISTORY ILLUSTRATION

Natural History Illustration
Honours students in Natural History Illustration are encouraged to develop their own projects which will be reviewed before students are accepted into the program. In the past students have come from a variety of discipline areas and projects have covered a wide range of topics. Prospective students are encouraged to submit their proposed project outline for consideration to the Natural History Illustration program convenor Dr Trevor Weekes. Applicants for admission must have successfully completed a relevant undergraduate degree or four year diploma in Illustration, Fine Art, Design or equivalent, including science, with a minimum GPA of 5.0 (Credit Grade Average overall) across the entire program.

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Wildlife Representation Group

Current Honours' student projects include:

- 'The secret life of the Platypus.'
- With the advent of 3D digital imaging has the need for traditional dioramas come to an end?
- Ordinary beauty of flora and fauna found in a specific land site – illustrated creatively and technically.
- Animation and illustration for a series of short stories.
- Evaluation and illustrated folio on plants considered as "weeds".

INFORMATION TECHNOLOGY

Data Mining on Health Research Data
Data Mining (DM) provides a means for exploratory analysis of large data sets. A number of IT tools are techniques are available for exploratory data analysis. This project aims to explore health research data collected on pregnancies using Data Mining techniques. The project entails working with both IT and Health researchers to analyse the data with the goal of developing a model to characterise status of a pregnancy based on the different characteristics of the data set. The student will use both statistical and DM IT tools to analyse the data and interact with IT and health researchers in interpreting/visualising them.

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Visual Information Processing (VIP) Group

Implementation of Database Privilege Monitor
Eliciting security privilege requirements from users pose a considerable challenge to IT administrators in today's complex IT environments. Further, IT users themselves are typically unaware of the different permissions that are needed to perform their daily activities, thus making it more difficult in determining these privilege requirements. This project aims to develop a tool, called Database Privilege Monitor, for SQL Server database server. The tool will allow IT administrators to determine permission requirements of users by observing the different actions the user performs on a SQL Server database. The student will develop a program to read SQL Server's Profiler trace (i.e. XML file) and determine the permissions needed by a particular user. These permissions will be displayed using a "Privilege Manager Console" to the IT administrator.

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Visual Information Processing (VIP) Group

The Utility of RFID Tagging Systems
This project will explore the use of RFID tags and the limitations that this increasingly popular technology places on applications development. What environments are suitable for RFID applications? How far can the technology be stretched?

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Visual Information Processing (VIP) Group

Computer modelling in economics, business and the environment
This project offers a number of potential topics for study that include:
a. Visualisation of massive quantities of model output data;
b. Web interfaces and implementations of models

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Visual Information Processing (VIP) Group

Real time sensor data on websites
This project offers a number of potential topics for study that include:

a. How much electricity do solar panels generate: Databases and website display of household solar panel data;
b. Comparing different sensor data.

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Visual Information Processing (VIP) Group

Reducing e-waste by extending the life of junked computing equipment

This project offers a number of potential topics for study that include:

a. Constructing grids of e-waste computers;
b. Software applications for grids of recycled computers (e.g. data cleaning and mining; database servers);
c. Business models for making grids of recycled computers financially sustainable;
d. Web and other applications using junked computing equipment.

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Visual Information Processing (VIP) Group

Advanced liver parenchyma segmentation for liver disease diagnosis using texture analysis and machine learning

This research aims to develop an innovative methodology that can segment liver parenchyma in multi-slice spiral/helical CT images. Automatic segmentation of liver parenchyma is crucial for an advanced computer-aided liver disease diagnosis and liver surgical planning system such as a system for liver transplantation. This research will achieve a breakthrough in non-rigid organ segmentation, a key area of medical image analysis. The segmentation algorithm is novel in that it combines CT image texture analysis with machine learning and adapts to the structures of neighbouring organs and tissues. This research will result in effective liver disease diagnosis, reduced risk for liver patient, higher quality in surgical planning and more effective interventions.

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Visual Information Processing (VIP) Group

Finding Temporal Patterns in a 3D Visualisation

In this project the student will develop a generic 3D visualisation of a large data set, such as stock market data or statistics from a football match. The key aspect of this display is that it will involve opposing and complementary forces, such as buyers and sellers in the stock market or two opposing football teams. The aim for the display is to find short temporal patterns in the data that help predict future outcomes, such as the price of the stock market or the winner of the football match.

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Visual Information Processing (VIP) Group

Information, Perception and Cognition in Multi-sensory Computer Games

Providing players with “Information” is often a critical consideration in the design of computer games. We may wish to increase or decrease the amount of information depending on the game situation and the player’s performance. This research investigates how we can manipulate the amount of information being displayed using multiple senses (visual, sound, touch). This is a broad topic area but it is only expected that the student will investigate a single relevant issue surrounding perception or cognition in the context of a current computer game.

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Visual Information Processing (VIP) Group

Navigating Knowledge using a Metro Map Layout
Metro maps were first introduced on the London Underground and now have become a common place tool for navigating transport routes around the world. Can more abstract knowledge be represented in this way? Would such a layout help novice users navigate through the unfamiliar content. For example, a university subject often contains a number of "tracks" or subject areas that overlap in places. Each track has topics which can be though of as "stations". In this project a Metro Map will be developed for a single university subject and then evaluated in a simple experiment.

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Visual Information Processing (VIP) Group

Simulating Agent-based Emotions
In this project the student will develop an agent-based simulation to be used in a computer game. A key aspect of these agents is that they will have a simple model of conflicting "emotions" that will influence the game play. The model of emotion may draw on existing ideas from psychology, neuroscience and artificial intelligence. The "emotional" model itself will be relatively simple although complex dynamics may emerge from the interaction of the agents in the game world.

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Visual Information Processing (VIP) Group

The Walkthrough Pharmacy
During a Pharmacy program students are expected to undertake blocks of professional experience in both community and hospital pharmacy settings. This is not always practical due to problems of distance and availability. The intention of this study is to develop virtual walk-throughs of three commonly encountered scenarios; a community pharmacy; a hospital pharmacy and; a clinical hospital ward. The intention is that the student can 'experience' these settings prior to actually seeing them n the real world. The project is expected to involve focus groups and interviews to define requirements, iterative prototyping and a formal, qualitative evaluation of the outcomes. This project will be in collaboration with Rohan Rasiah from the School of Biomedical Science and Pharmacy.

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Visual Information Processing (VIP) Group

Using Software Design Principles to 'improve' Teaching Materials
This research project investigates the use of software design approaches (object-modelling, processes, patterns, architectures) to improve the quality of instructional materials? The project will focus on existing courses in Bit degree and examine how a software engineering design approach could impact on the reusability, generativity, adaptability, scalability and quality of learning resources?

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Visual Information Processing (VIP) Group

Virtual Drugs
This project involves the development of a number of interactive 3D models to be used in teaching pharmacy practice. It is recognised that the continual practice of dispensing is a critical competencies required in the training of new pharmacy graduates. In particular, checking the dispensed item is an important step in the overall quality assurance process for dispensing. This project focuses on developing web-based interactive 3D models of commonly dispensed pharmaceutical items. A usability trial based on essential design criteria such as effectiveness, learnability and memorability will be used to evaluate and report on the outcomes.

This project will be in collaboration with Rohan Rasiah from the School of Biomedical Science and Pharmacy.

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Visual Information Processing (VIP) Group

Facilitating Collaborative Intelligence Analysis Using Computational Methods
The key question of this research area is: "How can the intelligence analysis process be improved through the utilisation of Digital Collaborative Environment technologies?". Collaboration within and between allied intelligence organisations is vital for effective national and international security. The review of available literature shows that there is a fundamental lack of collaboration within and between intelligence organisations. This lack of collaboration has been blamed for the failure to prevent of more than one terrorist attack, including the September 11th attacks. This research project aims to address some of these issues by investigating, designing, and developing digital collaborative solutions to facilitate Collaborative Intelligence Analysis.

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Visual Information Processing (VIP) Group

Current Honours' student projects include:

- Web interfaces to computer-based modelling.
- Predator/Prey model of software development.
- Application of web frameworks and content management systems for large datasets.
- Java applications on computing grids.

School of Environmental & Life Sciences

APPLIED SCIENCE (OURIMBAH CAMPUS)

Monitoring training load and responses in high-level junior swimmers
Swimming NSW, NSWIS and the University of Newcastle have developed a high-performance swimming squad located at The Forum that aims to target developing swimmers towards future Commonwealth and Olympic Games. An opportunity exists for student research that will contribute in the development of training monitoring techniques specific for swimming. The project presents an excellent chance for research development and experience working as an applied sports scientist.

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Exercise & Sport Science Group

Physiology of compression garments in females
Compression garments are increasingly popular amongst athletes, though there is very little scientific evidence to support their use. At present, no data is available on the benefits of wearing compression garments during exercise in females. The proposed benefits of wearing compression garments may possible benefit females differently to that reported in males. The research would specifically involve looking at endurance exercise performance, cardiorespiratory measures, changes in blood flow and muscle oscillation during exercise. The project is supported by ISC sports clothing.

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Exercise & Sport Science Group

Recovery practices in Masters Athletes
Little is known on the efficacy of popular recovery practices in Masters athletes and research is warranted to determine the time course of recovery and effectiveness of commonly used techniques in this population. It is well known that with age, the ability to recover is slowed following high-intensity exercise. At present, little research has investigated methods of speeding physiological recovery following high-intensity exercise, and thus, this project aims to report on several methods of recovery following such exercise.

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Exercise & Sport Science Group

Adaptation of resistance training methods to female steroid hormone fluctuations
The female steroid hormone oestrogen is known for its anabolic effects. It would therefore be expected that conditions for muscle growth are better when oestrogen is elevated. Thus the variability in oestrogen levels due to the menstrual cycle may affect the ability of skeletal muscle to respond to training. The aim of this research is to establish if adaptations of resistance training programs to fluctuations in oestrogen will result in greater strength gains than traditional training programs. Significant improvements with the oestrogen adapted training would revolutionize training regimes for female athletes and assist in improving musculoskeletal rehabilitation programs for females.

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Exercise & Sport Science Group

Applied Sport Science research in Soccer
There are opportunities for applied sport science research working with a professional soccer team. Details of the project will be determined in consultation with the soccer team's sport science staff.

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Exercise & Sport Science Group

The menstrual cycle and exercise performance
Hormonal changes throughout the menstrual cycle have many physiological effects, which may in turn affect exercise performance. There are opportunities for research projects in this area. Details of specific projects will be determined in consultation with the academic staff.

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Exercise & Sport Science Group

The effects of elastic cord towing on sprint kinematics
The ability to run fast is an important component to many different team sports. A range of training techniques are used in an attempt to improve sprinting ability. Overspeed sprinting is a speed training method whereby an athlete is towed by an external device that allows them to reach a supramaximal running velocity. Elastic cord towing is one such technique. The aim of this research will be to document how elastic cord towing affects the sprint technique of team sport athletes. This information can then be used to design specific speed training programs for these athletes.

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Exercise & Sport Science Group

The effects of nutritional supplementation and resistance training on muscle strength and hypertrophy
There are opportunities for research analysing the effects of resistance training in conjunction with a range of nutritional supplements on muscle strength and hypertrophy in trained and/or untrained individuals. Details of the project will be determined in consultation with sport science academics.

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Exercise & Sport Science Group

Exercise and prostate cancer
Androgen deprivation therapy (ADT) in men with prostate cancer is associated with a number of adverse effects, including reduced muscle mass and strength. The goal of this project is to characterise the effects of ADT on the fatty infiltration of muscle (myosteatosis) and the role that exercise may play in preventing this change in muscle composition as well as in enhancing physical function.

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Exercise & Sport Science Group

Exercise and surgical outcomes
Exercise has been shown to be beneficial in a number of disease states. However, little work has been undertaken in the role of exercise as a form of prehabiliation to enhance the recovery of patients following surgery. This is especially important for older persons who due to their deconditioned state may fall below the strength/functional thresholds for performing daily activities following surgery and the associated recovery period. This project will examine the effects of pre-surgical exercise on patient outcomes, including recovery time and functional status.

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Exercise & Sport Science Group

Exercise and sarcopenia: is the message getting out?
For the past two decades exercise has been shown to be an effective countermeasure against sarcopenia and the associated decline in physical function. However, how well this is recognised by physicians remains unclear, especially given the relatively low uptake of resistance training by older adults. The goal of this project is to ascertain the perception by physicians of resistance exercise as a training mode for older persons and develop strategies to enhance the promotion of this exercise mode.

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Exercise & Sport Science Group

Exercise prescription and programming preferences for people with Multiple Sclerosis (MS)
Physical exercise is beneficial for MS patients, improving health outcomes and quality of life. However, many people with MS remain sedentary. Understanding exercise programming and counselling preferences may represent an effective method for enhancing exercise participation and adherence in this patient group. The purpose of this project will be to investigate the exercise programming and counselling preferences for persons with MS with the goal to enhance physical activity/exercise participation.

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Exercise & Sport Science Group

Role of vitamin B12 polymorphism in hypertension
Vitamin B12 is crucial for folate dependent one-carbon metabolism and methyl group formation. It is cofactor for methionine synthase which converts homocysteine into methionine. Homocysteine is a vasculotoxic thiol that acts as an independent risk factor for CVD with the same magnitude of effect as cholesterol. This study will see if the transcobalamin II Pro259Arg polymorphism alters homocysteine level and acts as a risk factor for hypertension in an elderly Australian population.

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Nutrition, Food & Health Group

Vitamin B12 polymorphism in colonic adenoma formation

Vitamin B12 is crucial for folate dependent one-carbon metabolism and methyl group formation. It is cofactor for methionine synthase which converts homocysteine into methionine. Methionine contributes methyl groups for epigenetic modifications that modulate gene expression. If the transcobalamin II Pro259Arg polymorphism alters methionine level it may act as a risk factor for early dysplastic changes in the colonic epithelium via altered CpG methylation of DNA. The prevalence of this SNP will be examined in patients with and without colonic polyps.

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Nutrition, Food & Health Group

BIOLOGICAL SCIENCES

Characterisation and crystallisation of the Xer recombinases from *Pseudomonas aerophilum.*
The Xer site-specific recombination system has been extensively studied in *E. coli*, where it resolves chromosomal dimers to allow chromosome segregation. It is conserved through almost all bacteria and the archaea. The XerD recombinase is stimulated by direct interaction with a small domain of the FtsK protein, called γ. Structural studies on the E. coli proteins have proven difficult and it is hoped that the *P. aerophilum* homologues will be more amenable: the FtsK motor and γ domains from *P. aerophilum* have already been determined. The aim is to produce the Xer proteins and the γ domain separately and as fusions, show that they are active, and produce crystals of these proteins to determine the interaction with and/or with the Xer proteins' DNA binding site.

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Priority Research Centre for Chemical Biology

Characterisation of Xer-γ fusion proteins
The Xer recombinases recombine DNA at a site called *dif* to resolve chromosomal dimers. Recombination requires the physical interaction of XerD with the FtsK protein. However, fusion of the γ domain of FtsK to the C-terminus of XerC or XerD produces catalytically active proteins. This project aims to clone smaller portions of the γ domain, down to a few amino acids, to try to determine the minimal interactions necessary to stimulate recombination.

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Processing of a collapsed replication fork *in vivo*.
Recovery of replication forks after collapse is a fundamental process that all cells must cope with, and failure to do so can lead to mutation, cell death or cancer. Fluorescent repressor proteins, bound to arrays of operator sequences have been used to visualise chromosomal loci in live cells, both prokaryotic and eukarotic. Overproduction of the repressor protein can act as a block to replication forks in *E. coli*. Using this system, replication can be blocked at a given location in a population of cells. If a temperature sensitive replication protein is used, then the blocked replication forks can be made to fall apart by a simple temperature shift. The aim of this project is to introduce mutations in proteins suspected to be involved in processing collapsed replication forks to see their effect, and determine the pathways and kinetics of recovery *in vivo*.

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Analysis of transcription factor dynamics using ChIP-chip technology/ Bioinformatics
This project is designed to analyse the assembly and disassembly of transcription complexes on a genome-wide scale using chromatin immunoprecipiation techniques combined with DNA hybridisation to high density tiled microarrays. Using this approach we will be able to determine the order with which transcription factors bind to RNA polymerase, whether there are different classes of transcribing transcription complexes, and how transcription factors influence transcription termination at the end of a gene/operon. The bulk of this project will involve *in silico* analysis and would be ideal for a bioinformaticist/maths-biology major.

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Characterisation of the NusA-RNA polymerase binding site/ Molecular Biology
NusA is a transcription factor that is essential and unique to bacteria. Therefore, preventing NusA interacting with RNA polymerase would lead to cell death, and targeting this interaction represents a promising target for antibiotic development. We have recently determined the structure of NusA in complex with RNA polymerase, and determined at low resolution the regions of RNA polymerase and NusA that interact. This project is designed to carry out mutagenesis on the RNA polymerase binding domain of NusA, followed by mutant purification and binding assays to establish which specific residues of NusA are involved in its interaction. Results from this study can then be used in the rational targeting of this area to design inhibitors of the interaction.

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Construction of an inducible RNA polymerase for *in vivo* testing of novel antimicrobials/Molecular Biology
RNA polymerase is an underutilised target for antibiotics that are urgently needed to combat the increasing incidence of antibiotic-resistant infections. This project will involve the construction of strains of *Bacillus subtilis* (closely related to Golden Staph) and *Acinetobacter baylyi* (closely related to the very serious hospital pathogen *A. baumannii*) in which the production of RNA polymerase can be controlled through the addition/removal of special inducer molecules to the growth medium. These strains will be used to determine the effect of specific mutations on the ability of essential transcription factors to bind to RNA polymerase. Lack of binding will result in cell death, and represent an excellent framework for the development of useful lead antimicrobial compounds.

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Identification of competitive inhibitors of NusA interaction with RNA polymerase/Molecular Biology
Transcription is an essential process in all organisms, and the enzyme, RNA polymerase that carries out this process is highly conserved across the kingdoms. However, transcription factors, that are often essential, are not conserved across the kingdoms and so the interaction of essential transcription factors with RNA polymerase represents an excellent target for the development of new antibiotics. This project will utilise phage display technology to identify peptides capable of inhibiting the interaction of the essential transcription factor NusA with RNA polymerase.

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Metabolomics of bacterial responses to environmental stresses
Staphylococci represent a clinically significant group of bacteria that cause serious infections. The coagulase positive *Staphylococcus aureus* or "golden staph" is responsible for many life-threatening hospital-acquired (nosocomial) infections and can have multiple antibiotic resistances. The coagulase negative staphylococci, such as *S. epidermidis* and *S. lugdunensis,* can also cause nosocomial infections and are often associated with chronic infections with prosthetic joint implants and associated drug resistance. These staphylococci are all natural inhabitants of the skin surfaces in healthy individuals. The bacteria can respond to the environment to make the most of infection opportunities and change their mode of existence to a virulent form or survival form as appropriate. The staphylococci can form small colony variants (SCV) in response to exposures to antibiotics, ph, cold and osmotic stresses. These phenotypic variations represent obvious responses to environmental challenge and can invade intra-cellularly. This project will explore the metabolic changes associated with ultra-structural and colony changes in SCV formation. Gas chromatography-mass spectrometry will be used to measure biochemical profiles of cytoplasmic composition before and after stresses to determine how the bacteria adapt to specific environmental challenges. This will be coupled with electron microscope studies relating morphological changes with alterations in metabolic profiles. Several projects are available within this subject area.

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Metabolic Research Group

Research within the Plant Science Group is centred around two key themes:

1) **Nutrient allocation**, impacting upon crop yield and quality using molecular and cellular approaches;
2) **Reconstructing sustainable ecosystems** with native vegetation. Projects within theme 1 are listed under i) Nutriomics, ii) Transfer cell development, iii) Cotton fibre development and iv) Biofuels. Projects within theme 2 are listed under i) Rebuilding soils, ii) Reconstructing Ecologically Endangered Communities and iii) Restoration potential.

i) **Nutriomics.** Nutrient (especially sugars) transport and metabolism within organs of agronomic significance (e.g. fruit and seed).

Novel membrane transporters
As membrane transport of sucrose is a key determinant of crop yield, a detailed understanding of genes encoding sucrose transporters provides fundamental knowledge towards increasing crop yield. This project aims to determine the inter- and intracellular localizations of these important proteins.

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Plant Science Group

Control of cell wall biosynthesis for bio-energy and crop yield
This project will use cotton fibre and transfer cell as models to identify genes for modification of plant cell wall composition to increase efficiency of biofuel production and cotton fibre yield. Contemporary molecular, cellular and biochemical approaches will be utilized to address a set of hypotheses.

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Plant Science Group

Improving seed and fruit development using gene technology
Seed and fruit are organs of major agronomical importance. We recently identified a key regulatory gene, *INVINH1*, which controls tomato seed size and fruit sugar level by repressing activity of invertase (INV) (Jin et al 2009 *Plant Cell*). Further work aims to elucidate the molecular mechanisms and signalling pathways that controls the co-expression and interaction of the INVINH1 and its target, INV. The questions will be addressed by using contemporary molecular, cellular and biochemical approaches.

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Manipulating water channel genes for improving drought tolerance of crops
This project will study water channel genes in the control of water movement in plant cells and design innovative approaches to increase drought tolerance of crops. A combination of molecular, cellular and physiological approaches will be utilized to address relevant questions.

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Enhancing sugar accumulation in tomato fruit
Fruit sugar levels are a significant agronomic trait particularly in the tomato processing industry. We have identified sugar transporters which regulate hexose accumulation in tomato fruit, and have generated transgenic plants over-expressing these transporters. This project will involve molecular analysis of these transgenic plants to determine the physiological mechanisms leading to this outcome. A second project within this topic will screen site-directed mutants of transporters in a functional expression system to select those with enhanced kinetic properties, thus laying a platform for future targeted breeding strategies involving a non-GMO approach.

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Mechanisms of sugar transfer in AM symbiosis
AM fungi increase access to essential plant nutrients in exchange for up to 20% of plant sugars. Understanding this nutrient exchange is critical to future efforts to maximise AM benefit in agricultural production systems. The project will involve identification, localisation and expression analyses of key genes involved in sugar transfer.

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ii) **Transfer cell development.** These specialised cells play a vital role in nutrient transport/allocation in plants, and consequently are key factors in determining plant performance and hence crop yield. Understanding the biology of transfer cells will provide new avenues for addressing the global imperative of food security into the future.

Building transfer cell wall ingrowths
Transfer cells have intricately-invaginated wall ingrowth labyrinths that greatly amplify their plasma membranes which in turn contain high densities of nutrient transporters. The wall ingrowths are initially deposited as papillate structures at loci in response to inductive signalling by ethylene, reactive oxygen species (ROS) and Ca^{2+}. This project involves isolation of lipid rafts (membrane

aggregation centres for wall building molecules) and visualization of their distribution when transfer cell induction is perturbed using signal cascade inhibitors. The concept of lipid raft involvement in wall deposition is new; outcomes of the project will contribute significantly to our understanding of wall ingrowth formation.

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Genetic Control of Transfer Cell Development
This project will use the model species *Arabidopsis thaliana* to investigate genetic control of transfer cell development. We have identified several novel transcription factors as candidate regulators of transcriptional cascades initiating the development of transfer cells. Identifying the key regulators of such transcriptional cascades will provide new avenues for manipulating crop yield and development of improved feedstock for biofuel uses. The project is funded by an ARC Discovery grant and will involve gene expression analysis, fluorescence microscopy, mutant analysis and determining protein-protein interactions by yeast 2H assays.

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Deep Sequencing Analysis of Transfer Cell Development
This project will perform RNA-Seq using Illumina-based sequencing to analyse transcriptional changes occurring during induction and wall ingrowth building of transfer cells. The experimental approach will use either transfer cell induction in *Vicia faba* cotyledons and/or phloem parenchyma transfer cells in the model genetic species *Arabidopsis thaliana*. The project would be ideal for a student interested in developing bioinformatics skills and would suit a biology/maths double major.

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iii) ***Cotton fibre development*****.** A single-cell system, ideal for studying cell growth and cellulose synthesis.

Cotton is the most important textile crop world-wide due to its cellulose-enriched fibres developed from the seed epidermis. Each cotton fibre is a single-cell that elongates up to 3~6 cm long and synthesizes a massive amount of cellulose. This project aims to understand the molecular and cellular basis of rapid fibre cell expansion and cellulose synthesis with the final goal to improve fibre yield, quality and tolerance to drought by manipulating identified key genes and processes.

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iv) ***Biofuels*****.** Maximising carbon capture by key crops as a biofuel feedstock.

Sorghum, a biofuel feedstock for arid environments.
Increasing fuel costs, finite resources and the need to develop more carbon neutral and cleaner fuels have created a need for renewable resources. *Sorghum bicolor* (Sorghum) is a crop plant adapted to the hot water limited environments of northern Australia, both as a grain and forage crop. As a result of its rapid growth rate, sorghum is an ideal crop for biofuel production from grain, sugar and biomass accumulation.

1. ***Identification and characterisation of novel cell wall mutants in Sorghum and Arabidopsis.***
2. ***Identification of regulatory mechanisms important in biomass accumulation.***

These projects will involve:

- Quantitative expression analysis using RT-qPCR from RNA isolated from plant tissues and organs.
- Immunolocalisation of selected proteins.
- Functional characterisation of transporters in heterologous systems including yeast mutants and Xenopus oocytes.
- FTIR microscopy and GC-MS analyses.

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***Setaria*, an ideal model for dissecting biomass quality traits**

Lignocellulosic bioethanol derived from plant biomass will provide a cost effective contribution to environmental sustainability and energy security. *Setaria italica* (foxtail millet) is an ideal genetic model to dissect biomass quality traits. A large number of plant lines exhibiting broad genetic diversity will be screened using Fourier Transform Infra-Red (FTIR) spectral analysis to identify those ecotypes with differing cell wall composition. Quantitative expression analysis of key genes using RT-qPCR, will be undertaken on the most divergent ecotypes as a platform to unravel the pathways and mechanisms contributing to variation in cell wall composition. Outcomes of this project will contribute significantly to our understanding of the capacity to tailor cell wall attributes to maximise digestibility of plant biomass.

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Reconstructing Sustainable Ecosystems

i) ***Rebuilding soils*.** Use of plant-microbe associations to re-establish nutrient cycling.

Rebuilding soil function

In badly disturbed ecosystems such as where logging, grazing and mining have occurred, soil function has largely been lost or restricted by erosion, compaction, and physical disturbance. Our principal aims are to capture remaining components of soil biota, determine their role in functional soil, culture them, and return them to reconstructed forest and woodland using experimental methods. Manipulation of the physical characteristics of a site can promote these interactions. The effect of site amelioration, including decompaction, scarification, adding organic materials and inoculation on plant and microbe survival and health, is also being investigated.

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ii) ***Reconstructing Ecologically Endangered Communities (EECs).*** Finding the best methods of restoring endangered ecological communities.

A number of vegetation communities are particularly threatened by development and have therefore been classified EECs. These are of particular interest when it comes to reconstructing communities on disturbed land. Experimental testing of techniques such as scalping or ripping the land prior to seeding and planting with a wide range of species are being investigated to determine the best

methods of restoring these communities. The cost-benefit relationship of particular reconstruction strategies is also being undertaken. Some species may be difficult to re-establish and research into factors contributing to this including mycorrhizal associations, seed dormancy and site conditions is being developed.

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iii) ***Restoration Potential.*** Addressing ecological bottlenecks by modifying, monitoring and modelling native vegetation communities.

Restoration Potential, Dispersal, Sustainability and Resilience
Ecosystems that have suffered loss of structure and function due to disturbances such as logging and grazing can have bottlenecks preventing pollination, dispersal and the development of regeneration potential. As part of this research we are building and calibrating models of sustainability and resilience. The ecological conductance model seeks to explain the ease or difficulty that organisms confront in completing their life cycles and building restoration potential. Current research is focussed on quantifying the resistances to life cycle completion, including pollination success; seed production and viability; the ability to be recruited into a sustainable population; to form associations with soil microbes; and the development of both spatial and temporal dispersal vectors.

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The roles of cytoskeletal proteins on the fertilisation and embryonic development in a marine invertebrate, *Galeolaria caespitose*
The project aims to produce a high definition Blue-Ray DVD movie to in-real-timely show how a single fertilised egg of *Galeolaria* develops through the cleavage and gastrulation stages into a larva using our Zeiss physiological microscopic digital recording system. We shall image those events in 2D florescent and stereo phase-contrast formats, which allow us to understand the roles of the dynamic changes of actin filaments and tubulin microtubule during the fertilisation and early development. Some critical moments of those reproductive and developmental events will be backing by electron microscopic pictures.

The results should improve our understanding of the reproductive physiology of this Australian marine species. The project will provide information on evaluation of whether the *Galeolaria* has potential to be a bi-monitor species for our ocean environment, as this species is so widely distributed along the east coast from Queensland to Victoria; and easy to be handled in the laboratory conditions.

An Honours student is invited to join this project. He/She will be involved in all activities in this project. Thus, the student will receive training on gamete and embryo culture, video imaging and tracking embryonic development, cell identification by immunofluorescent markers, and operations of fluorescent and electron microscopes.

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Priority Research Centre for Reproductive Science

Btbd12 – role in oogenesis
Proteins with a bric-a-brac, tramtrack, broad-complex (BTB) domain are implicated in a broad variety of biological processes, including DNA binding, regulation of gene transcription and organization of macromolecular structures. We have generated a unique Btbd12 null (knockout) mouse, which has a male and female infertility phenotype. Pilot experiments confirm that this gene is highly expressed in meiotic germ cells. The aims of this project are to characterise the expression of Btbd12 mRNA and protein in the mouse ovary and to investigate the use of protein:DNA binding experiments to elucidate genes under the transcriptional control of Btbd12.

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Characterisation of FZR1 in spermatogenesis
We have created a tissue–specific FZR1 knockout in oocytes and spermatogonia by cross-breeding the floxed FZR1 mice with a mouse that contains a Cre-recombinase driven by the driven by the Ddx4 (DeadBox 4) promoter. Mice havemale germ cells have been depleted of FZR1.

The role of FZR1 in spermatogenesis is unknown – however our preliminary analysis suggests that FZR1 gene and protein expression is highly upregulated in the early stages of spermatogenesis in the testes. Indicating that FZR1 is likely to play a key role in meiotic segregation in spermatocytes. The aims of this project are to characterise the expression of FZR1 mRNA and protein in the mouse testes and to investigate the use of shRNA experiments to elucidate signalling pathways controlled by FZR1.

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Cytokines and ovarian folliculogenesis
Female germ cells or oocytes are sequestered in primordial follicles before birth and remain quiescent in the ovary until recruited into the growing pool throughout the reproductive years. Programmed follicular cell death continues throughout a woman's reproductive lifetime and ultimately 99.9% of all oocytes are lost prior to ovulation with no opportunity to be fertilised. Very little is known about what triggers follicle activation, nor the intracellular mechanism by which the coordinated differentiation of somatic cells is harmonized with oocyte growth yet this holds the key to female germ cell maintenance as well as optimising oocyte cell health and development.

Studies of pleiotrophic cytokines have suggested that the mechanisms behind follicle activation involve a complex network of bidirectional signalling between cellular components of the ovarian follicle. However little is known about the intracellular signaling pathways activated by these pleiotrophic cytokines.

In our pilot microarray gene expression surveys and confirmed by our protein localisation studies, we have identified that two key intracellular signaling molecules Signal Transducers and Activators of Transcription 3 (STAT3) and Suppressor of Cytokine Signalling 4 (SOCS-4) are induced on activation of the murine primordial follicle. The overall goal of our proposed project is to characterise the intracellular cytokine signalling pathways regulating activation and maintenance of mammalian ovarian primordial follicles.

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Smoking: impacts on female fertility
All female mammalian ovaries contain a limited supply of primordial follicles which are present from birth. Recently it has become apparent that xenobiotics, such as organochlorine pesticides, polychlorinated biphenyls, dioxins, alkyl phenolic chemicals, phthalates and synthetic oestrogens are capable of interfering with normal female reproductive function in both humans and animals. Some xenobiotics that are prevalent in cigarette smoke including DMBA and benzo[a]pyrene, have been shown to target primordial follicles and trigger atretic oocyte depletion of the ovary leading to premature menopause. Our recent studies of the effects of xenobiotic exposure in the ovary have demonstrated that environmental agents can cause significant primordial follicle loss and oocyte damage through oxidative stress. Our proposed model is based on preliminary findings which indicate that xenobiotic exposure has direct consequences on ovarian function. The aims of this project are: To elucidate the action of xenobiotics in the developing ovary and in particular the role of the Phase I enzymes (Cytochrome p450's) in the generation of reactive oxygen species. To quantify the role of xenobiotic derived oxidative stress on mitochondrial function, plasma membrane fluidity and oocyte dysfunction. To characterize the ovarian follicle signalling pathways activated by xenobiotics and their role in oocyte growth, follicle differentiation and survival. Insight into these processes will illuminate the origins of primordial follicle loss and oocyte dysfunction leading to subsequent ovarian failure and infertility in human females.

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Meiosis: role of Msi2 in male germ cell development
Gametogenesis is whereby primordial germ cells differentiate into gonocytes the precursors of physically mature viable gametes. This process needs strict control over translational regulation and is achieved through RNA binding proteins (RBPs) which have been implicated in the regulation of spatial temporal and functional dynamics of mRNAs. The RBPs bind and regulate the translation of mRNA by attaching to specific target sites in the 3' untranslated region (UTR).

The Musashi family of RNA binding proteins are important translational regulators in gamete formation and are evolutionarily conserved across species. Recent evidence has revealed that both Musashi family homologues Msi1 and Msi2 are involved during early and late stages of gametogenesis. Msi1 is expressed in the germ line stem cells and spermatogonia and involved in proliferation, where as Msi2 expression is localised to the progenitor cells and is active in meiosis.

The aims of this project are to identify mRNA and proteins which interact with Msi2 – this is intended to identify mRNA targets of translational regulation in gametogenesis using Msi2 protein:RNA and Msi2 protein:protein pull downs.

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miRNAs and spermatogenesis
MicroRNA are a recently discovered class of noncoding RNA molecules of about 20-22 nucleotides long. These miRNA molecules specifically target the 3' untranslated region of mRNA molecules to repress their translation and thus control their expression. MicroRNAs are involved in many developmental processes such as spermatogenesis and regulate more than 30% of human genes. MicroRNA expression is disrupted in several diseases such diabetes, Alzheimer's and cancer including testicular germ cell cancer. The aims of this project are to obtain detailed Information as to the causes of testicular cancer by examining the gene expression and miRNA expression within mouse gonocytes and spermatogonia, and comparing to that obtained in normal human testes and testicular tumours. The changes in miRNA expression will be examined using a microarray and confirmed with real time PCR. The target gene expression pattern will be examined using real time PCR. The role of miRNA within spermatogenic stem cells as well as testicular germ

cell tumours will be examined using shRNA knockdown within spermatogonia and the T-Cam2 cell line which was derived from a seminoma tumour.

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Non surgical sterilization for the control of fertility in domesticated animals and feral pests

The intention of this study is to develop a humane, safe and effective method of sterilising female domestic animals without surgical intervention. This study intends to target the supply of dormant eggs in the ovaries of female mammals. Every female mammal is born with a finite supply of eggs, once this supply is exhausted, reproduction ceases. Our study intends to isolate and characterise pharmaceutical agents which can specifically destroy the dormant egg population resulting in irreversible sterilisation.

Using a technique known as phage display we have isolated several small proteins, known as peptides, which are capable of specifically binding eggs (oocytes) in vitro. Binding in some cases results in a substantial loss of oocytes, with no significant damage being done to any of the surrounding tissue. This study intends to increase the virulency of these peptides by attaching to biological agents which facilitate the destruction of the oocytes cellular membrane. Ultimately resulting in a sterilisation agent which is effective at low concentrations, providing a low cost alternative to surgical sterilisation.

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Retention of Spermatogonial Stem cell phenotype

Crucial to spermatogenesis are a number of RNA binding proteins, which are expressed in germ cells. These proteins are responsible for the control of post-transcriptional regulation of the multitude of mRNAs coding for proteins essential for latter stages of germ cell and spermatozoal development. Musashi (Msi) is an RNA binding protein family and we recently investigated the role of Musashi family in the Drosophila and mouse testes and showed that Drosophila Msi is both expressed and required in spermatogonial stem cells for maintenance of stem cell fate. We also found that cell-autonomous loss of Msi in the Drosophila testis results in the premature differentiation of spermatogonial stem cells, indicating an intrinsic requirement for Msi for regulation of stem cell maintenance – we have produced a transgenic msi1 mouse for overexpression studies and this project aims to characterise this mouse.

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Translational control of folliculogenesis and oocyte development: role of the RNA binding protein Musashi-1

Coordinated post-transcriptional regulation of the oocyte mRNA pool is critical for the control of the finite pool of primordial follicles, normal progression of chromatin condensation and ultimately healthy oocyte production. Using our mouse and Drosophila model systems, we have recently identified the Musashi family of RNA binding proteins as key regulators of folliculogenesis and oocyte development. Historically, Musashi proteins have been identified in both neural and epithelial stem cells where they function as translational repressors. We have recently identified a novel member of the Musashi family in *Drosophila* ovary, which also functions as a translational repressor of key regulators of oocyte nuclear maturation and meiotic progression and have characterised the expression of the mammalian homologue Musashi-1 in the mouse ovary. In this project we aim to characterise the signalling pathways of Musashi-1 oocyte specific overexpression and knockout in transgenic and null mice using gene and protein expression profiling.

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An assessment of DNA packaging in human sperm.
Human sperm package DNA with protamines to protect it from damage. However, a significant proportion of the genome remains poorly packaged and accessible to DNA damaging agents. We have developed an assay to assess packaging in human sperm. The project will use the assay to determine the extent of variation in packaging between humans.

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Evaluating the effect chronic exposure has in generating DNA damage in the paternal germline.
DNA damage in the male germline is postulated to lead to detrimental effects such as cancer in the offspring. We are developing mouse models of chronic exposure to assess the genotoxic effect of chemicals. The project involves examining gene and protein expression in testis from exposed animals. We will also investigate the nature of the DNA damage generated.

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Molecular Pathways of Germ Cell Differentiation 1: regulation of gene expression in spermatogonia
Using array technology we have previously identified a number of genes regulated by retinoids in spermatogonia. We have identified a pathway of genes that responds to retinoids via a transcription factor not previously implicated in retinoid signalling. The project involves assessing regulation of a target of this transcription factor at the promoter level via a reporter construct. We will use gene knockdown to evaluate the role of the transcription factor in the pathway.

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Molecular Pathways of Germ Cell Differentiation 2: regulation of BMP4 gene expression
We are seeking to understand the transition from spermatogonia to spermatocyte at the molecular level. We have identified 2 signalling pathways that interact during spermatogonial differentiation: the BMP4 and retinoid pathways. Previously, we have found that the metabolites of vitamin A, known as retinoids, regulate BMP4 gene expression. The major metabolite of vitamin A is not the active molecule in this case. This challenges a dogma. Testis and germ cells will be examined for vitamin A metabolites. Retinoids, both extracted and commercially available, will be tested by assessing their affects on BMP4 gene expression in isolated cells.

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Advanced proteomic research – application of molecular imprinting

i) ***Recognition of Different Conformations of Protein Secondary Structure by Molecular Imprinting***

Turner et al have performed proof of concept studies of using molecular imprinting to recognise different isoforms of the same protein. This study suggests that direct discrimination of isoforms via an artificial receptor is possible, however this initial work needs validating with further examples.

This honours project will aim to provide this, by studying alternate model systems (Lysozyme and α-lactalbumin) to verify the validity of this technique. As well as using the techniques developed in the pilot study, this project will look at modifying the imprint matrix to improve sensitivity and affinity.

This project would suit a biochemist, with interests in structural biology, molecular recognition, and/or chemistry at the biological interface.

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Priority Research Centre for Reproductive Science

ii) ***Removal of Interfering Proteins from Blood Serum***

Human Serum Albumin (HSA) makes up approximately 50-60% of blood serum protein, and as such can be a problem when screening serum for biomarkers, which tend to be short peptides. A matrix that could specifically filter out this abundant protein, leaving other components behind would be highly beneficial.

Molecular imprinting is a technique which creates artificial recognition sites (binding pockets) in polymeric materials, and has demonstrated the potential to specifically bind proteins. This project will focus on creating a gel filter matrix that by size exclusion and molecular imprinting will be able to specifically remove albumin from serum, without removing any markers of interest. Success will create a material which will improve screening processes for molecular biological applications.

This project would suit a biochemist, with interests in protein chemistry, molecular recognition, and/or chemistry at the biological interface.

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Analysis of the mechanisms generating DNA damage in human spermatozoa

This project involves examining the nature of the environmental factors that might induce DNA damage in human spermatozoa. Current emphasis is on the identification of an endonuclease which we believe to be activated by a variety of stressors (temperature/oxidative stress/electromagnetic radiation/age) and be responsible for the induction of much of the DNA damage we see in infertile patients. The results of this research will have a bearing on assisted conception therapy and public awareness of the impact of environmental factors on reproductive heath.

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Assessment of oocyte and embryo quality

A major task in the assisted conception industry is to develop no-invasive methods for the evaluation of oocyte and embryo quality. We have patented an approach to this problem and now wish to refine the assay technique, using conditioned embryo culture media from Hunter IVF and samples of follicular fluid. The same fundamental chemistry will be used to develop a diagnostic test for male infertility.

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Assisted Conception and Early Development

The overall purpose of the studies grouped under this heading is to improve the management of human infertility by evaluating the causes of diminished gamete quality and resolving the impact of this damage on the developmental potential of the embryo.

i) ***Proteomic and Metabolomic Analyses of Gamete and Embryo Quality***

This clinically–orientated project research project involves the development of a close interface with collaborators in assisted conception clinics to refine our understanding of gamete and embryo quality. This project will use state-of-the-art techniques in metabolomics and proteomics to define the molecular basis of impaired gamete function and to identify markers for the assessment of embryo quality. Current emphasis is on resolving the molecular basis of impaired gamete interaction at fertilization and the role of oxidative stress in the disruption of fertilization and impaired embryonic development. This project would provide training in advanced mass spectrometry as well as insights into the assisted conception industry.

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ii) ***Epigenetic Defects***

Preliminary clinical data is available to suggest that infertile males generate gametes that possess methylation defects that might have an impact on the developmental potential of the embryo and the health and well being of the subsequent offspring. These defects are characterized by hypomethylation of key sites, which we have hypothesised is due to oxidative damage to the corresponding CpG islands. High-throughput DNA methylation profiling will be used to screen for genome wide methylation defects in the gametes of infertile men. These profiles will subsequently be correlated with presence of oxidative base damage to the sperm DNA. In addition we shall correlate any defects seen in the methylation profiles with the developmental potential of the embryo and the normality of DNA methylation in the offspring.

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Cell Biology of Spermatozoa

i) ***Epididymal Transit and Maturation***

Upon leaving the testis, spermatozoa are incapable of progressive movement or the cascade of cellular events that result in fertilization of the oocyte. These functional characteristics are only acquired as spermatozoa undergo maturation during epididymal transit. Given the absolute importance of epididymal maturation for the generation of fertile spermatozoa, it is clearly important that the molecular mechanisms supporting this functional transformation be elucidated. Success in this area will have implications both for development of reversible male contraceptive agents and the aetiology of male infertility. This project aims to characterise changes in tyrosine phosphorylation and mitochondrial activation which appear to be particularly important parts of epididymal maturation.

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ii) ***Capacitation and Development of Fertilizing Ability***

Transcriptionally inactive spermatozoa rely heavily on post-translational modifications in order to acquire functional competence. These processes occur in two distinct phases as spermatozoa pass through the epididymal lumen and then ascend the female reproductive tract. It is well established that both events are essential for fertility, however the biochemical mechanisms behind the maturation of these cells remains unclear. This project aims to characterise the entire complement of proteins present in spermatozoa. It will also decipher which proteins are up/down regulated, acquired and/or completely lost during both maturation procedures.

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iii) ***Mitochondrial Function and Reactive Oxygen Species***

Reactive oxygen species (ROS) are conventionally considered as detrimental by-products of cellular metabolism, which generate a state of oxidative stress in susceptible cells. Despite the pathophysiological significance of ROS generation in the male germ line, neither the sub-cellular origin nor the biochemical basis for this activity has been established. The major source of ROS generation in somatic cells is postulated to involve electron leakage from the mitochondrial electron transport chain during cellular respiration. In view of our poor understanding of mitochondrial function in spermatozoa, and the potential importance of these organelles as a potential source of oxidative stress in the male germ line in particular, this project is an analysis of the potential competence of human sperm mitochondria to generate ROS and to characterise the significance of this activity in the aetiology of defective sperm function.

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iv) ***Monotreme Sperm Biology***

As iconic symbols of Australia's unique fauna the platypus and echidna generate considerable interest from tourists and the Australian public, thus ensuring that their display in zoos is of significant commercial value. Nevertheless, the record of breeding the 3 extant monotremes in captivity is poor, and the New Guinea echidna faces extinction in the wild. Consequently, knowledge of monotreme reproductive biology is important for conservation practices. This project focuses on elucidation of the molecular processes leading to fertilization in monotremes, including: the proteins which form sperm into bundles to greatly enhance their motility (a unique sperm competition strategy) and the mechanisms involved in sperm bundle formation. The work will provide an understanding of the biological significance of adaptations unique to mammals, the need for maturation of sperm in the epididymis and a subsequent period of capacitation before they are capable of fertilizing an ovum.

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Fertilisation and Contraception

i) ***Formation of Sperm Zona Receptor Complex***

Mammalian sperm-egg interaction is arguably one of the most remarkable processes in biological science. This exquisitely specific cell recognition event depends upon a complex cascade of interactions between free-swimming sperm and ovulated eggs. Elucidating the nature of these interactions has been the subject of intense investigation by many laboratories. Although this has led to extensive characterization of the respective gametes, such studies have failed to elucidate the molecular basis of this event. In our considered judgement this lack of success stems from the incorrect assumption that the sperm receptor is a single molecular entity that is constitutively expressed on the cell surface.

In contrast, recent research from our laboratory has provided support for a novel hypothesis that sperm-egg interaction is mediated by a multimeric sperm receptor complex. Furthermore, we have compelling evidence that this complex is assembled on the sperm surface through the concerted action of a family of molecular chaperone proteins that reside within specialised membrane domains, known as lipid rafts. In this project we aim to confirm the validity of this model, establish the molecular composition of the sperm surface receptor complexes and characterise the downstream signalling cascades that culminate in fertilisation.

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ii) ***Oolemma sperm receptors***

Post-coitus, sperm encounter the ovulated oocyte within the fallopian tube, which serves as the site of fertilisation. By the time sperm reach the site of fertilisation they have undergone the prerequisite series of capacitation-associated changes necessary for ultimately achieving fertilisation. Upon penetrating the Zona pellucida, sperm must then recognise and bind to the oocyte plasma membrane. Together, the molecular machinery present in both cell membranes must then interact in a precise manner necessary to facilitate the energetically costly event that is the merger of sperm and egg membranes.

This research aims to identify and characterise egg surface proteins implicated in sperm-egg interaction, by identifying the important GPI-anchored protein(s) as well characterising the role of the tetraspanins and their interacting web partners. In vitro binding and fusion experiments will be used as functional bioassays and mass spectrometry (MS)-based proteomics and bioinformatics-based analyses will be employed to compile oocyte protein databases and to identify candidate proteins responsible for mediating sperm-egg interaction, such as newly identified candidate GPI-anchored proteins.

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iii) ***Spermicides and microbicides***

There is an urgent clinical need to research novel methods of fertility control that are also protective against sexually transmitted diseases (STDs) such as the human immunodeficiency virus (HIV) or Chlamydia. The most obvious way to generate such a dual-purpose contraceptive method would be to develop safe, effective spermicides that were also active against a wide range of pathogenic organisms. The currently available formulations such as nonoxynol-9, gramicidin and benzalkonium chloride are effective spermicides but are toxic to the vaginal epithelium and do not provide protection against STDs. Over 60 agents are in clinical trials as potentially safer topical spermicides and/or microbicides. Compounds that have reached this stage of development include acid buffers, detergents, dendrimers, non-nucleoside reverse transcriptase inhibitors and anionic polymers.
In addition, a number of potential spermicides/microbicides are the subject of preclinical investigation, including beta-cyclodextrin, cyanovirin, porphyrins, cyclotriazadisulfonamides, dermaseptins, short-interfering RNA (siRNA) and HIV antibodies. This project aims using to characterise the biological activities and mode of action of newly developed target specific compounds as novel dual spermicides/microbicides.

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vi) ***Identification and validation of targets for fertility regulation***

There have been no significant advances in planned fertility regulation since the introduction of the oral contraceptive pill in the 1960s. The purpose of this project is to use our advanced proteomics platform to identify targets for male and female fertility regulation on the basis of their specificity, functional significance and drugability. The current focus is on the identification of phosphoproteins that are critical to the process of fertilization and then through a knowledge of the kinases and phosphatases that regulate their phosphorylation statu,s to select contraceptive targets that can then be validated by functional genomics in vivo and in vitro.

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Spermatogenesis and Stem Cells

i) ***DNA damage in the Germline***

DNA damage in the male germline is associated with poor fertilization rates following IVF, defective preimplantation embryonic development, and high rates of miscarriage and morbidity in the offspring, including childhood cancer. This damage is poorly characterized, but is known to involve hypomethylation of key genes, oxidative base damage, endonuclease mediated cleavage and the formation of adducts with xenobiotics and the products of lipid peroxidation. There are many possible causes of such DNA damage, including abortive apoptosis, the oxidative stress associated with male genital tract infection, exposure to redox cycling chemicals, and defects of spermiogenesis associated with the retention of excess residual cytoplasm. Physical factors such as exposure to radiofrequency electromagnetic radiation or mild scrotal heating can also induce DNA damage in mammalian spermatozoa, although the underlying mechanisms are unclear. Ultimately, resolving the precise nature of the DNA lesions present in the spermatozoa of infertile men will be an important step towards uncovering the aetiology of this damage and developing strategies for its clinical management.

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CHEMISTRY

Characterisation of Solid – Liquid Interfaces in Dye Solar Cells (DSC).
It is clear that burning fossil fuels is not sustainable in the long term. The DSC is a cheap and versatile technology for large scale production of solar cells. The basic element of a DSC is a assembly of titanium dioxide nanoparticles about 20 nm diameter, well connected to their neighbours. As TiO_2 only absorbs a small fraction of the solar energy, dye molecules are attached to the TiO_2 surface to harvest a greater portion of solar light. This project will characterise the structure of the solid – liquid interfaces within the DSC, which will lead to the new DSC designs with increased energy conversion efficiencies.

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Effect of Electrode potential on Ionic Liquid Interfacial Structure
Interest in ionic liquid (IL) based electrochemistry increased markedly around the year 2000, primarily as a consequence of ILs often wide electrochemical windows. Until now atomic force microscope (AFM) experiments have only been conducted at the open circuit potential (OCP), but we have recently modified our AFM cell to allow force curves to be obtained as a function of potential. As the magnitude of the potential is increased the strength with which IL ions are bound to the surface also increases, which will affect a variety of electrochemical processes, including electrodeposition, batteries and capacitors. Experiments planned for this topic will examine interfacial forces as a function of potential across the whole electrochemical window, which will reveal how IL interfacial structure evolves with potential. The effect of dissolved solutes (particularly ions) on interfacial properties will also be examined, allowing mechanisms for tuning interfacial structure to optimise electrochemical performance to be determined.

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Ionic Liquid Lubricants
The use of ILs as lubricants was first proposed in 2001 and since then about 80 articles have appeared on the topic, the majority describing macroscopic measurements. Strong ion adsorption at solid surfaces and robust physicochemical properties, in particular negligible vapour pressure, could lead to high end lubrication applications, such as in electronics or high vacuum environments where ILs could be used without significant product loss. The tendency for ILs to adsorb and spontaneously arrange into interfacial layers results in a coating of ions at the solid interface. In an article published last year we reported that particles suspended in a protic IL were stable to aggregation but settled six times faster than predicted by the Stokes equation, and suggested that the same interfacial IL structure that imparts stability could have a lubricating effect. This project will measure friction as a function of cation alkyl chain length, after which the cation and anion species will be varied.

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Nanostructures in Ionic Liquids
Ionic liquids are molten salts, which means they are salts in a liquid phase, not simply salts dissolved in water. Surfactant molecules dissolve in ionic liquids and can self assemble into nanostructures like micelles, liquid crystals and microemulsions, just like they do in water. This project will examine various surfactant structures in ionic liquids. Our aim is to use surfactant templating of glass-forming ionic liquids as a way of designing and creating permanent high surface area structures from microemulsions and liquid crystals. These materials could be used in catalytic or separation technologies.

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Advanced Supercapacitors
Modern electronic devices (e.g., consumer electronics and electric/hybrid vehicles) place considerable demands on their respective power sources, to the point where device efficiency is compromised. The inclusion of a supercapacitor has the potential to improve the specific power density and also cycle efficiency of all types of power source. We have recently made considerable advances in improving supercapacitor performance (e.g., 800 F/g for existing systems compared to >2000 F/g in our advanced materials). Projects in this area will be focus on both understanding the origin of this improved performance, as well as implementing these materials into prototype supercapacitors. This work is funded by CSIRO Division of Energy Technology and CAP-XX, and is also in collaboration with the Ecole Polytechnique de la Universitie de Nantes and National Taiwan University.

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Catalysts for Fuel Cells
Energy can be stored in many chemical forms, and hence used in many different ways. One way is in a fuel cell, of which there are numerous varieties. The cathodic reaction in all though involves reduction of O_2 to H_2O on the surface of a suitable catalyst. This is currently the limiting performance feature of all fuel cell technologies because of its slow reaction kinetics. This focus of projects in this area is to examine the factors that cause slow O_2 reduction kinetics, and to then address these limitations with novel solutions. One particularly important aspect is to examine the role that adsorption plays in determining O_2 reduction kinetics. This work is in collaboration with the Massachusetts Institute of Technology.

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Corrosion Phenomena in Electrode Materials
Corrosion is an electrochemical phenomenon that can have a devastating effect on all forms of infrastructure if it is not properly monitored and controlled. Projects in this area are focussed on understanding the corrosion phenomena that metals such as titanium and copper undergo, and then developing strategies to minimize their corrosion. Titanium, for example is used as the anode substrate in many modern high volume electrolysis processes, yet it is subject to corrosion and passivation which effectively destroys its performance. Similarly, copper is used as an earthing electrode in modern power infrastructure, in which case its corrosion and failure lessens the safety of such a network. Support for these projects comes from Energy Australia.

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High Performance Battery Systems
The backbone of energy storage in modern society is the battery. Of course many systems are commercially available, each having been developed to power a specific type of electronic device. The importance and extent of efficient energy storage will increase in the future due to the required move away from fossil fuel powered energy. Projects in this area will focus on the development of advanced materials, and improving our fundamental understanding of the charge storage mechanisms various materials possess. Funding in this area comes from the CSIRO Division of Energy Technology (Li-ion systems), Duracell (advanced MnO_2), Pure Energy Battery Systems (rechargeable MnO_2), and Litronik Batterietechnologie (battery systems for implantable pacemakers).

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Hydrogen Production
Hydrogen has been variously described as the perfect fuel. It is abundant, chemically non-toxic, and it burns to produce non-toxic species. However, its main limitation to commercial uptake is its synthesis, since it requires more energy to produce hydrogen than what is returned upon its combustion. Projects in this area revolve around the use of the Hybrid Sulfur (HyS) Cycle for the large scale production of hydrogen. Using renewable energy inputs water can be split into its components through the use of a sulphur-based intermediate. Part of the HyS cycle involves an electrolysis step (SO_2 oxidation to H_2SO_4), the efficiency of which is a significant limitation to the overall process. Therefore, our focus will be on developing an understanding of the oxidation mechanism, and developing new catalysts to facilitate its improvement. This work is in collaboration with the CSIRO Division of Energy technology.

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Molecularly Imprinted Polymers (MIPs)
Molecular imprinting is an effective method of imparting highly specific and selective recognition sites in synthetic polymers. First, a molecule of interest (target) is used as the template and allowed to pre-associate with polymerisable (a molecule with a double bond) molecules (*in situ* imprinting) called the functional monomers. The degree of association between the monomer and the template (T) depends on their functionalities but mostly based on simple molecular interactions such as hydrogen-bonding. Secondly, the association between the template and monomer can be fixed in place by polymerisation in the presence of a huge amount non-interacting monomer (e.g. crosslinker), which can impart the robustness required for the polymer. Thirdly, the template is extracted from the monolithic or particulate polymer to leave behind a cavity containing binding sites that are oriented to compliment the functional groups of the template molecule and capable of rebinding the target. Molecular imprinting can also be achieved by *post*-polymerisation imprinting on a pre-prepared polymer. This technique is very useful for the preparation of MIP films.

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PNIPAAM-Based Molecularly Imprinted Polymers
Poly(N-isopropylacrylamide) (PNIPAAM) is a thermoresponsive polymer and is characterised by a lower critical solution temperature (LCST). Below its LCST, PNIPAAM is water-soluble; above its LCST, it is water-insoluble. The LCST of PNIPAAM can be tuned by copolymerisation. For example, its LCST can be lowered to 10^{o}C in the presence of the hydrophobic monomer styrene. Thus, by choosing co-monomers that can interact with a target molecule of interest, it is possible to use PNIPAAM copolymers to create molecular moulds. Simply by using the target molecule as template at temperatures below the LCST and preserving the target imprints at temperatures higher than the LCST, PNIPAAM copolymers can be imparted with molecular recognition sites which can be capable of selectively binding the target molecule in the presence of other analytes. This project will focus on the evaluation of the molecular imprinting capability of PNIPAAM copolymers and will involve (a) synthesis of NIPAAM polymers, (b) preparation of PNIPAAM MIPs (c) evaluation of PNIPAAM MIP binding capability (d) characterisation of PNIPAAM polymers and MIPs.

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MIP as Reaction Catalyst
The ability of a MIP to recognise and trap a template/target molecule makes it an attractive alternative catalytic system. Considering the hypothetical synthetic reaction, R1 + R2 → DP + BP, this project will involve (a) the generation of a MIP selective to either DP or BP, (b) evaluation of the selectivity of the MIP with respect to the other substances involved in the reaction – R1, R2 and DP or BP (c) testing the catalytic effect of the MIP by evaluating reaction yields.

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Investigation of the Mechanism of Imprinting: Kinetics of the Formation of Imprints

Recent studies have shown that the formation of molecular imprints is affected by temperature, solvents and polymer composition, and that the imprinting effect can sometimes be missed due to the high binding capacity (though superficial) of its non-imprinted equivalent (NIP). Most of the reported evidence deals with the beginning - presynthetic studies (i.e. molecular modelling and spectroscopic studies) and the end - binding performance of the MIPs and NIPs, but no evidence has been gathered during the early stages of the formation of imprints (i.e. within 12 hours of polymerisation). This study proposes to investigate the early stages of MIP formation with the aim to understand the effect of the template on the polymer structure and the kinetics of template-monomer association and will involve (a) molecular modelling using Spartan (b) NMR experiments (c) free radical polymerisation (d) quantitation and species identification by GC or LC MS.

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Preparation of Molecularly Imprinted Nanoparticles by Phase Inversion

Phase inversion, that is the immersion of a polymer solution, in a solvent, is one of the techniques utilised for the preparation of molecularly imprinted polymeric films. Molecularly imprinted polymers (MIPs) are molecular moulds generated by templating with the target analyte and can be introduced *in-situ* or post-polymerisation as in the phase inversion technique. This project aims to prepare phase-inversed MIP nanoparticles, not films, by ultrasonicating the polymer solution in the presence of a non-solvent. The MIP nanoparticles can be used as extractant and as recognition element for sensing devices.

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Aqueous chemistry of CO_2, as relevant for greenhouse abatement

A significant reduction in CO_2 output is crucial for the climate and long-term stability of the planet. In the Australian context an eminently promising method is post-combustion capture (PCC) of carbon dioxide in fossil fuel power plants. While the technology is not new, the process needs to occur on such a scale that it demands significant improvement in overall efficiency. In collaboration with CSIRO our research is directed at developing a complete understanding for the first time of the fundamental chemistry of carbon dioxide removal by amine solutions. Detailed examination of the speed (kinetics), extent (thermodynamics) and energy requirements (calorimetry) of all reactions for a range of amines will produce a model to guide technological improvements. This project is well funded and there is a good prospect of being able to continue working in this field after the Honours year.

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Flow Chemistry / Medicinal Chemistry / Organic Chemistry
Traditional organic synthesis is conducted in a batch manner, i.e. small quantities of materials are mixed and heated for a standard period of time, and the product extracted and purified. Recent advances in flow technologies allow continuous production of novel materials. This technology has been introduced to the medicinal chemistry group at the University; it is currently the best-equipped flow chemistry laboratory in Australia. Reactions are conducted at higher temperatures and pressures, which has the effect of increasing reaction yield and compound purity, largely removing the more tedious aspects of compound purification. Students working in this area will develop new approaches to drugs spanning three research programs: anti-epileptic, anti-cancer and anti-parasitic drugs. This new technology requires subtle optimisation and students will be exposed to cutting edge equipment and ultimately be responsible for the development of new drugs and biological tools to a considerable number of our national and international collaborators.

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Medicinal Chemistry / Drug Design
Today 1% of the worlds' population suffer from epilepsy, of these 30% fail to respond to existing anti-epileptic drugs. Current anti-epileptic drugs were discovered in the 1960s. We have identified a protein called dynamin as a new ant-epileptic drug target and have advanced compounds that only target epilepsy at seizure onset, a significant advance on existing treatments. This is a major collaborative drug discovery and development effort drawing medicinal chemistry experience at the University of Newcastle (McCluskey), neurobiology and neurochemistry at the Children's Medical Research Institute Westmead Hospital (Prof Phillip Robinson), epilepsy (medical aspects) at the Royal Melbourne Hospital / Melbourne University (Prof Terry O'Brien), and the National Institute of Health (USA) (Captain Jim Stables). Students working in this area will experience the full drug development cycle through synthesis and biological evaluation of new drugs. You will advance these drugs to the next stage of evaluation and potentially to animal studies in both Melbourne and USA. During the course of your studies you will be trained in the latest technologies associated with drug design and chemical synthesis (see Flow Chemistry below).

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Medicinal Chemistry / Drug Design / Smart Devices
Current anti-epileptic drugs act by reducing chemical signalling in the brain, **and are always 'on'.** This means that patients have reduced functional capacity, at best it has been compared to being drunk, at worst patients are physically incapacitated and physically ill. Huge numbers of patients are left unable to perform simple day-to-day tasks. This project represents a major advance in the 'on-demand' administration of drugs with the epileptic seizure triggering the release of an anti-epileptic drug at seizure onset. It will develop implantable organic electronic devices with the ability to specifically absorb and release anti-epileptic drugs 'on-demand'. This project is at the interface of chemistry, biology, physics and medicine, a unique opportunity to advance drug delivery in the 21st century.

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Nanomaterials / Organic Electronics
Amyloid fibrils are linked to some of mankind's most crippling diseases, such as Cystic Fibrosis, Alzheimer's and type II diabetes, BUT they are emerging as exciting biocompatible, biodegrable, high strength (environmentally friendly), nano-materials, for use in a range of electronic devices. Amyloid fibres have excellent potential as electrically conducting nano-wires. This project will investigate the influence changing the rate of fibre growth has on the physical and chemical properties of the resulting nano-wires. This work will open the door to the next generation of electronic devices.

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Chemical Taxonomy of Brown Alga Cystophora spp.
In 1995 two significant papers appeared regarding the chemical taxonomy of alga from the *Sargassaceae* (formerly *Cystoseiraceae*) family. Chemical taxonomy uses the secondary metabolites present in an organism to elaborate their evolutionary and taxonomic relationships; Algae that produce similar compounds are closer to each other on the 'family tree' than those that have no compound types in common. Algae from the *Cystophora* genus belong to the *Sargassacea* and since they are not well studied and are, by and large, only found in temperate Australasian waters, it seemed to us that we could make a significant contribution in this area. This study is a mixture of interpretation of our previous results and those of others, and investigating the metabolites of the remaining unstudied algae in the genus. Work in this area will also lead into the study of marine chemical ecology.

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Advanced Synthetics Materials Group

Searching for New Lead Compounds as Dynamin Inhibitors
Dynamin is an important enzyme in the process of vesicle formation which is one of the mechanisms used to transport chemicals and small particles across membrane walls or as a way of insulating an organism from endogenous or exogenous toxic compounds. In this project we are looking to the marine environment as source for compounds that can act as leads to new classes of dynamin inhibitors. In the initial stages new active compounds will be used to probe the, as yet poorly understood, mechanism of action of this enzyme. In the future this may lead to drugs useful in the treament of diseases associated with dynamin kinetics, e.g. some common neurological disorders.

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Advanced Synthetics Materials Group

Surfactant and polymer adsorption
Surfactant and/or polymer coated interfaces are present in the use of everyday formulations from shampoo to paint. A quartz crystal microbalance instrument will be used to investigate the adsorption of surfactant and polymer molecules at the solid/liquid interface in an effort to develop a sophisticated understanding of the adsorption mechanism and subsequent interfacial behaviour in a variety of solvents (aqueous, non-aqueous, ionic liquids). This project will be cosupervised by Dr Rob Atkin.

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Advanced Synthetic Materials Group

Direct observation of bubble or droplet coalescence using high-speed video imaging
Colloidal particles can be used to stabilise foams and emulsions in the absence of any surfactant by adsorbing in close-packed particulate monolayers at the interface. We are investigating the mechanism of bubble and droplet coalescence using high speed video at up to 3500 frames per second in order to understand the role of particles at the interfaces of coalescing bubbles and droplets. Such coalescence processes are important wherever there are bubbles from champagne to mineral separation by froth flotation, and in emulsions from foods to cosmetics. In addition, we have recently installed an important new instrument capable of complementary simultaneous measurement of interfacial elasticity and surface tension. This will greatly increase our knowledge of bubble-bubble interactions for a range of industries. You will use both techniques to directly observe particle-stabilised bubbles or droplets and their coalescence.

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Priority Research Centre for Advanced Particle Processing and Transport

Mineral processing using minimal water

There is a need to develop methods to process minerals that will reduce the need to use the large unsustainable quantity of water that is currently used. An important characteristic of any new method is that it must be selective to differences in the physical or chemical properties of the valuable mineral, which is often a sulfide, as distinct from the host rock in the ore, which is usually a silicate. The aim of this project is to attempt to separate various minerals using triboelectric (surface charging) separation, thus obviating the need for water intensive processes such as flotation.

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Smart polymeric coatings

Polymer films can radically change the surface of a material while leaving the bulk properties of the material intact. The polymer surface coating controls the interaction with other objects through nanoscale forces. We will construct the next-generation of polymer films that contain an inbuilt molecular-scale switch from attractive to repulsive interactions, offering a means for dictating macroscopic character such as the wettability, adhesion or friction of a surface. Academic and industrial interest in these coatings is increasing rapidly, for potential application as low-friction coatings for confined parts or rheology modifiers. This project can have either a polymer synthesis, characterisation (atomic force microscopy, optical reflectometry etc), or materials engineering focus. You will join the group effort aimed at synthesising and studying these smart polymer coatings and perform state-of-the-art surface characterisation that will ultimately determine their use!

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Nature-inspired silicate nanomaterials for biosensor and biocatalysis applications

Biosensors are used to detect disease markers and toxins and biocatalysis is increasingly used for manufacturing high yield chemical products with low waste production. Silicate nanostructured materials fabricated based on nature-inspired processes offer major advantages over existing materials. For example, high surface area silicate nanoparticles can be used to immobilise and stabilise a wide range of enzymes under neutral conditions and with high efficiency. The project will create innovative advanced processes for the coentrapment and stabilisation of active enzymes within silicate nanostructured materials, for new biocatalytic chemistry and biosensing applications. This project will give you the opportunity to gain transferable skills in the areas of biochemistry, physical chemistry and nanotechnology.

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DEVELOPMENT STUDIES

Geographies of urban regeneration
The regeneration of our cities in the face of growing environmental. social and population pressures will be a major challenge facing urban Australia over the coming decades. Both national and comparative research is needed on how we can imagine, govern and operationalise successful regeneration to have environmentally and socially acceptable outcomes. Research topics might include case study investigations of regeneration processes and outcomes, studies of community involvement in regeneration, studies of the politics of regeneration governance.

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Centre for Urban and Regional Studies (CURS)

Urban Carbon Governance
Effective responses to climate change hinge on the capacity to govern carbon, especially in our growing cities. Australia's urban carbon governance framework has proved ineffective, and there is no systematic knowledge of it to inform improvement. This research project would contribute to a wider project aimed to document and analyse the 'who', 'how' and 'where' of urban carbon governance, and the related politics and spatiality. The project will provide empirical and theoretical knowledge to advance the capacity to govern carbon and enhance Australia's environmental

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Urban social inclusion
Cities have long been sites where the uneven distribution of resources and recognition is expressed. Recent policy initiatives have been framed around the notion of 'social excluded' places and people and the challenge of attaining 'social inclusion'. Yet we have relatively poor understandings of how social inclusion is both understood and experienced differentially across diverse communities and neighbourhoods with diverse levels of mobility and connectivity. Research topics in this field could address both urban spatial variations in the availability of resources and opportunities and the diverse understanding and experience of social inclusion.

For these or other urban-related topics, please contact:

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Geographies of home and home making
Recent research in geography has investigated the homemaking as a dynamic process. Research in the field has investigated the home making practices of newly arrived migrants, new suburban residents, people living in medium density developments, public housing tenants, gay men, people with an intellectual impairment and the experiences of people living with animals as pets and pests. Other research has looked at practices of home-making that occur in gardens and neighbourhoods. This honours research topic would further our knowledge of home making practices by examining one of the following:

- Home making on the Newcastle suburban fringe
- Home making in a retirement village

- Home making in share households
- The adoption of green domestic technologies and home making practices
- The role of food and cooking in homemaking

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Understanding Neighbourhood Dynamics

Recent research on neighbourhood has emphasised that neighbourhoods cannot merely be understood as a set of socio-economic characteristics, but rather are brought into being through the actions of neighbourhood residents and other people who use the neighbourhood. At the cutting edge of urban research, this notion that neighbourhoods are performed, requires further investigation. Students could choose to investigate the role of social interactions in creating the neighbourhoods, the role of new developments or threatened developments in provoking the mobilisation of neighbourhood resources or the role of particular sorts of community assets such as schools and green spaces in developing neighbourhood. Potential topics include:

- Neighbourly relations and social capital in neighbourhoods
- Protest movements and neighbourhood development
- Schools as neighbourhood resources
- Green spaces as a neighbourhood resources

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Geographies of mobility

Issues of mobility and transport access are crucial to developing more sustainable cities. Recent geographical research has emphasised the importance of understanding flows of people around cities. While research on mobility in geography is growing, there is considerable scope to contribute to our understanding of mobility in Australia. Some potential research projects include:

- Cycling as a form of commuting in Newcastle
- Cycling activism as a form of urban intervention in Australian cities
- Public transport and mobility
- Transport access and neighbourhood development on the urban fringe
- Managing multiple demands in daily commuting
- The journey to university: transport choices amongst workers and students

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Case Studies of community/mining company relations

The minerals sector remains one of Australia's most important corporate players today influencing governmental decision-making at all scales. Its relations with communities, however, are not always as transparent as they could be and this can often lead to contestation over access to land and resources as well as concerns over possible environmental damage. These issues remain compelling ones for all sectors of society.

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Incorporating resource peripheries into the globalising economy
Remoteness and distance have often been given as reasons for excluding particular places from playing an active role in the globalising economy and important decision-making. Frequently, however, these perceptions are stereotyped and bear little resemblance to the reality of these places on the ground, which more often than not, are very productive spaces. There remains a need for better understanding of remoteness as a concept so as to avoid the peripheralisation of places that continues today despite globalisation's claims to have created a 'border-less' world.

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The effects of Climate Change on small Island states
Climate change remains an ongoing global threat though its effects will be felt first by small island states. Understanding how these places adapt to stresses placed upon them by a changing climate and what strategies exist or need to be developed to help respond to these challenges will be an ongoing concern for researchers and governments alike.

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The creation of green spaces through better environmental planning
As population numbers continue to grow globally, as a consequence, more land is consumed often denuding our environment of 'green spaces'. Recently, however, there have been calls for better planning initiatives which promote and encourage developments which emphasise 'greening' the environment. Developments such as golf courses have recently been touted as a means for creating such spaces. Debates continue though as to whether this privileges the rich over the poor by controlling who has access to use these spaces and who is excluded and why.

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With any enquiries about these or any other potential Honours opportunities in Geography and Environmental Studies Honours and Development Studies Honours, please contact Honours Co-ordinator Dr Meg Sherval via email at: Meg.Sherval@newcastle.edu.au.

EARTH SCIENCES

Monitoring of cave systems: CO2 fluxes at Wombeyan.
Understanding CO2 fluxes in caves is of primary importance to understand calcium carbonate deposition with implication for palaeoenvironmental reconstructions. The work includes monthly visits to Wombeyan caves. Collection of drip rate data on selected drips, continuous pCO2 monitoring with Vaisala probe, pH measurements of drip waters monthly resolution, temperature measurement within and outside caves. Rainfall data from meteorological stations.

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Petrography and diagenesis of climate-sensitive continental carbonates
The work observations in thin sections (optical microscope) of cave carbonates, including lamina counting, and on freshly cut pieces (Scanning Electron Microscope). XRD analyses to determine phases, fluorescence and back-scattered electron analyses (at Newcastle) to determine and map compositional changes. Recognition of fabrics and phases is of primary importance. Focus is to determine if diagenetic processes altered the original fabrics and, consequently, the geochemical signals. Work will be carried out on specimens from Nullarbor (Australia), 1 to 3 million years old.

A second thesis could be on specimens from the Dolomites (N Italy), probably 1 million year old. Affected by glacial and interglacial climate and hydrology for the past at least 800,000 years.

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Petrography of ancient stalagmites from the Italian Alps as powerful tool for palaeoclimate and uplift history.
This exciting study is targeted to unravel how regional hydrology recorded in the shape and arrangement of calcium carbonate crystals was influenced not only by glacials and interglacials, but also by tectonics. Tools of the study are the petrographic polarising microscope, Scanning Electron Microscopy and the interpretation of fabrics as related to their geochemistry, which will be already available. The study capitalises on collaboration through an ongoing project with researchers from Italy and Austria (University of Innsbruck).

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Petrography and diagenesis of marine carbonates in karst areas
The work includes fieldwork at Wombeyan caves to characterize the karst rock hosting the cave system. Geologic survey, collection of rock samples, observations in thin sections (optical microscope) and on freshly cut pieces (Scanning Electron Microscope). XRD analyses to determine phases, fluorescence and back-scattered electron analyses (at Newcastle) to determine and map compositional changes. A bit of geochemistry to understand diagenetic alterations and present-day dissolution.

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Assessment of General Circulation Model's (GCMs) ability to realistically simulate local and large-scale drivers of natural climate variability in southeast Australia

Since the release of the IPCC 4th Assessment Report research has been directed at evaluating the ability of GCMs to simulate the present/historical climate in an attempt to identify the GCMs that are best for the region/application of interest. At present, most metrics used to assess the ability of GCMs to simulate climate variables (such as rainfall, temperate etc.) are based on seasonal and annual time scales. However monthly, seasonal, or longer averages can hide biases or systematic errors. This project aims to investigate the potential of an alternate GCM assessment technique which seeks to identify the GCMs that successfully simulate the major local and large-scale climate drivers known to be important for southeast Australia. We already know which GCMs do a particularly poor job at simulating El Niño-Southern Oscillation (ENSO), but what about the other drivers known to influence southeast Australia (e.g. Indian Ocean Dipole, Southern Annular Mode, Interdecadal Pacific Oscillation, Sub-Tropical Ridge, ENSO Modoki etc)?

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Contact: Dr Danielle Verdon-Kidd
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Characterising southern hemisphere dry epochs and their causal processes

This project aims to firstly catalogue the location, duration and severity of dry epochs in the Southern Hemisphere. This will involve a literature review and analysis of both instrumental and pre-instrumental (paleo) records. Secondly, the climatic drivers of the identified dry epochs will be investigated with the ultimate objective being to put the current southeast Australian drought into context and to more realistically quantify drought risk so more robust adaptation strategies can be developed.

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Environmental & Climate Change Group

Characterising southern hemisphere wet epochs and their causal processes

This project aims to firstly catalogue the location, duration and severity of wet epochs in the Southern Hemisphere. This will involve a literature review and analysis of both instrumental and pre-instrumental (paleo) records. Secondly, the climatic drivers of the identified wet epochs will be investigated with the ultimate objective being to put recent flood events in QLD and NSW into context and to more realistically quantify flood risk so more robust adaptation strategies can be developed.

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Characterising Victorian bushfire risk and its causal processes

This project aims to firstly catalogue the location, duration and severity of bushfires in southeast Australia, specifically Victoria. This will involve a literature review and analysis of both instrumental and pre-instrumental (paleo) records. Secondly, the climatic drivers of the identified bushfires will be investigated with the ultimate objective being to put the recent "Black Saturday" Victorian bushfires into context and to more realistically quantify bushfire risk so more robust adaptation strategies can be developed.

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Defining 'east coast' climate

The area of land between the tablelands and the coast of NSW and southern Queensland is home to more than nine million people. A variety of high impact weather events occur in this area, generating damaging winds, flooding, hail, heavy seas and swell. Rainfall during these weather events also plays a critical role in our State's water supply, filling dams and supplying base flows for inland river systems and groundwater recharge. However, the climatic processes in this part of Australia are the least well-understood in terms of climate change and its impacts. This project will identify the drivers of climatic variability in the 'east coast region and highlight differences between the 'east coast' and other areas of Australia. The project will form the basis for addressing the gaps in our knowledge relating to the impacts of climate variability and change along the 'east coast'. This is necessary to develop informed and robust planning and adaptation strategies to ensure the sustainability of this heavily populated region.

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East Coast Lows and the Newcastle Pasha Bulker Storm

The June 2007 Pasha Bulker storm was one of the most significant meteorological events in Australia's history. It was the 4th largest general insurance loss since insurance records were started in 1968. The storm consisted of three distinct impacts (1) flash flooding in the urban area of Newcastle on the 8 June (about 1 in 100 year return period) (2) more general flooding on the Hunter River 3 days later and (3) high winds and wave heights, the worst in the Newcastle-Sydney region since the "Sygna" storm in 1974. Both the Pasha Bulker and Sygna storms were the result of an East Coast Low (ECL). ECLs are the cause of most major flood events on the East Australian Coastal strip. The context for the June 2007 ECL and the resulting storm will be provided. How big was it historically? Where and when have similar ECL occurred before, and how frequently? What are the "typical" impacts associated with ECLs and was the June 2007 ECL "typical"? What is the likely trend of ECL intensity and frequency with climate change? What is the likelihood of similar events occurring elsewhere in Australia?

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Establish the long-term (1000 years) natural variability of East Coast Lows

East Coast Lows (ECL) are complex weather systems that travel parallel to the east coast of Australia from south-east Queensland to Victoria. They can cause significant storm damage to both the natural system and human infrastructure (e.g. the Pasha Bulker storm). The historical records over the past century show that the magnitude and frequency of ECLs is linked to decadal-scale variability in the climate system. This project will use insights into the mechanisms that drive climate variability in Australia to produce a time-series of

ECL frequency and intensity over (a) the last century using instrumental records and (b) the last 1000 years using proxy data based on palaeo reconstructions. The project will provide the basis for risk assessment of extreme ECL events both under natural and anthropogenic climate change.

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Research into the use of Worms in Mitigating Greenhouse Gas Emissions from Dairy Farms.

The recently carried Carbon Farming Initiative (CFI) of the Australian Federal Government is a response to the political realities that make agriculture a 'no-go' area as far as outright carbon taxation applies while acknowledging that agriculture itself represents around 17% of the nation's total greenhouse gas outputs. The CFI offers a voluntary scheme to farmers in which carbon credits may be earned through greenhouse gas mitigation projects in line with Australia's undertakings through the Kyoto Protocol. Such credits would be tradable both within Australia and overseas as such markets become operational. Consequently, farmers may obtain significant earnings capacity through such measures. However, in order to qualify any proposed methodology must be rigorously scientifically tested, peer reviewed and largely proven and the methodology itself must be monitored in an on-going manner to further prove the actual savings in order for the payments/credits to be secured. A project is available in collaboration with a small, non-profit company located in Sydney's south west which has worked on waste reduction measures for many years including worm farming. Many of the worms they grow are fed cow manure and they have noted the capacity of worms to reduce the impact of manure as a greenhouse gas emitter. The research project would aim to test and quantify these claims with a view to determining whether worm farming represents a viable greenhouse gas mitigation strategy.

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A comparison of Drought Indices – which one is best for Australia?

With drought being such a large problem faced so often in Australia, it is crucial that a sufficient method be developed to effectively monitor the various categoriesand stages of drought. The current system employed in Australia to classify and monitor drought-affected areas (primarily agricultural drought) is the Rainfall Decile System, however there are a number of problems associated with this method, highlighting the need to apply alternative techniques. Therefore, the aim of this project is to review and assess the applicability of existing methods and indices (developed in the USA and Europe) for monitoring drought in Australia that will include, but are not limited to, the Palmer Drought Severity Index, Crop Moisture Index, Byram-Keetch Drought Index, Antecedent Precipitation Index, Standardised Precipitation Index, Total Water Deficit, Rainfall Anomaly Index and the Rainfall Decile System.

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Exhumation of eclogites and blueschists – a tectonic ambiguity?

The exhumation of deep crustal depths is an enigmatic process not comprehensively explained by tectonic theory. In the New England Orogen, eclogite and blueschist facies rocks (from depths of 20-60 km) are exposed and generally enveloped by highly deformed serpentenite. This project will use information deciphered from detailed analysis of tectonic fabrics formed in serpentinite and tectonic melanges to provide inferences on structural processes associated with exhumation of deep crustal rocks. The results of this project will provide important information on a long-standing tectonic ambiguity that has puzzled tectonicists for years.

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NSW Institute for Frontier Geoscience

Formation of eclogites and blueschists – what can they tell us about plate tectonics?
Eclogite and blueschist facies rocks form under high-pressure tectonic conditions and are generally associated with processes occurring along plate margins. This project will use detailed petrography and thermodynamic modelling to provide constraints on the evolution of eclogite to blueschist facies rocks exposed in the New England Orogen, NSW. Thermodynamic modelling will be carried out using the computer software THERMOCALC and will involve the calculation of phase diagrams with the aim of constructing pressure-temperature paths. The primary aim of this project is to provide robust physical constraints on the processes that occur in subduction zones.

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Identifying contraction and extension cycles in orogenic belts
The geological record of the New England Orogen preserves evidence of successive periods of contraction and extension. The role of these contraction and extension cycles on controlling crustal growth and genesis of base metal deposits is still poorly understood. In this project, the student will unravel the deposition and then deformation history of Permian-Triassic basins exposed throughout the New England Orogen. To tighten up timing constraints on basin forming and closing events, geochronology will be an integral part of the project. This project will deliver improved timing and kinematic constraints on the evolution of an advancing-retreating orogenic system, which can be integrated into crustal growth or ore genesis models of Australia.

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Is crustal growth controlled by tectonic setting?
The New England Orogen provides an ideal location to study the potential relationships between crustal growth and tectonic setting. During its 200 million year history, the New England Orogen was characterised by periods of advancing and retreating subduction as well as high and low geothermal gradients. As result, granite genesis during these periods can be studied to evaluate the contribution of crustal vs. mantle material - which can be achieved by carrying out U-Pb and Hf zircon studies. A recent reconnaissance study has revealed a link between periods of lithospheric thinning and direct mantle contributions to granites (in turn encouraging crustal growth). The aim of this project is to carry out U-Pb and Hf zircon studies on granites that were emplaced during periods of crustal thickening vs. crust thinning. This will test the hypothesis that tectonic setting is strongly linked to crustal growth.

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Unravelling the structural characteristics of accretionary wedges
This project will involve combining field mapping with geophysics to interpret the internal structure and kinematic evolution of an accretionary wedge, located as part of the New England Orogen, eastern Australia. The aim of this project will be to compare the structural evolution of this accretionary wedge with analogue (sandbox modelling) and numerical models. This work will significantly add to our understanding of how accretionary wedges and fold and thrust belts evolve.

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ENVIRONMENTAL SCIENCE AND MANAGEMENT

The following represents a partial list of projects available. Please contact the respective academics for more details.

Behavioural and physiological correlates of ecological invasion: resource use in the Indian mynah (Ourimbah or Callaghan)
Why do some species become highly successful ecological invaders, while other species go extinct? Various hypotheses have been tested using a literature-based large-scale species comparative approach, but rarely experimentally at an individual species level. Our research program uses the Indian mynah, a songbird and highly successful ecological invader, as a model system to identify which behaviours allow this avian species to expand faster than any other native Australian bird species. This project will study mynahs in the lab and in the field to identify which food resources are key to mynah success and which habitats are most suitable to mynah expansion.

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Environmental Biology and Biotechnology Group

Indian mynah, *Acridotheres tristis*, population control and oral contraceptives (Ourimbah or Callaghan)
MOST SUITED TO A MID-YEAR INTAKE TO COINCIDE WITH MYNAH BREEDING SEASON
Indian mynahs are an introduced highly invasive bird species that has become so abundant in the last two decades that it has the potential to pose a threat to native bird species, particularly in the competition for tree hollows for nesting. Current population control practices involve labour- and time-intensive trapping programs. The present project will aim to design the necessary behavioural and anatomical tests to explore the effects of an oral contraceptive chemical commonly used in several other avian species, but not tested to date on the Indian mynah.

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Environmental Biology and Biotechnology Group

Assessment of the bioaccumulation of lead in chicken eggs from residential backyards in the vicinity of a disused Lead/Zinc smelter.
Lead is a widely occurring environmental contaminant. In humans, it acts as a potent neurotoxin and is of particular concern during childhood development. The primary exposure pathway is via ingestion of contaminated soil or dust, but with increases in urban farming, exposure via home-grown produce is an increasing concern. The purpose of this study is to investigate the potential for lead accumulation from soil into chicken eggs produced in urban backyard chicken coops. The metal content of eggs, soil and chicken feed will be measured in 30 backyard coops across the Lake Macquarie and Newcastle regions and a survey of household consumption habits will enable estimation of lead exposure via home-grown eggs.

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Assisted Reproduction in Amphibians for Conserving Threatened Species
Many amphibian species are in decline or threatened with extinction across the globe, including Australia. Assisted Reproductive techniques such as IVF and gamete and embryo cryopreservation for genome banking have the potential to improve the management of threatened species. This project is concerned with developing new and improved techniques for cryopreservation of amphibian sperm, eggs and embryos and other reproductive and somatic tissues, and new ways of generating functional embryos from these cells and tissues.

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Environmental Biology and Biotechnology

Distribution of the green and golden bell frog throughout the Hunter Region
The green and golden bell frog was once one of the most commonly encountered frog species in the Hunter Region but is now considered endangered due to the effects of disease, introduced predators and development pressure. As a result, the bell frog range has contracted dramatically but it is still unknown to what extent, information that is essential if the threat to species persistence is to be evaluated and sufficient recovery actions implemented. This study will involve conducting surveys of numerous former habitat sites to identify whether bell frog populations persist. The prospective student will become part of a large and dedicated team focused on understanding the ecology of the green and golden bell frog for conservation purposes and will gain experience in field survey design and methods, navigation, animal capture and handling as well as the use of probabilistic extinction models and mapping software.

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Environmental Biology and Biotechnology

Juvenile dispersal patterns of the green and golden bell frog in the Lower Hunter
The green and golden bell frog is an endangered pond breeding species that is currently under threat in the Lower Hunter from disease and development pressure and numerous studies are underway to understand how these threats affect population dynamics now and into the future. However, one area of bell frog ecology remains a mystery. The juvenile life stage of the green and golden bell frog is poorly known as individuals tend to disperse away from natal ponds only to return as reproductively mature individuals years later. In order to conserve this species, a thourough understanding of survival rates is required for all life stages and the first step in this process is to identify how animals distribute themselves in the environment. This project will identify where juveniles disperse to following metamorphosis using a number of different field methods and will incorporate a radiotracking component. The prospective student will become part of a large and dedicated team focused on understanding the ecology of the green and golden bell frog for conservation purposes and will gain experience in field survey design and methods, animal capture, trapping, handling and marking and radiotracking.

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Environmental Biology and Biotechnology

Determining the reproductive output of the green and golden bell frog in the Lower Hunter

The green and golden bell frog is an endangered pond breeding species that is currently under threat in the Lower Hunter from disease and development pressure. One of the factors limiting population growth appears to be low levels of reproductive output, relative to the abundance of reproductively mature individuals. Reproduction is one of the four vital rates driving population size and viability and an understanding of factors suppressing the number of individuals recruited into each generation is required is the population is to be managed effectively and declines prevented. This project will require extensive field-based survey of frogs, tadpoles and relevant habitat features, including any potential causal agents identified for low reproductive output, throughout the spring and summer months. The prospective student will become part of a large and dedicated team focused on understanding the ecology of the green and golden bell frog for conservation purposes and will gain experience in field survey design and methods, animal capture, trapping, handling and marking. The student will also gain knowledge of how vital rates drive population dynamics and how they can be manipulated for management and conservation.

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Environmental Biology and Biotechnology

Estimating population size of the green and golden bell frog in the Lower Hunter

The green and golden bell frog is an endangered pond breeding species that is currently under threat in the Lower Hunter from disease and development pressure. In order to recognise the occurrence and extent of decline in this population it is essential that the population size is known. Population size estimates are generated from mark-recapture data and will require extensive periods in the field catching frogs throughout the spring and summer months. The prospective student will become part of a large and dedicated team focused on understanding the ecology of the green and golden bell frog for conservation purposes. The student will gain experience in field survey design and methods, animal capture, handling and marking as well as the generation of widely used population models in program MARK.

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Assisted Reproduction for Dasyurids

Native carnivorous marsupials such as quolls and Tasmanian devils are increasingly at risk of extinction. The conservation of such dasyurid species is important for ecosystem maintenance because, as top carnivores, they have essential roles in pest control, carcass removal and subsequent disease control. This project aims to develop both short- and long-term sperm preservation methods for a well studied dasyurid model species, the fat-tailed dunnart, as well as examining their applicability various endangered quoll species and the Tasmanian devil. The isolation, culture and maturation of dasyurid oocytes will also be examined with the long-term aim of establishing intracytoplasmic sperm injection (ICSI) methods for dasyurids. Such assisted reproductive techniques (ART) will provide valuable tools for maximising the genetic diversity in current

captive breeding programmes for Eastern quolls and the Tasmanian devil, and for gene banking in the longer-term.

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Fertility-based population control for the feral Common (Indian) Myna

Progress is being made in the US and Europe using various chemical sterilants to control feral birds. One in particular Nicarbazin (an antibacterial drug used in the poultry industry) is registered in the USA for pigeon control and is being tested experimentally for a range of pest species. Ovocontrol acts in birds to reduce egg hatching or egg production. The project will examine the dose effects and delivery strategies of Nicarbazin for the Common Myna.

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Synchronisation of female cycles in marsupials

Synchronising female reproduction is at the core of all assisted breeding for people (IVF) or agricultural animals (AI & Embryo transfer) but similar systems based on ovarian hormones or agents have not been successful in marsupials. The project will examine the usefulness of GNRH agonists used in human and animal treatment to regulate cycles centrally (brain level) in the dunnart (a small marsupial) as an experimental model. Many components of assisted breeding are developed for marsupials (eg. sperm freezing, AI, oocyte culture) but all need reliable control of the female cycle if they are to be used in conservation programs.

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Environmental Biology and Biotechnology

Toward a Chlamydia Vaccine for the Koala

The *Chlamydias*, particularly the strains *C. pecorum* and *C. pneumoniae*, are a major cause of disease in koalas. Chlamydial disease in the urogenital tract causes wet bottom, inflammation, lesions and sterility. Infection of the respiratory tract and eyes causes pneumonia, conjunctivitis and blindness. Yet there is currently no preventative treatment for this disease in koalas. This project aims to underpin the development of an effective koala chlamydia vaccine by establishing the fat-tail dunnart as a marsupial model species for *Chlamydia* infection. Longer-term, vaccine formulation and delivery strategies capable of eliciting appropriate protective immune responses in the marsupial reproductive tract will also be investigated.

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Assessment of General Circulation Model's (GCMs) ability to realistically simulate local and large-scale drivers of natural climate variability in southeast Australia

Since the release of the IPCC 4th Assessment Report research has been directed at evaluating the ability of GCMs to simulate the present/historical climate in an attempt to identify the GCMs that are best for the region/application of interest. At present, most metrics used to assess the ability of GCMs to simulate climate variables (such as rainfall, temperate etc.) are based on seasonal and annual time scales. However monthly,

seasonal, or longer averages can hide biases or systematic errors. This project aims to investigate the potential of an alternate GCM assessment technique which seeks to identify the GCMs that successfully simulate the major local and large-scale climate drivers known to be important for southeast Australia. We already know which GCMs do a particularly poor job at simulating El Niño-Southern Oscillation (ENSO), but what about the other drivers known to influence southeast Australia (e.g. Indian Ocean Dipole, Southern Annular Mode, Interdecadal Pacific Oscillation, Sub-Tropical Ridge, ENSO Modoki etc)?

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Environmental & Climate Change Group

Characterising southern hemisphere dry epochs and their causal processes
This project aims to firstly catalogue the location, duration and severity of dry epochs in the Southern Hemisphere. This will involve a literature review and analysis of both instrumental and pre-instrumental (paleo) records. Secondly, the climatic drivers of the identified dry epochs will be investigated with the ultimate objective being to put the current southeast Australian drought into context and to more realistically quantify drought risk so more robust adaptation strategies can be developed.

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Research into the use of Worms in Mitigating Greenhouse Gas Emissions from Dairy Farms
The recently carried Carbon Farming Initiative (CFI) of the Australian Federal Government is a response to the political realities that make agriculture a 'no-go' area as far as outright carbon taxation applies while acknowledging that agriculture itself represents around 17% of the nation's total greenhouse gas outputs. The CFI offers a voluntary scheme to farmers in which carbon credits may be earned through greenhouse gas mitigation projects in line with Australia's undertakings through the Kyoto Protocol. Such credits would be tradable both within Australia and overseas as such markets become operational. Consequently, farmers may obtain significant earnings capacity through such measures. However, in order to qualify any proposed methodology must be rigorously scientifically tested, peer reviewed and largely proven and the methodology itself must be monitored in an on-going manner to further prove the actual savings in order for the payments/credits to be secured. A project is available in collaboration with a small, non-profit company located in Sydney's south west which has worked on waste reduction measures for many years including worm farming. Many of the worms they grow are fed cow manure and they have noted the capacity of worms to reduce the impact of manure as a greenhouse gas emitter. The research project would aim to test and quantify these claims with a view to determining whether worm farming represents a viable greenhouse gas mitigation strategy.

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Environmental & Climate Change Group

Characterising southern hemisphere wet epochs and their causal processes
This project aims to firstly catalogue the location, duration and severity of wet epochs in the Southern Hemisphere. This will involve a literature review and analysis of both instrumental and pre-instrumental (paleo) records. Secondly, the climatic drivers of the identified wet epochs will be investigated with the ultimate objective being to put recent flood events in QLD and NSW into context and to more realistically quantify flood risk so more robust adaptation strategies can be developed.

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Characterising Victorian bushfire risk and its causal processes
This project aims to firstly catalogue the location, duration and severity of bushfires in southeast Australia, specifically Victoria. This will involve a literature review and analysis of both instrumental and pre-instrumental (paleo) records. Secondly, the climatic drivers of the identified bushfires will be investigated with the ultimate objective being to put the recent "Black Saturday" Victorian bushfires into context and to more realistically quantify bushfire risk so more robust adaptation strategies can be developed.

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East Coast Lows and the Newcastle Pasha Bulker Storm
The June 2007 Pasha Bulker storm was one of the most significant meteorological events in Australia's history. It was the 4th largest general insurance loss since insurance records were started in 1968. The storm consisted of three distinct impacts (1) flash flooding in the urban area of Newcastle on the 8 June (about 1 in 100 year return period) (2) more general flooding on the Hunter River 3 days later and (3) high winds and wave heights, the worst in the Newcastle-Sydney region since the "Sygna" storm in 1974. Both the Pasha Bulker and Sygna storms were the result of an East Coast Low (ECL). ECLs are the cause of most major flood events on the East Australian Coastal strip. The context for the June 2007 ECL and the resulting storm will be provided. How big was it historically? Where and when have similar ECL occurred before, and how frequently? What are the "typical" impacts associated with ECLs and was the June 2007 ECL "typical"? What is the likely trend of ECL intensity and frequency with climate change? What is the likelihood of similar events occurring elsewhere in Australia?

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Establish the long-term (1000 years) natural variability of East Coast Lows
East Coast Lows (ECL) are complex weather systems that travel parallel to the east coast of Australia from south-east Queensland to Victoria. They can cause significant storm damage to both the natural system and human infrastructure (e.g. the Pasha Bulker storm). The historical records over the past century show that the magnitude and frequency of ECLs is linked to decadal-scale variability in the climate system. This project will use insights into the mechanisms that drive climate variability in Australia to produce a time-series of ECL frequency and intensity over (a) the last century using instrumental records and (b) the last 1000 years using proxy data based on palaeo reconstructions. The project will provide the basis for risk assessment of extreme ECL events both under natural and anthropogenic climate change.

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Defining 'east coast' climate
The area of land between the tablelands and the coast of NSW and southern Queensland is home to more than nine million people. A variety of high impact weather events occur in this area, generating damaging winds, flooding, hail, heavy seas and swell. Rainfall during these weather events also plays a critical role in our State's water supply, filling dams and supplying base flows for inland river systems and groundwater

recharge. However, the climatic processes in this part of Australia are the least well-understood in terms of climate change and its impacts. This project will identify the drivers of climatic variability in the 'east coast region and highlight differences between the 'east coast' and other areas of Australia. The project will form the basis for addressing the gaps in our knowledge relating to the impacts of climate variability and change along the 'east coast'. This is necessary to develop informed and robust planning and adaptation strategies to ensure the sustainability of this heavily populated region.

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A comparison of Drought Indices – which one is best for Australia?

With drought being such a large problem faced so often in Australia, it is crucial that a sufficient method be developed to effectively monitor the various categoriesand stages of drought. The current system employed in Australia to classify and monitor drought-affected areas (primarily agricultural drought) is the Rainfall Decile System, however there are a number of problems associated with this method, highlighting the need to apply alternative techniques. Therefore, the aim of this project is to review and assess the applicability of existing methods and indices (developed in the USA and Europe) for monitoring drought in Australia that will include, but are not limited to, the Palmer Drought Severity Index, Crop Moisture Index, Byram-Keetch Drought Index, Antecedent Precipitation Index, Standardised Precipitation Index, Total Water Deficit, Rainfall Anomaly Index and the Rainfall Decile System.

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Characterizing the cost of resistance to chemical stressors in invertebrates from a chronically-contaminated field site

Human activities have lead to a number of chronically-contaminated terrestrial and aquatic habitats in Australia. A key question related to these sites is what the long-term effect of exposure to the existing chemical residues has had on resident organisms. This project will focus on a contaminated site in either NSW (e.g. Cockle Creek, Lake Macquarie) or farther afield (e.g. Port Pirie, South Australia) and use both laboratory and field techniques to determine if aquatic invertebrates from the site exhibit resistance to chemical stressors and if this resistance has an energetic cost as determined by metabolic rate.

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Environmental Water Science Research Group

Relationships between increased metabolic rate and demands on food resources in aquatic invertebrates

This project could be conducted with marine or freshwater invertebrates and has the potential for using chemical stressors and/or increased temperature associated with climate change as the driver for metabolic change. The basic question is 'Do animals with elevated metabolic rates eat more and so impose greater pressure on available food resources?"

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Surveys of the freshwater mussel fauna and associations of mussel assemblages with other freshwater invertebrates in the Hunter River catchment

Freshwater mussels are among the most endangered aquatic species on a global scale and there is an urgent need to develop indicators of habitat condition that can be used to rapidly evaluate the health of river reaches that support mussel assemblages. Surveys of aquatic insects have been used extensively to evaluate water quality and this group has the potential to serve as early indicators of changing water quality that could impact freshwater mussel survival. In this field-based project, surveys of both mussels and aquatic insects will be undertaken in select rivers of the Hunter-Central Rivers catchment. The specific objective will be to determine if there are specific aquatic insect taxa that are consistently associated with healthy freshwater mussel assemblages and if other landscape-level factors also influence where mussels occur in rivers.

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**Prof Joe Bidwell is also has Research Interests in:*

- Evaluating the quality of urban stormwater in Newcastle,
- Developing indicators of ecosystem function in the Kooragang wetlands,
- Determining salinity tolerances and energetic effects of exposure to freshwater pulses in intertidal invertebrates.

Comparative Evaluation of Different Small Scale Waste Treatment Systems

This project is to compare the performance of different wastewater treatment systems, particularly sand mound systems and constructed wetlands in treating domestic wastewater.

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Environmental Water Science Research Group

Remediation of Acid Mine Drainage

The project is at a derelict mine site and trials are proposed for the remediation of contaminated water at the site. Trials may involve the use of constructed wetland systems and other small scale treatment options.

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Interpretation of Mine Monitoring Data

Coal mines in the Hunter Valley present their air quality monitoring data quarterly to Community Consultative Committees and there is often little scientific rigour in the presentations. At times various explanations are proposed for "exceedances" with respect to air quality goals . A project is proposed which would involve using standard data presentation methodology that examines wind direction and speed with depositional dust or Hi Vol data to examine these exceedances and to give a better understanding of air quality impacts on particular areas. The spatial analysis may suit a student interested in using a GIS based approach.

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Effects of estrogenic compounds on native molluscs
Estrogenic compounds are a subset of endocrine disrupting chemicals which mimic the female sex hormone estrogen. Such compounds are present in sewage effluent and are discharged into our own local aquatic waterways via sewage treatment effluents. We are interested in how estrogenic compounds influence the production of the female egg yolk protein vitellogenin, and using this as a biomarker of exposure in real field situations. We are also interested in the "gender-bending" properties of estrogenic compounds and how estrogens may facilitate sex change, turning males into females in aquatic organisms. There are possibilities for honours students conducting studies both in the field and at the Fisheries Research Station at Port Stephens investigating effects of estrogens on molluscs, including the native commercial, edible species, the Sydney Rock oyster. Such a project would provide both experience in lab and field work and also working within an industry context.

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Effects of endocrine disrupting chemicals on gene expression involved in fish steroidogenesis
In recent years, there has been growing public and scientific concern about environmental chemicals that have the potential to alter the normal functioning of the endocrine system in humans and wildlife. These chemicals, often called endocrine disrupting chemicals (EDCs), may be found in many everyday products, including plastic bottles, metal food cans, detergents, flame retardants, toys, pharmaceuticals, personal care products, and pesticides. The aquatic environment is an important sink for chemicals. Exposure to EDCs, even at minute concentrations, has been linked to abnormal development of gonads, inter-sex conditions, skewed sex ratios and decreases in reproductive success in wild and laboratory aquatic animals. Thus, EDCs have emerged as a major long-term threat to biodiversity and sustainability of aquatic ecosystems.

Steroidogenesis (biosynthesis of steroid hormones) is one of the important biological levels at which EDCs can exert their effects. In fish, early steroidogenesis occurs in the interrenal organ (which is analogous to the mammalian adrenal cortex) of developing embryos. We propose that a subset of EDCs can specifically alter gene expression involved in fish interrenal organogenesis and steroidogenesis, and thus disrupt the normal production of steroid hormones during early development. It is anticipated that certain responsive genes could be used as indicators of EDC exposure and integrated components of bioassays for EDC detection. The aims of the project are therefore to (1) identify EDC-responsive genes involved in interrenal organogenesis and steroidogenesis in zebrafish (*Danio rerio*) embryos; and (2) correlate the changes in their expression levels to the size of the interrenal organ and the endogenous levels of key steroid hormones in EDC-exposed embryos. The outcome of this research would advance the technology to detect EDCs and provide new mechanistic insights into modes of action of EDCs.

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Cryptic invader: green alga *Codium fragile* ssp. tomentosoides in NSW
Codium fragile ssp. tomentosoides is one of the most invasive algae, and its introduction to NSW can have serious environmental implications. Due to its similarity to the native subspecies (tasmanicum and novae-zelandiae), the introduction is likely go undetected until the alga is well established. This study will undertake the first quantitative assessment of the invasion by non-native *C. fragile* in NSW and document its distribution and abundance along rocky shores and estuaries of the state. This will help to identify the degree of infestation and to assess potential damage to the environment.

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Sustainable Use of Coasts & Catchments Group

GEOGRAPHY & ENVIRONMENTAL STUDIES

Climate Change Adaptation: Household, Neighbourhood and Businesses Innovation
How are households, neighbourhoods and businesses responding to concerns about climate change? What sorts of changes are people making? What sorts of factors are influencing changes in behaviour?

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Centre for Urban and Regional Studies (CURS)

Community Enterprise Case Studies
Case studies of community enterprises focusing on various aspects of operation, including:

- the economic, social and environmental ethics that shape how enterprises operate
- the diverse economic practices that enterprises use to enact their ethics
- how enterprises are governed and how this is shaped by their ethics
- evaluation of the impacts of community enterprises.

Case studies could be conducted using a combination of participant observation, and interviews and focus groups.

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Critical development geographies
Civil society organisations have emerged in the past two decades as key drivers of community aspirations in development. While this increased influence is acknowledged by donors, doubts remain as to the best ways of incorporating community knowledge and local aspirations into the operations and practices of larger development institutions for more socially just outcomes. Topics in this emerging field could include:

- Debates around 'participation' and 'partnerships' in international development. How participatory are donors given their stated intentions? Are non-government organisations (NGOs) being co-opted or is there genuine 'bottom-up' channelling of community knowledge?

- The relationships between civil society groups, for example, NGOs, community-based organisations (CBOs) or faith-based groups and their beneficiaries (i.e., the community that it serves). To what extent are civil society groups helping or hindering the incorporation of community knowledge and local aspirations into larger institutional structures?

- Exploring what community-driven and socially just outcomes look like. How are these playing out in communities? What community strengths exist and how can these inform a rethink of 'top-down' development practices?

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Geographies of urban regeneration
The regeneration of our cities in the face of growing environmental. social and population pressures will be a major challenge facing urban Australia over the coming decades. Both national and comparative research is needed on how we can imagine, govern and operationalise successful regeneration to have environmentally and socially acceptable outcomes. Research topics might include case study investigations of regeneration processes and outcomes, studies of community involvement in regeneration, studies of the politics of regeneration governance.

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Urban Carbon Governance
Effective responses to climate change hinge on the capacity to govern carbon, especially in our growing cities. Australia's urban carbon governance framework has proved ineffective, and there is no systematic knowledge of it to inform improvement. This research project would contribute to a wider project aimed to document and analyse the 'who', 'how' and 'where' of urban carbon governance, and the related politics and spatiality. The project will provide empirical and theoretical knowledge to advance the capacity to govern carbon and enhance Australia's environment.

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Urban social inclusion
Cities have long been sites where the uneven distribution of resources and recognition is expressed. Recent policy initiatives have been framed around the notion of 'social excluded' places and people and the challenge of attaining 'social inclusion'. Yet we have relatively poor understandings of how social inclusion is both understood and experienced differentially across diverse communities and neighbourhoods with diverse levels of mobility and connectivity. Research topics in this field could address both urban spatial variations in the availability of resources and opportunities and the diverse understanding and experience of social inclusion.

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Geographies of home and home making
Recent research in geography has investigated the homemaking as a dynamic process. Research in the field has investigated the home making practices of newly arrived migrants, new suburban residents, people living in medium density developments, public housing tenants, gay men, people with an intellectual impairment and the experiences of people living with animals as pets and pests. Other research has looked at practices of home-making that occur in gardens and neighbourhoods.

This honours research topic would further our knowledge of home making practices by examining one of the following:

- Home making on the Newcastle suburban fringe
- Home making in a retirement village
- Home making in share households
- The adoption of green domestic technologies and home making practices
- The role of food and cooking in homemaking.

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Understanding Neighbourhood Dynamics
Recent research on neighbourhood has emphasised that neighbourhoods cannot merely be understood as a set of socio-economic characteristics, but rather are brought into being through the actions of neighbourhood residents and other people who use the neighbourhood. At the cutting edge of urban research, this notion that neighbourhoods are performed requires further investigation. Students could choose to investigate the role of social interactions in creating the neighbourhoods, the role of new developments or threatened developments in provoking the mobilisation of neighbourhood resources or the role of particular sorts of community assets such as schools and green spaces in developing neighbourhood. Potential topics include:

- Neighbourly relations and social capital in neighbourhoods
- Protest movements and neighbourhood development
- Schools as neighbourhood resources
- Green spaces as a neighbourhood resources

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Geographies of mobility
Issues of mobility and transport access are crucial to developing more sustainable cities. Recent geographical research has emphasised the importance of understanding flows of people around cities. While research on mobility in geography is growing, there is considerable scope to contribute to our understanding of mobility in Australia. Some potential research projects include:

- Cycling as a form of commuting in Newcastle
- Cycling activism as a form of urban intervention in Australian cities
- Public transport and mobility
- Transport access and neighbourhood development on the urban fringe
- Managing multiple demands in daily commuting
- The journey to university: transport choices amongst workers and students

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Case Studies of community/mining company relations
The minerals sector remains one of Australia's most important corporate players today influencing governmental decision-making at all scales. Its relations with communities, however, are not always as transparent as they could be and this can often lead to contestation over access to land and resources as well as concerns over possible environmental damage. These issues remain compelling ones for all sectors of society.

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Incorporating resource peripheries into the globalising economy
Remoteness and distance have often been given as reasons for excluding particular places from playing an active role in the globalising economy and important decision-making. Frequently, however, these perceptions are stereotyped and bear little resemblance to the reality of these places on the ground, which more often than not, are very productive spaces. There remains a need for better understanding of remoteness as a concept so as to avoid the peripheralisation of places that continues today despite globalisation's claims to have created a 'border-less' world.

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The effects of Climate Change on small Island states
Climate change remains an ongoing global threat though its effects will be felt first by small island states. Understanding how these places adapt to stresses placed upon them by a changing climate and what strategies exist or need to be developed to help respond to these challenges will be an ongoing concern for researchers and governments alike.

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Centre for Urban and Regional Studies (CURS)

The creation of green spaces through better environmental planning
As population numbers continue to grow globally, as a consequence, more land is consumed often denuding our environment of 'green spaces'. Recently, however, there have been calls for better planning initiatives which promote and encourage developments which emphasise 'greening' the environment. Developments such as golf courses have recently been touted as a means for creating such spaces. Debates continue though as to whether this privileges the rich over the poor by controlling who has access to use these spaces and who is excluded and why.

Contact: Dr Meg Sherval
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Centre for Urban and Regional Studies (CURS)

- **Analyses of particular development projects (in Australia and overseas)**
- **Local impacts of global change**
- **Environmental politics and social justice**
- **Effects of neoliberal development on women**
- **The constructions of "globalisations from below" by social movements**
- **Migration to Newcastle and transnational communities**
- **Sustainable agriculture and alternative agriculture networks**
- **Indigenous tourism**
- **Indigenous social enterprise**

*Contact: Dr Sarah Wright***
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Centre for Urban and Regional Studies (CURS)

**Sarah's research interests are in development studies, sustainability, social movements and feminist theory, particularly women in development. She has done work in Southeast Asia, the Pacific, Australia and Latin America. She has also worked extensively with Indigenous people mostly in Arnhem Land. Honours projects might involve a trip overseas but also could look at issues of development within Australia. The topics listed for Sarah are general ideas and would need to be refined with an appropriate case study or more specific topic in consultation with Sarah.

With any enquiries about these or any other potential Honours opportunities in Geography and Environmental Studies Honours and Development Studies Honours, please contact Honours Co-ordinator Professor Pauline M^{c}Guirk via email at: pauline.mcguirk@newcastle.edu.au.

Note that Dr Mee and Dr Sherval will not be available as sole supervisors in 2012.

School of Mathematical and Physical Sciences

MATHEMATICS

Cycles and Symmetry in Graphs / Graph Theory
The well-known Lovasz Problem (1969) asking whether every connected vertex-transitive graph has a Hamilton path has generated considerable research since it was posed. This project involves an examination of recent progress made on the general question.

Contact: Dr Brian Alspach
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Graph Searching/Graph Theory
An active area of current research in graph theory revolves around the basic idea of trying to determine whether an intruder is located somewhere in a graph, and designing strategies to capture an intruder. This project involves an examination of one or two models for graph searching and a possible exploration of an unsolved problem (of which there are many).

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Radiation
One of the major challenges of contemporary physics is the direct detection of gravitational radiation. (The slowing down of pulsars as accounted by Einstein's quadrapole formula is indirect evidence.) However, there isn't really a good definition of what exactly gravitational radiation is! (The usual definitions only apply to perturbations about some fixed spacetime background.) Although the electromagnetic case is much better understood (there are a number of exact solutions available) there are still many ambiguities in trying to give a precise definition of what radiation is. These have been discussed in the literature (largely over the last 40 years). Part of this project would be a literature review. A more specific topic to investigate would be the use of conformal transformations to relate the world line of an inertial charge to that of a uniformly accelerating charge, and to see what this tells us about the radiation of the latter. (This is not an original idea, but discussion of this topic can be found in fairly recent sources).

Contact: Dr Ian Benn
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Compressed Sensing/ Nonlinear Optimization
To analyze optimization methods for finding sparse signals which reconstruct known measurements. Traditionally in signal or image reconstruction problems, the scientist recovers a signal and then compresses it using JPEG, wavelet or other methods of reducing the size of the data set to be stored. Recent exciting work performed by Australian Fields medallist Terry Tao among others has focussed on determining *ab initio* sparse reconstructions. The theory behind current methods for such *compressed sensing* is poorly understood and the project offers considerable room to make mathematical discoveries.

Contact: Laureate Professor Jon Borwein
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Computer assisted discovery and proof / Experimental Mathematics
To work on the implementation and design of methods to assist with the discovery and or proof of analytic objects, such as inequalities in one and more variables, identification of values of series and integrals and much more. One goal is to provide `intelligent agents' to allow human researchers to quickly validate or falsify conjectured inequalities and in the former case to provide automated proofs whenever possible. This project will provide also an opportunity to learn a great deal about modern computer algebra systems.

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High Precision Integration / Computational Mathematics
To work on the implementation and analysis of algorithms to compute physically meaningful integrals to at least double precision in more than two dimensions. Such integrals arise in statistical mechanics, quantum field theory, geosciences, mathematical finance and many other places; and their accurate evaluation is one of the central challenges of modern numerical and symbolic computer analysis.

Contact: Laureate Professor Jon Borwein
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Statistical group theory
What does a ``random'' element or subgroup of an infinite group look like? How can one define random in the context of infinite sets, and what definitions are ``natural''? This project will explore examples from geometric group theory and topological groups, and try to prove statistical properties of these examples. It may also involve computer experiments to explore random behaviours in these examples.

Contact: Dr Murray Elder
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Growth series for infinite groups
This project aims to construct examples of infinite groups which have growth series which are D-finite and D-algebraic, two important classes of (generating) functions in combinatorics. Many examples are known with rational growth series, and certain examples have been shown to have algebraic but not rational growth series. Techniques from analytic combinatorics, geometric group theory, and computer experiments will all be applied to construct these new examples.

Contact: Dr Murray Elder
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Stack sorting and pattern avoiding permutations
Knuth showed that a permutation of n distinct numbers can be sorted in ascending order by passing the numbers through a (first in last out) stack if an only if the permutation contains no pattern of the form 231, meaning a big number cannot sit in between a medium and a small number. The number of such permutations of length n is the n-th Catalan number. One can try to generalise this result in several ways: count the number of permutations avoiding some specified list of patterns; classify (and count) the permutations that can be sorted using two or more stacks, or different kinds of (token passing) networks. Computer experiments could be useful in this project, although their power is limited since the number of permutations is n!.

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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

New integer programming based theory, formulations and decomposition techniques with applications to integrated problems

Integer linear programs allow a huge variety of practical scientific and business problems to be effectively modelled. However for many practical problems, especially problems that integrate two or more sub-problems, currently available theory and solution methodology are unable to solve the resulting integer program, leading to loss of accuracy and suboptimal solutions. Researchers in this area will readily admit that current theory is insufficient to characterize this phenomenon. New theory and algorithms are needed.

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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Uncertainty relations for Multi-channel signals and Clifford algebra

In recent years, mathematicians and electrical engineers have developed Fourier-type integral operators for the analysis and processing of multi-channel signals, such as colour images. The kernels of these operators are similar in nature to the classical Fourier kernel, but also have important differences. In particular, these kernels (and the signals themselves) take values in an appropriate Clifford algebra where multiplication is non-commutative. Here we explore the uncertainty relations satisfied by these new operators and also their applications in colour image processing. This project will require some programming in MATLAB.

Contact: Dr Jeff Hogan
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Applications of biorthogonal systems in approximating higher order derivatives

Finite element methods based on biorthogonal systems are proved to be very effective in solving partial differential equations with a weak constraint. Weak constraints can be used to reduce the order of derivatives in numerical approximation. Higher order derivatives occur frequently in data smoothing, image processing and binary mixtures. The aim of the project is to analyse the performance of biorthogonal systems in approximating higher order derivatives. Programming skill in MATLAB is required to complete the project.

Contact: Dr Bishnu Lamichhane
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Variational approach in image processing

The finite element method has become a very powerful and popular tool to solve boundary value problems coming from science and engineering. This project is concerned with applying finite element method in image processing. One example is to remove the mixture of impulsive and Gaussian noise from an image. Programming skill preferably in MATLAB is required to complete the project.

Contact: Dr Bishnu Lamichhane
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Applying finite element method for solving applied partial differential equations
Finite element method is a powerful tool to approximate partial differential equations. This project is concerned with applying the finite element method to solve partial differential equations like heat and reaction-diffusion equations. This is an applied project and involves a lot of programming.

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Nonlinear Analysis and Fixed Point Theory
Many problems in the behavioural, communication, computational, economic, life and physical sciences and in engineering and technology translate into problems concerning fixed points of certain mappings. For instance; equilibria of discrete and continuous dynamical systems correspond to fixed points of nonlinear maps on infinite dimensional function spaces. The solution of nonlinear optimization and control problems lead to variational inequalities and thence to the search for fixed points of related nonlinear operators.
Nonexpansive maps arise when modelling conservative or dissipative situations and their fixed point theory presents a tantalizing intermediary between the classical theorems of Banach and Brouwer which has led to a fertile interplay between metric geometry and fixed point theory.

A principal goal is to further our understanding of nonexpansive and related types of mappings, with an emphasis on identifying widely applicable, easily verifiable conditions on Banach, and more generally metric, spaces that ensure the existence of fixed points for all nonexpansive self-mappings of appropriate nonempty domains such as closed bounded, convex and possibly weakly compact subsets of a Banach space. Special emphasis is given to the more difficult cases, where the underlying space lacks the nice geometric structure of, for example, a Hilbert space, or situations where there is no natural linear structure. Recently such situations have arisen in robotics and models of cognition.

Alternating projection algorithms, first considered by von Neumann in 1932, and variants of them have become standard tools for handling inverse and signal/image reconstruction problems, where one seeks a feasible point in the intersection of a family of constraint sets. When all of the constraint sets are convex subsets of a Hilbert space these iterative schemes for approximating fixed points of an appropriate map have rigorous theoretical under-pinnings. However, despite the absence of any sound theoretical justification, for more than three decades the same algorithms have been routinely and successfully employed solve real world problems involving non-convex constraints. We seek to provide theoretical foundations in such situations and in spaces other than Hilbert space. These investigations lead to a variety of potential projects.

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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Learning and Pricing: Uncensoring Lost Demand
We consider a capacity provider who offers a new product to a new market. The provider is uncertain about two elements: the value of the product and the size of the market. The information is revealed during the sales period by the market response. A method has been developed to update the provider's prior belief based on market responses, and update the price to maximize expected revenues over a rolling horizon. However, the method assumes the provider can observe the lost demand, an assumption which is not valid in some settings. We want to extend the method to be able to uncensor the lost demand.

Contact: Dr Masoud Talebian
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Integer programming theory, algorithms, and applications
Project to advance knowledge in an area of interest in optimization, in particular, integer programming and discrete optimisation, using state-of-the-art techniques. Please arrange a topic for a potential project with me prior to submission of your application.

Contact: Dr Hamish Waterer
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Classify simple totally disconnected groups.
The simple connected groups have been completely classified since the middle of the 20th century but until recently there was no prospect of such a classification for totally disconnected groups. However the structure theory currently being developed is beginning to provide tools and structural invariants that might be used in a classification. Making a complete classification would be an enormous program of research but there are many sub-projects that will contribute, including some of the previous ones.

Contact: Professor George Willis
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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

Invariant subspaces of shift operators
Shift operators are easily described and have some obvious invariant subspaces. In some cases, it is known that the obvious invariant subspaces are the only ones but in others it is not. This project aims to understand these other cases.

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Simple subgroups of the automorphism group of a tree
Many examples of simple automorphism groups of trees are known. The aim is to develop our understanding of these groups to be more than a set of examples.

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Symmetry groups of graphs and complexes
The project aims to relate properties of the automorphism group of a graph or simplicial complex to properties of the graph.

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Number theory and special functions
Investigate arithmetic and analytic properties of special functions (including modular and hypergeometric functions) and their values, discover and prove identities for them.

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Priority Research Centre for Computer Assisted Research in Mathematics and its Applications (CARMA)

PHYSICS

Determination of Magnetic Topology Using Ultra Low Frequency Waves Recorded in Antarctica
Quasi-sinusoidal, mHz frequency variations of the geomagnetic field at high latitudes are associated with local field line resonances. The resonant frequency depends on magnetospheric dimensions and hence solar wind conditions. In this project magnetohydrodynamic theory will be used in combination with geomagnetic field and plasma density models to determine the expected resonance frequencies and compare these to observations from four closely spaced magnetometers near Davis station, Antarctica.

Contact: Dr Sean Ables
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Centre for Space Physics

The Ionospheric Alfven Resonator
The Earth's ionosphere acts as a resonant cavity for electromagnetic plasma waves. This project will involve numerically solving the time dependent Maxwell wave equations in 2D to explore the properties of this cavity, and compare with experimental data. The model is unique in combining realistic descriptions of the conductivity and geomagnetic field.

Contact: Dr Murray Sciffer
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Centre for Space Physics

Tracing Ionised Particle Trajectories in Space
High energy electrons exist in near-Earth space. One of the proposed energisation mechanisms involves plasma wave to particle energy transfer. Using existing 2-D computer models, this project will advance understanding of the trajectories and energies of particles in near-Earth space.

Contact: Dr Murray Sciffer
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Centre for Space Physics

Numerical Simulations in Space Physics
This project will teach you how to solve differential equations that describe fully charged, magnetised fluids. Using existing 2-D models, this project will add extra code to include pressure and temperature dependent waves and the relationship with other wave modes. Simulation results will be compared with experimental satellite and ground data.

Contact: Dr Murray Sciffer
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Centre for Space Physics

Numerical Simulations in Ionosphere Physics
This project will teach you how to solve differential equations that describe mixtures of neutral and charged magnetised fluids. This involves a conductivity tensor. The project applies to the Earths ionosphere and will extend our existing 1-D simulations into 2-D using a formulation that is Fourier analysed in time ($e^{-i\omega t}$). The solution will involve teaching you to use tri-diagonal, sparse matrix solvers in Fortran on multi-processor computers.

Contact: Dr Murray Sciffer, A/Prof Colin.Waters
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Centre for Space Physics

Radar Signatures of the Plasmapause
An important dynamic structure in the inner magnetosphere is the plasmapause. Modeling work suggests that ULF wave energy transfer from the auroral regions to Australian latitudes critically depends on the structure and location of this boundary. Observations of ULF wave signatures using our HF radars in Tasmania and New Zealand have shown a distinct localized band of enhanced ULF power. Are these the signature of wave growth associated with a well formed plasmapause? This project will use existing methods for locating the plasmapause, (EUV instrument onboard the IMAGE spacecraft, ground magnetometer data, GPS data) to identify the radar signature of this structure. This will be excellent training in the operation and data returned from multi-pulsed HF radar instrumentation, similar to those use in defence surveillance.

Contact: A/Prof Colin Waters
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Centre for Space Physics

Remote Sensing of ULF Waves in Geospace Plasma Using SuperDARN Radars
This project uses HF radars in Tasmania and New Zealand to study the signatures of ULF plasma waves in the high latitude ionosphere. The project focuses on advanced analysis techniques used in geophysics, including spectral and correlation algorithms, to elucidate the spatio-temporal and spectral structure of ULF waves and obtain new information on their generation and propagation mechanisms.

Contact: A/Prof Colin Waters
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Centre for Space Physics

Remote sensing killer electron energisation electric fields in space
Ground magnetometers detect small variations in the geomagnetic field which are caused by magnetised plasma wave energy in near-Earth space. The associated electric fields energise electrons to high energies which pose a threat to spacecraft operations. This project will develop the link between the recorded ground magnetic signals and the electric fields in space and compare these with spacecraft data.

Contact: A/Prof Colin Waters
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Centre for Space Physics

Spatial Properties of ULF Resonance structures
Low frequency variations in the plasma of near-Earth space are enhanced at various resonances. These are important for remote sensing various properties above 5000 km altitude. This project will use magnetic field variation data and high frequency (HF) Doppler returns data from Scandinavia to determine the differences in the remote sensed parameters using these different data sets.

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Centre for Space Physics

Substorm signatures in over-the-horizon radars
Large releases of energy in near-Earth space result in almost daily 'substorms' that cause auroras and damaging effects on technological systems. A characteristic magnetic field perturbation, called Pi2, is produced at substorm onset. Pi2 have mostly been studied using ground magnetometer arrays. We have developed techniques to more directly and precisely identify and image Pi2 using over-the-horizon radars such as those that form the backbone of Australia's defence surveillance. This project will use our own HF radars to image the substorm ionosphere and identify the dual (2-D) radar signature of Pi2, characterise the properties of these, and explain causative the physical mechanism. This will bring new understanding to this most important topic.

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Centre for Space Physics

Drivers of High Energy Radiation Arriving into the Atmosphere

Very high energy particles precipitate from the Earth's radiation belts into the atmosphere and may cause significant damage to mobile electronics including low-Earth orbiting spacecraft. The physics driving this process is largely unknown. This project will investigate what effect ultra-low frequency plasma waves propagating through near-Earth space have on the precipitation process. The project will involve collaboration with the British Antarctic Survey, Cambridge, and the University of Otago, New Zealand, using a new world-wide network of Very Low Frequency (VLF) radio sounders to monitor the arrival of high energy particles in the atmosphere, and the TIGER and Unwin SuperDARN over-the-horizon radars operated jointly by Newcastle and LaTrobe Universities.

Contact: Professor Fred Menk
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Centre for Space Physics

How Does Solar Wind Energy get to the Nightside?

The Earth's magnetic field lines extend a considerable distance into space and influence the motion of ions and electrons. Variations in solar wind pressure cause changes in the shape and position of field lines and particle motions on the dayside. How we get a response on the nightside, and the form of that response, is an open but important question. This project will involve collaboration with the British Antarctic Survey, Cambridge, using remote sensing techniques based on VLF radio and ground magnetometer measurements, over-the-horizon radar measurements, and in situ spacecraft data, to investigate the effects of solar wind variations and magnetic substorms on field lines in the nightside.

Contact: Professor Fred Menk
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Centre for Space Physics

Mapping the Radio Sky at Southern Polar Latitudes

We have operated an imaging riometer at the Australian Antarctic station Davis for some years. This space weather instrument measures variations in radio noise reaching the ground from the sky. This project will involve collaboration with IPS Radio and Space Services, Bureau of Meteorology, to (a) determine whether individual radio stars or galaxies are detected; (b) use such discrete sources to check the calibration of the antenna beam pattern and sensitivity; and (c) investigate scintillation effects. This has not been done before and will provide new information on the performance of these instruments.

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Centre for Space Physics

Microscale Fluctuations in GPS Signals

Many navigation and aircraft landing systems rely upon precise radio signals transmitted from GPS spacecraft at 20,200 km altitude. These signals suffer amplitude and phase perturbations due to plasma density irregularities along the transmission path. This project will involve collaboration with IPS Radio and Space Services, Bureau of Meteorology, and use high time resolution GPS data and ground magnetometer observations from the Australian sector to investigate whether such perturbations are caused by ULF (few mHz) plasma waves propagating through space. Such waves occur for hours every day at all locations, and their presence in GPS data may have important implications for precise navigation systems.

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Centre for Space Physics

MRI-based treatment guidance for cancer treatment
Combinations of magnetic resonance imaging (MRI) scanners and linear-accelerators for radiation therapy treatment are currently under development. A proposal for an installation at Liverpool Hospital in Sydney is under development. The Mater Hospital is also soon to install a state-of-the-art 3T MRI scanner. These next-generation devices will enable high contrast real-tim MRI images to be used to guide the treatment dose to the tumour while avoiding normal tissues. The aim of this project is to acquire multiple MRI images for a group of patients and develop and test methods to use these scans to plan and guide radiation therapy treatments.

Contact: A/Prof Peter Greer
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Medical Physics Group / Priority Research Centre for Information Based Medicine

Real-time image-based dosimetry for radiation therapy
Flat-panel Imaging devices can record dose from high energy modulated radiation beams in real-time during cancer treatment. These measurements could be combined with a dose calculation model to calculate dose to the imager in real-time. This would be compared with the expected dose in real-time. This could ensure that treatments are accurate and that errors in treatment are detected and avoided.

This project will investigate methods to measure the dose in real-time with the imaging device including investigating a new imaging system design. Methods for fast comparison of expected and measured dose will be developed potentially with GPU devices. This would be the first system to verify patient dose distribution delivery in real-time with imaging devices.

Contact: A/Prof Peter Greer
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Medical Physics Group / Priority Research Centre for Information Based Medicine

A dual imaging/dosimetry system for radiation therapy
Current flat-panel imaging devices in radiation oncology are designed for high quality imaging and have severe limitations as dosimeters to verify accurate dose delivery. We have developed a novel design for an imaging system that performs extremely well for dosimetry but less well for imaging. The aim of this project is to develop methods to adapt this design to perform as a dual-mode imager enabling both high quality imaging and high quality dosimetry. This work could facilitate the development of a new device for radiation therapy verification.

Contact: A/Prof Peter Greer
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Medical Physics Group / Priority Research Centre for Information Based Medicine

Automatic prostate segmentation using MRI for improved accuracy of prostate radiation therapy
For prostate radiation therapy a radiation oncologist manually delineates (segments) the border of the prostate on a planning magnetic resonance imaging (MRI) scan to define the target high dose region and to limit the doses to surrounding normal tissues. However for the same patient there are differences in the borders of the prostate outlined by different clinicians (inter-observer variability) which produces uncertainties in the prostate location. This project is a collaboration with CSIRO and will develop advanced methods to automatically segment the prostate on MRI scans using our expertise in advanced atlas-based image segmentation. This project has the potential reduce the uncertainties and margins in prostate treatment leading to lower normal tissue doses and improved quality of life following treatment.

Contact: A/Prof Peter Greer
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Medical Physics Group / Priority Research Centre for Information Based Medicine

Does the initial treatment plan predict doses delivered to normal tissues during prostate radiation therapy?

Increasing the dose to the prostate (dose escalation) in radiation therapy has been shown to increase local control for medium and high risk patients with five year survival rates now very high. However, increasing the dose increases the risk of long-term bladder, rectal and other toxicity which can reduce the quality of life for these patients. At present we use a computed tomography (CT) scan acquired prior to the treatment course to predict these doses. However changes in bladder and rectum size and shape and beam positioning changes occur during the nearly forty daily treatment deliveries. This could change the doses received by these organs and our initial prediction of the dose may not be a good estimate.

In this project we will determine actual delivered doses to these organs using daily on-treatment CT scans to capture the anatomical shape and size at each treatment, combined with calculation of delivered dose on each on-treatment scan. We will then determine whether the initial treatment plan is predictive of delivered doses to the rectum and bladder. This will allow us to determine the uncertainties in these current treatment plan predicted doses. The results will lead to development of better methods to determine actual delivered doses to improve patient treatments.

Contact: A/Prof Peter Greer
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Medical Physics Group / Priority Research Centre for Information Based Medicine

Three-dimensional real-time patient dosimetry for radiation therapy

Flat-panel Imaging devices can record dose from high energy modulated radiation beams in real-time during cancer treatment. These measurements could be combined with a dose calculation model to calculate dose to the patient in real-time. This would be compared with the expected dose in real-time. This could ensure that treatments are accurate and that errors in treatment are detected and avoided. The calculation of dose within a patient in real-time from transit dose images requires very fast calculations. The aim of this project would be to develop graphical processor units (GPU) based physics models for real-time patient dose verification in radiation therapy treatment.

Contact: A/Prof Peter Greer
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Medical Physics Group / Priority Research Centre for Information Based Medicine

Biosensors from Plastic Electronics

Current state-of-the-art biosensor fabrication involves assembling complex molecular structures on hard conventional semiconductor materials such as silicon. Our aim is to demonstrate that low cost biosensors can be fabricated by simply incorporating bioactive materials into organic field effect transistors. Using soft electronic polymers as the matrix for the bioactive material eliminates the need for complex molecular surface assembly. Previous work at the University of Newcastle has clearly demonstrated that prototype sensors can be built using OFETs. This project will involve building and characterising OFETs and is focussed on understanding the device physics of these electronic components. The long term goal of this project is the development of flexible and inexpensive biosensors for a variety of applications.

Contact: Prof Paul Dastoor
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Priority Research Centre for Organic Electronics

Developing a Helium Beam Microscope
Scanning helium microscopy offers the tantalizing possibility of using the wave-particle nature of helium atoms to image the structure of delicate surfaces with unprecedented resolution. This project will involve developing the new ARC-funded helium beam microscope at Newcastle and producing preliminary images. This project will involve collaboration with the Cavendish Laboratory at the University of Cambridge.

Contact: Prof Paul Dastoor
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Priority Research Centre for Organic Electronics

Extending the Spectral Response of Organic Solar Cells
State-of-the-art organic solar cells are limited by the wavelength response of the active semi-conducting polymer layer since these materials typically only photogenerate charges below 500 – 550 nm. In the natural world, plants use a range of porphyrin-based molecules (such as chlorophyll) to allow photosynthesis to occur across the solar spectrum. This project aims to develop photovoltaic devices containing artificial porphyrin light harvesting molecules. The goal of this project is to develop, for the first time, plastic solar cells that generate electricity from the entire solar spectrum.

Contact: Prof Paul Dastoor
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Priority Research Centre for Organic Electronics

Field Ionisation He Detection using Carbon Nanotubes
Scanning helium microscopy is an emerging imaging technology that uses low energy (<50 meV) helium atom beams as a completely non-perturbing probe of nanoscale structure. However, this exciting new technology is currently limited by the lack of an effective 2D imaging system for neutral He atoms. Carbon nanotubes (CNTs) offer the possibility of acting as effective field ionisation tips for He atoms thus allowing them to be detected. This project will aim to grow CNT arrays using a new state-of-the-art chemical vapour deposition (CVD) system in the Centre for Organic Electronics.

Contact: Prof Paul Dastoor
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Priority Research Centre for Organic Electronics

Large Area Printing of Organic Solar Cells
The development of new sources of renewable energy is urgently required if the worst effects of man-made climate change are to be avoided. This project will build on the recent exciting advances made by the Centre for Organic Electronics (COE) in device fabrication to develop new methods for printing large photovoltaic arrays based on semi-conducting polymers. This project will make use of the new state-of-the-art ink jet printer that has been recently purchased by the COE for developing organic electronic circuits.

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Priority Research Centre for Organic Electronics

Novel Electrodes for Organic Solar Cells
The capability of organic solar cells to provide large scale global sustainable energy solutions will be limited by the current high costs and supply issues associated with the current electrode materials. This project will explore novel inverse architectures and transparent conducting materials to address the issue of developing low cost electrode structures for these exciting new devices.

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Priority Research Centre for Organic Electronics

Novel Encapsulants for Organic Solar Cells
State-of-the-art organic solar cells are limited by the durability and lifetime of the active layer materials in these blended devices. This project will study the role of new encapsulant materials and structures to extend the lifetime of these devices.

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Priority Research Centre for Organic Electronics

Phase Contrast Mechanisms in Scanning Helium Microscopy
The aim of this multinational collaborative research project is to develop the world's first imaging detector for neutral helium atoms for use in a new surface-imaging instrument – the scanning helium microscope. Scanning helium microscopy is an emerging imaging technology that uses low energy (<50 meV) helium atom beams as a completely non-perturbing probe of nanoscale structure. Currently, there is little understanding of the mechanisms that would provide contrast in this microscopy. The ultimate goal of this project is to understand the phase contrast mechanisms that would operate in scanning helium microscopy and is motivated by recent research by Dr Dastoor and colleagues at the University of Cambridge. This project will involve modelling work with the goal of understanding the phase contrast processes.

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Priority Research Centre for Organic Electronics

Photocurrent Mapping of Organic Solar Cells
State-of-the-art organic solar cells are limited the complex morphology and structure of these blended devices. This project will use a Near-Field Photocurrent Microscopy (NSPM) to simultaneously map the photocurrent and the morphology of organic solar cells. NSPM is a new technique that has been recently developed at the University of Newcastle and is the first technique that is capable of directly measuring the photocurrent from organic solar devices. This project will apply NSPM to the study of P3HT/PCBM blend structures, which are the most efficient blend materials currently available.

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Priority Research Centre for Organic Electronics

Printing of Electronic Arrays using State-of-the-art Ink Jet Printing
The Centre for Organic Electronics has recently purchased a new state-of-the-art ink jet printer for developing organic electronic circuits. This project will involve developing organic thin film transistor arrays for a variety of sensor applications. The project will involve developing an understanding of the device physics of these transistor arrays.

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Priority Research Centre for Organic Electronics

Structure and Morphology of Conducting Polymer Blends
Conducting polymer blends underpin all of the activities of the Centre for Organic Electronics, especially in the areas of organic solar cells and biosensors based on organic transistors. This project will study the role of structure and morphology in these blend materials as characterised by advanced synchrotron based techniques. The successful Honours student will be required to travel to use the new synchrotron facilities in Melbourne and may be required also to undertake experiments at the Advanced Light Source, Berkeley, USA.

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Priority Research Centre for Organic Electronics

Ultra-fast Laser Spectroscopy of Organic Electronic Materials
The charge generation and charge conduction mechanisms involved in organic electronic devices occur on extremely short timescales and as such are not well understood. This project will aim to use a state-of-the-art femtosecond laser spectroscopy system to probe these mechanisms using pump-probe spectroscopy.

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Priority Research Centre for Organic Electronics

Laser Processing
This project will use a state-of-the-art femtosecond laser, continuous diode laser and nanosecond pulsed lasers to investigate annealing and welding of materials in organic solar cell development.

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Priority Research Centre for Organic Electronics

Two-Photon Microscopy
Two-Photon Microscopy allows deep imaging of live tissues. The optical arrangement and optimisation of a two-photon microscope incorporating a novel scan engine will be the topic of this work.

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Ultra-fast Laser Continuum Generation
Supercontinuum generation in optical materials is widely used in ultra-fast spectroscopy. This project will use a state-of-the-art femtosecond laser spectroscopy system to generate and analyse continua in microstructured optical fibre.

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Priority Research Centre for Organic Electronics

A new approach for imaging in the transmission electron microscope
Imaging is almost always based upon the measurement of intensities. We have recently been using new methods to measure the phase of electron beams instead. Initial results suggest that very interesting effects can be observed when we consider the phase changes of inelastic scattering. The aim of this project is to explore and develop this new technique, both from a theoretical and experimental standpoint.

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Surface and Nanoscience Group

Predicting optical properties of materials
Predicting and understanding the optical properties of materials from first principles can be considered as one of the "last frontiers" in solid state physics. Whilst many other properties of materials, such as mechanical and electronic properties are very well described by fundamental quantum mechanical methods, optical properties often remain poorly described. The reason for this lies in the fact that the optical properties are related to the excited electron states within the material, where the complex response of the electrons to the incident light, including the response of the other electrons must be included. This project will use the latest generation of computer codes to perform such calculations. A variety of metals, semiconductors and insulators will be examined and the applicability of the different levels of approximation to each of these types of materials will be examined.

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Surface and Nanoscience Group

Surface plasmons: beyond gold and silver
Surface plasmons are collective excitations of valance electrons that propagate along a surface. They are currently of enormous technological interest for applications such as single molecule detection, sub-wavelength optics and even tumour therapy. However, to date, all materials have been based on either gold or silver. This project will explore the possibility of improving and designing the plasmon response using new metal alloys.

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Surface and Nanoscience Group

Why Don't Girls Do Physics?
Many other fields have overcome the traditional gender imbalances and yet the number of girls choosing to study physics at the secondary and tertiary level remains stagnant. This project will question and explore the nature of physics itself, in the context of gender interests and preference. The question of if and how the intrinsic nature of physics differs from that of public perception may also be addressed.

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Surface and Nanoscience Group

Secondary Ion Mass Spectrometry of Implant Diffusion in Silicon
In the NASA Genesis mission, a spacecraft orbited the sun for 3 years collecting atoms given off by the sun, the so-called solar wind, into silicon wafers. The spacecraft returned to Earth and the wafers are now being analysed. During the collection phase, the samples were at a temperature of 200 degrees C so solar wind atoms implanted into the silicon diffused. In this project the diffusion of solar wind elements in silicon wafers will be measured by secondary ion mass spectrometry to understand the atomic motion in the original Genesis samples.

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Surface and Nanoscience Group

Radiation Damage in MAX Phase materials
MAX phase materials have the capacity to operate in extreme environments and may be candidates for high temperature and high radiation environments. One particular environment is as a construction material in a fusion reactor where it would experience significant radiation damage. This project would involve the investigation of ability of MAX phase materials to withstand exceptionally high levels of radiation damage

while retaining key physical properties. The experiments will involved accelerated radiation damage with ion implantation, RBS, SIMS and XRD.

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Surface and Nanoscience Group

Control Systems for Low Dose Surface Analysis using Low Energy Ion Scattering
New equipment has been purchased which will allow the automated control of a low energy accelerator and data acquisition system. The goal in this project is to bring the key elements together in a Labview application which has considerable flexibility to maintain a broad range of experiments while also minimising radiation damage to the surface under analysis.

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Surface and Nanoscience Group

Computational Single Molecule Molecular Electronics
One of the major theoretical endeavours of the Surface and Nanoscience Group is to contribute to the development of the new field of molecular electronics by modelling processes which will allow control of the positioning and functionality of individual atoms on silicon and germanium surfaces. This project builds on past successes in describing the interaction of acetone [$(CH_3)_2CO$], water, and phosphine (PH_3) molecules with the Si(001) surface and will employ a theoretical modelling based on ab initio techniques.

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Priority Research Centre for Energy / Surface and Nanoscience Group

Experimental Single Molecule Molecular Electronics
One of the major experimental endeavours of the Surface and Nanoscience Group is to contribute to the development of the new field of molecular electronics. By using a scanning tunnelling microscopy (STM), this project involves a fundamental understanding on the interactions between organic molecules and silicon surfaces at an atomic level. The formed structures will be used to make organic silicon hybrid devices for single molecule molecular electronics.

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Priority Research Centre for Energy / Surface and Nanoscience Group

Reaction energetics of dioixins with copper surfaces
Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/F's) are among the most harmful pollutants to health and the environment. Despite the enormous amount of research on PCDD/F's in the last two decades, driven largely by their high toxicity, their formation mechanisms are not yet understood in sufficient detail. This project will explore the role copper and copper oxides in the catalytic formation of PCDD/F's using first principles density functional theory calculations will be performed.

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Priority Research Centre for Energy

STATISTICS

Correspondence analysis - its theory and application
Correspondence analysis is a graphical statistical technique that provides a visual perspective to understanding the nature of the association within a contingency table. It provides a graphical understanding of conclusions obtained from the traditional chi-squared test of independence and correlation. This project will explore the statistical development of correspondence analysis and consider the various ways in which the association between categorical variables may be visualised.

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Statistics Research Group

Understanding the Duckworth-Lewis method for one-day international cricket
The Duckworth-Lewis method is designed to provide a means of resetting a target for a one-day international (and domestic) cricket match in the event of a rain (or other) interruption. This project will investigate the statistical processes underlying this method (including aspects of the model used) and will make use of international cricket data provided by Tony Lewis (one of the founders) covering 331 international cricket matches.

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Statistics Research Group

Bayesian Hierarchical Modelling
Bayesian techniques have increasingly been used in the analysis and reporting of performance measures in health care, education and industry. This project will explore the effects of various Bayesian models on parameter estimation and/or methods for monitoring processes, with a focus on the model's use in organisational quality improvement. The methods may be applied to health care, education, business or industry depending upon the student's preferences.

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Statistics Research Group

Statistical methods in climate change research
The impacts of climate change are well documented in the Northern Hemisphere, where phenology (flowering time, birds) provide much of the basis of climate effects reported (2001 and 2007 IPCC). There is however a dire scarcity of phenological recording in Australia. No Australian contribution on phenological indicators of climate change appeared in the 2001 IPCC report. The development of a Southern Hemisphere phenological climate proxy is of national priority. This project will develop new statistical theory and methods for climate research in any of the following areas: time series clustering; combining time series; wavelet methods; functional data analysis in time and space; meta analysis for global studies; synchronization mathematics; trajectory analysis using Bayesian and non Bayesian mixture analysis; transition state methods and Bayesian hierarchical methods. As such this project offers scope for individual theoretical research.

This project will build on work by Professor Hudson published in 2010 in the book entitled, *Phenological Research: methods for environmental and climate change analysis Mathematics and Statistical Methods, Design & Applications,* Springer. Your research is anticipated to be added to a chapter of a new book on southern hemisphere climate change. Methods will be applied and tested on Australia wide data from the Bureau of Meteorology (BoM), Climate Watch and the National Climate Change Adaptation Research Facility.

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Statistics Research Group

Co-supervisors: Dr M Keatley, University of Melbourne; and researchers at Cambridge University, UK

Bioinformatics and Chem-informatics in Drug Discovery
The principle that chemical structure determines molecular activity has meant that preliminary High Throughput Screening of molecules in search of new drugs has focused on identifying molecules with a similar structure to a known active molecule (protein). High throughput docking of small molecule ligands into high resolution protein structures has revolutionised computational approaches to drug discovery. The receptor structure is kept fixed, while the optimal location and conformation of the ligand is sought via sampling algorithms.

This project will develop novel Bayesian and non Bayesian methods (mixture, artificial intelligence and support vector machines) for classification and create new indicators of molecular ligand binding for drug discovery. The theory will be tested on calpain inhibitors for cataract treatment. The mathematical tools and new indicators developed will provide alternatives to diagnostics currently used in molecular libraries, and aim to provide better prediction and less false positives and negatives in drug evaluation. Other molecular libraries will be accessed to test the robustness and predictive accuracy of the methods. Local input will be sought from the Priority Research Centre for Bioinformatics, Biomarker Discovery and Information-Based Medicine (CIBM), the University of Newcastle. This research is part of an ongoing collaboration with the University of Cambridge, UK, the University of Adelaide, and GKSS, Berlin.

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Statistics Research Group

Co-supervisors: Professors Abell, University of Adelaide, & Cambridge University, UK, and Dr Joanne Thandrayen, School of Mathematical and Physical Sciences

Using movements to uncover mental processes
There are well-established mathematical theories of the cognitions underlying simple choices, but discriminating between the most sophisticated competing theories is difficult, given existing data. A new source of data might help constrain the theories and shed light on what happens in the moments before a choice is made. One new method uses data measured from movements - an observer makes a decision and simultaneously reaches their arm toward a target. This project will involve integrating data from movement-based experiments with cutting-edge theories of decision making and related statistical theory (wavelets, survival methods, transition state approaches, dynamic mixture models).

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Statistics Research Group

Co-supervisors: Professor Andrew Heathcote, A/Prof Scott Brown, and Dr Ami Eidels,
School of Psychology

Statistical surveillance methods in climate and health
The field of health informatics, a discipline at the juncture of information science, computer science, and health care has experienced a tremendous growth in tandem with the development of new computational and e-technologies. This project will explore and develop spatial and temporal and also mixture statistical methods for surveillance studies, as applicable to topological climate maps, and to the surveillance of health, disease and injury. Data will be available from the School of Medicine and Public Health, the School of Health Sciences (Faculty of Health) and the WHO.

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Statistics Research Group

Co-supervisor: Dr Joanne Thandrayen
School of Mathematical & Physical Sciences

Modelling Trajectories: Longitudinal and Time Series methods

How can we best model trajectories incorporating exposures, interventions, treatments (or otherwise) to best represent progression, accounting for the inherent variability within and between subjects/patients? The aim of this project is to develop a suite of rigorous mathematical statistical and visual methods to model trajectories and allow for a significant reduction of multivariate, say, patient data, into a workable number of specific trajectories and to model these efficiently. This project will explore and develop the theoretical framework for such joint modelling of multivariate profiles over time. The methods will be tested and applied to some of the datasets, as listed below. These are based on NHMRC funded research - in collaboration with investigators at the University of Newcastle and the University of Adelaide.

The data sets pertain to 4 projects: [1] Control Laws for Reach-to-Grasp coordination in people with stroke (Professor Paulette Van Vliet, Priority Research Centre for Brain and Mental Health Research (CBMHR)); [2] Motor cortex facilitation during speech listening and quiet reading in children born preterm (A Prof Pitcher, the Robinson Institute, The University of Adelaide); and [3] Psychological treatment of co-morbidity and other trajectories, Professor Amanda Baker (CBMHR), Hunter Medical Research Institute (HMRI) and the CBMHR; [4] Patterns of optimal use of a web based weight loss program to maximise weight outcomes (Professor Claire Collins, Priority Research Centre in Physical Activity and Nutrition, University of Newcastle). You can choose at least one of the datasets, and as such this project offers scope for individual research and choice of areas of application (stroke research, neuro-physiological and/or psychometric research).

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Co-supervisors depending on the data used to test the theory:
- *Professor Van Vliet, Priority Research Centre for Brain & Mental Health (CBMHR);*
- *Professor Pitcher, the Robinson Institute, University of Adelaide;*
- *Professor A Baker, Hunter Medical Research Institute (HMRI), and the Faculty of Health, University of Newcastle;*
- *Professor C Collins, Priority Research Centre in Physical Activity and Nutrition*

Sleep Research: Fatigue modelling algorithms for railway drivers

Fatigue is a major contributor to deaths and injuries both on the road and in many workplaces. This research aims to create of new work-related fatigue models for the rail industry and has clear work, health and safety implications. This project involves the development of multivariate Bayesian mixture and other multivariate time series methods to classify railway drivers' sleep/duty/wake/break profiles. Methods and models will accommodate time series of highly disparate lengths across drivers, and of high dimension. This research is part of a CRC Rail Innovation Grant funded project, and a collaboration with the University of SA, Centre for Sleep Research.

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Statistics Research Group

Co-supervisor: Dr Darfiana Nur
School of Mathematical and Physical Sciences

Estimation methods for flexibly shaped statistical distributions
Investigating the process of estimation of the parameters of statistical distributions that can take on a wide variety of shapes contributes to our understanding of distributional shape. Such distributions are of particular interest to psychologists and physical environmental scientists. This project could either focus on analytical approaches, or be based on simulation studies of different methods.

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Statistics Research Group

Functional data analysis for spectra
Functional data analysis works on entire functions of the real line. This project will work on time-varying spectral data from physics and/or chemistry.

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Statistics Research Group

Image analysis for robot location
This project involves work with the University of Newcastle's robot soccer team, the NUBots. The robots find where they are on the field (localise) using information from the picture taken by the camera in their head. This project will work on improving the image analysis module.

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Statistics Research Group

Statistical Design for strategy assessment in robot soccer
This project involves work with the University of Newcastle's robot soccer team, the NUBots. The robot software is overseen by a “behaviour” module that decides what the robot should do. This project will design a series of tests for candidate strategies.

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Statistics Research Group

Socio-spatial statistics: Boundary effects
The spatial pattern of disadvantage shows different features at different geographic levels. This project will consider the role of geographic level, particularly the effects of different types of boundaries, and investigate social statistics of areas in the Hunter region. This project would ideally suit a student with a background in both statistics and geography.

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Statistics Research Group

Adaptive estimation in Threshold AR models
The Threshold Autoregressive (TAR) model is one class of nonlinear times series models that has been applied in many areas, from Finance to Ecology. The aim of the project is to explore the adaptive estimation of TAR models by weakening the assumption on the distribution of the errors. For example, if the error follows a t-distribution, then under some conditions, we should be able to obtain the efficient estimates as

when it was normally distributed. This project will include understanding the established theory in the literature, a bit of programming and their applications.

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Statistics Research Group

Markov models in DNA sequences modelling

Many genome sequences display heterogeneity in base composition in the form of segments with similar structure. Early evidence of segmental genomic structure was noticed early on that in the salivary glands of *Drosophila melanogaster* whereas the problem of statistically segmenting DNA sequence has a history about four decades. One approach describes DNA sequence structure by a hidden Markov model (HMM). This project focuses on the various change-point identification of a Bayesian hidden Markov model describing homogeneous segments of DNA sequences.

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Statistics Research Group

Psychosocial effects of Cancer

The death rate from colorectal cancer has declined in recent years due to improved screening methods and advances in treatment. Hence a growing population of people are living with a history of colon cancer. This project will assess the psychosocial outcomes of longer term survivors using structural equation modelling, a multivariate technique. Bayesian approaches will be implemented to account for some of the data characteristics (non-normality for example) within this modelling framework.

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Statistics Research Group

Bayesian inference - noninformative priors

An advantage of the Bayesian approach is the possible inclusion of prior information/knowledge. However, it is desirable, for the purpose of scientific communication and sensitivity analysis, always to base inference on “noninformative” priors also. The currently recommended methodology to obtain such priors is reference analysis, but our research indicates that this methodology is incomplete. When dealing with extreme data, reference priors can be shown to be too informative for the binomial and Poisson parameters, for example. Possible research topics include the identification of alternative criteria when reference analysis fails in this manner, and the study of appropriate noninformative priors in related applications such as logistic and Poisson regression.

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Statistics Research Group

School of Psychology

PSYCHOLOGY

Addressing smoking and other health risk behaviours for people with mental illness
Smoking and rates of other health risk behaviours are higher for people with a mental illness than for the general community, and morbidity and mortality associated with a range of chronic diseases are higher as a consequence. Collaborative, cross-disciplinary projects available may examine the 'determinants' of these inequities in health risk, including the role of health care providers, health care services and other 'system' factors, and also developing and trialing interventions to effect change.

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Clinical and Health Psychology Group

Changing 'SNAP' health risk behaviours (Smoking, Nutrition, Alcohol, Physical Activity) for population groups at risk
Effectively addressing the SNAP risk factors at a population level (or for high risk population sub-groups) provides the potential to substantively reduce rates of our most common and fatal chronic diseases - including cardiovascular disease, respiratory disease, diabetes and many cancers. Collaborative, cross-disciplinary projects available may explore the determinants of behaviour change for SNAP risk factors - including a consideration of individual, societal and systems influences - as well as developing and trialing interventions to effect change.

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Clinical and Health Psychology Group

i) Harm perception of cannabis versus other drug use among people with psychotic disorders.
ii) Role of Fear Appeals in changing health behaviour.
iii) 'What doesn't kill me will only make me stronger' is this stress-related growth?

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Clinical and Health Psychology Group

The relationship between confidence, accuracy and response time in recognition memory.
Recent research has been providing new insights into how people make decisions by studying the relationship between choices that are made, the time to make them and the confidence with which they are made. Some advocate that the time taken to reach a decision is predictive of the confidence one feels in the decision made. Others advocate that the relationship is not as straight forward, suggesting instead that sampling procedures, common to all people, mediate the association. Although there have been attempts to explore this relationship for perceptual and general knowledge choices no attention paid to decisions about memories. Experiments run in this project will explore the connections between speed, accuracy and confidence in recognition memory.

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Human Experimental and Applied Dynamics (HEAD) Group

A Modern Take on a Textbook Classic: Hick's Law
When people have to make decisions, they take longer if there are more alternatives to choose between. The slow-down is logarithmic with the number of choices, and this has been known as "Hick's Law" for more than 50 years. Despite being written about in every introductory textbook, there are no good theories for why Hick's Law arises. We will run some experiments and develop mathematical theories for the law.

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Human Experimental and Applied Dynamics (HEAD) Group

Fast, or Careful?
When making decisions, we are constantly faced with the need to trade speed for accuracy: we can make lots of decisions quickly, but with lots of errors; or we can make a few decisions slowly, but accurately. There are comprehensive mathematical theories for how this tradeoff occurs, and these theories have been well accepted by the scientific community for decades. However, some of the basic assumptions of those theories have never been tested – we will conduct experiments to find out which assumptions hold up to closer scrutiny.

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Human Experimental and Applied Dynamics (HEAD) Group

Human faces as evolved signalers
Human faces convey information about age, sex, health, fertility, etc. and movements of the face operate as complex social signals. Any project investigating people's sensitivity to these signals. I am particularly interested in non-verbal dynamic signalling in a variety of social contexts and in the evolution of attractiveness cues.

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Human Experimental and Applied Dynamics (HEAD) Group

Sex differences in spatial cognition
To what extent can we understand human sex differences in spatial memory and navigational ability in terms of the different evolutionary selection pressures faced by males and females in our ancestral past?

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Human Experimental and Applied Dynamics (HEAD) Group

Evolution of cognition: Spatial
How has the ability of nectar feeding birds to remember locations in their environment been shaped by the spatial and temporal distribution of their food?

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Human Experimental and Applied Dynamics (HEAD) Group

Avian visual cognition
Birds inhabit very different visual ecologies to land-based mammals and have fundamentally different brains. How has this impacted on the way in which they process movement and depth information and recogise objects?

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Human Experimental and Applied Dynamics (HEAD) Group

Familiarity effects on memory as a function of test type
The effect of the familiarity of to-be-remembered items (e.g., nonwords, words) on memory performance will be investigated using multiple memory paradigms (e.g., recall, recognition).

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Human Experimental and Applied Dynamics (HEAD) Group

Working memory, processing speed, and intelligence
This project will investigate the effect of training on working memory and processing speed tasks and examine how this relates to measures of intelligence.

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Human Experimental and Applied Dynamics (HEAD) Group

Human reasoning in familiar and unfamiliar situations
The aim of this project is to examine the processes that underlie human reasoning in familiar and unfamiliar situations.

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Neuroscience Group

Cognitive Psychology: Are human faces special?
People are extremely efficient in recognizing other peoples' faces. We can recognize a familiar face from distance, in dim light, and even if the face is partially occluded. Contemporary theories of face processing argue that faces are special because different facial features (eyes, nose, mouth) are combined together to create a 'holistic' experience. We shall test this assertion using the well-known Garner paradigm.

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Human Experimental and Applied Dynamics (HEAD) Group

Cognitive Psychology: 'Hot Hand' in computer games.
The 'Hot Hand' phenomenon in basketball (Kahneman & Tversky), or other sports, refers to one's ability to make a successful shot after a sequence of successful shots, compared to her or his chances of making the next shot after unsuccessful shot(s). Presumably, high confidence after a successful trial improves performance on subsequent trial(s). We shall test if the 'Hot Hand' phenomenon exists in computer games, and focus on whether or not gamers are willing to take higher risks after successful trials.

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Cognitive Psychology: Challenging the automaticity account of the Stroop phenomenon. In a Stroop task, participants are presented with colour names printed in colour and are asked to indicate the print colour, while ignoring the word. People are often slower in naming the colour of incongruent displays (such as the word GREEN printed in red) compared to naming the colour of congruent displays (RED printed in red). Presumably, this slowdown in performance (termed the Stroop effect) is due to the automatic nature of reading: when presented with words, people cannot ignore the words, which in turn slow them down on incongruent trials. We shall challenge this account and test whether is mandatory.

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i) Developing Test Items to Improve The Reliability of a Spatial Ability Test

ii) Relationship Between Spatial Understanding and 3D Design

iii) Improving Spatial Performance Using Online 3D Learning Tasks

iv) Identifying Practice Effect and its Impact on Learning in a Graphical Communication Environment

v) Investigating the Relationship Between Spatial Ability and General Academic Ability

vi) Exploring Factors of the Spatial Ability Construct

vii) Relevance of Response Time in the Measurement of Spatial Performance

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Auditory Temporal Processing
Sounds are dynamic in nature, containing rapid transitions in amplitude and frequency over time. These transients convey information crucial for accurate perception of speech, music and information essential for adaptive behaviour. This research program seeks to better understand the perceptual and neural basis of our extraordinary ability to hear these temporal characteristics of sound by examining the relationship between brain electrical responses (EEG/ERP methods) and perceptual (psychoacoustic/psychophysical methods) sensitivity to temporal variations in sound.

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Brain mechanisms in binaural hearing
One of the most remarkable features of auditory perception is our ability to very small detect differences in the timing of sound arriving at each ear. This sensitivity to the microsecond level of timing of sounds is an order of magnitude more precise than any other sensory modality and underlies our ability to localise sounds in space as well as to accurately perceive sounds in noisy environments. This research seeks to better understand the role of the auditory brain in the representation and analysis of binaural information using measures of brain electrical activity (EEG/ERP) and psychoacoustic methods.

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Neuroplasticity in somatosensory cortex
Previous EEG studies have shown that entrained neuroelectric activity of somatosensory cortex to prolonged or rapidly repeated tactile stimulation reflects activity of a synchronously active neural population. Recent research has shown that this response is not static, reflecting only the hardwired connections to the skin, but is modified progressively and is reversible over short periods of time (seconds to minutes). This suggests that this measure of EEG activity may provide an important index of brain plasticity with potential applications to clinical populations such as stroke.

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Tactile Sensitivity of the Hand
Evaluating the sensory motor function of patients following stroke provides the clinician with a means to measure and monitor recovery of function during post-stroke recovery and rehabilitation. Currently a sensory glove has been developed to measure responses to sensory stimulation of the fingers. We now wish to measure responses in normal controls in order to establish baseline data before testing the glove with stroke patients.

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Brain, behaviour and ecology in the Indian mynah (Ourimbah or Callaghan)
Why do some species have bigger brains than others? Do big brains confer greater intelligence? Do some environments select for greater intelligence? Indian mynahs, an exotic songbird and vocal mimic with a large relative brain size, exhibit problem-solving abilities that rival some of Australia's crow species, generally thought to represent the pinnacle of bird intelligence. This project will investigate the relationship between brain anatomy, cognitive performance, and ecology to explore the neural and ecological factors that support the evolution of complex cognition and intelligence.

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Exploring the minds of nonhumans: episodic memory in the Indian mynah (Ourimbah or Callaghan)
Exciting new advances in the study of nonhuman minds, notably in birds, have revealed the existence of complex cognitive abilities that extend well beyond those expected from basic associative learning mechanisms. These include capabilities like the ability to recall past events and to plan for future ones ('mental time travel'), to extract information from a given learning situation and apply it to novel situations, and to recall information about specific past events ('where, when, what (WWW) memory' also known as episodic memory). Building on these recent advances, this project will aim to test the existence of episodic memory in an exotic songbird and vocal mimic, the Indian mynah.

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Vocal and motor mimicry in the Indian mynah (Ourimbah or Callaghan)
The Indian mynah is an exotic species of songbird and vocal mimic, which means they can learn to imitate the vocalizations of other avian species, including humans. The mynah also has an outstanding ability to display novel innovative behaviour when foraging for food, and to learn from watching the behaviour of other mynahs in a group. This project will explore the relationship between the ability to learn from watching the behaviour of other mynahs and the ability to imitate sounds.

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Behavioural and physiological correlates of ecological invasion: resource use in the Indian mynah (Ourimbah or Callaghan)
Why do some species become highly successful ecological invaders, while other species go extinct? Various hypotheses have been tested using a literature-based large-scale species comparative approach, but rarely experimentally at an individual species level. Our research program uses the Indian mynah, a songbird and highly successful ecological invader, as a model system to identify which behaviours allow this avian species to expand faster than any other native Australian bird species. This project will study mynahs in the lab and in the field to identify which food resources are key to mynah success and which habitats are most suitable to mynah expansion.

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Environmental Biology & Biotechnology Group

A learning outlook to the fear and categorization of ethnic others
Intergroup anxiety (the anxiety experienced during anticipated or actual interactions with individuals of other ethnicity) and intergroup categorization (the act of mentally separating us from them along ethnic dividers) are powerful predictors of intergroup prejudice and discriminatory behaviour in society. The present project takes a systematic approach to explore the extent to which intergroup anxiety, as well as out-group categorization processes, can be modified through both direct experience of an aversive interaction with ethnic faces, and observation of another person's (the 'demonstrator') aversive experience. The student will work under the supervision of a researcher in learning and cognition (Dr Griffin) and a researcher in social psychology (Dr Paolini), both internationally recognized experts in their fields and learn to use state-of-the art technology to manipulate direct and observational aversive learning, assess ethnic categorization of human faces, and measure psychophysiological responses of arousal. This exciting new line of research has the potential to inform the design of individual-level treatments of anxiety and stereotype reduction, as well as group-level intervention programs aiming to reduce racial tension in society.

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Extinction and Habituation
Extinction and Habituation appeared to be extremely simple and distinct mechanisms. Habituation is one of the non-associative forms of learning and extinction necessitates associative learning to take place before it can occur. However, if we take a close look, the procedures that give rise to the two and the behavioural consequences of the two are identical: the animal stop responding to a given stimulus. Using pharmacological tools we will explore the underlying mechanism that give rise to these phenomena and see if they are indeed identical.

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Investigating why intergroup interactions can be detrimental to the relations between rival social groups *Area: Social stereotyping, prejudice, and discrimination*
Fifty years ago, Gordon Allport, an influential social psychologist, proposed that face-to-face interactions, or 'contact', between individuals of potentially rival groups may reduce prejudice, discrimination, and conflict and lead to more harmonious intergroup relations. Since then, this idea has inspired desegregation policies in Australia and around the world. Recent reviews of the intergroup contact literature have confirmed that positive contact with individuals of the 'other' group or 'outgroup' improves intergroup relations. This optimistic view of the future, however, is at odds with a sharp increase in intergroup conflict that our multicultural society is experiencing. In the proposed research, we aim to clarify why intergroup conflict continues to be a key social issue in Australia and abroad despite increased contact between social groups. In particular, we use a variety of social psychological research methods to address the following critical questions:

- Does negative (i.e., unpleasant) contact with outgroup members make people more aware of their respective group memberships than positive (i.e., pleasant) contact and does it have a greater impact on group attitudes?
- Why might negative intergroup contact have a disproportionate impact on intergroup relations?
- Are there conditions under which negative contact does *not* make people more aware of their group memberships and does *not* have a greater impact on group attitudes?

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i) Early life programming of heath and Disease
The research focus of the laboratory is the role of early life events in the programming of development. Over the past 15 years our laboratory has been addressing the impact of maternal and neonatal factors on fetal development and subsequent susceptibility to pathology in later life. Utilising a variety of animal and human models, we have been working towards providing a perinatal etiology for chronic pain, anxiety, schizophrenia, and irritable bowel syndrome. Whilst appearing diverse, these disorders all appear to have common links to infection in early life. We are also focusing on the possible epigenetic pathways that transmit such predispositions from one generation to the next non-genomically. We currently have projects available for PHDs in the following areas:

ii) Fetal origins of cancer
A relationship between early life infection and childhood leukaemia has been demonstrated. This project will investigate this proposal in an animal model of human breast cancer. We are also interested in exploring the relationship between smoking during pregnancy and cancer development in the offspring.

iii) Role of early life infection in schizophrenia and cognitive alterations in working memory
There is a long history relating viral exposure during pregnancy to the onset of schizophrenia in later life. This project is investigating the relationship between infection in early life and the development of schizophrenia and cognitive alterations in later life in an animal model.

iv) Role of early life infection on predisposition to psychopathology

Previously, we have demonstrated early life exposure to bacteria results in an increased propensity for adult onset anxiety using a rat model. This project will examine what transgenerational implications such a predisposition may hold. In other words could infection in early life induce anxiety in one generation that is then transmitted to subsequent generations.

v) Does the early life environment predispose to drug use in adulthood

In this project we are using an animal model to investigate the possibility that early life stress or early life exposure to cannabis can increase the likelihood of drug taking behaviour in adulthood.

vi) Developing new approaches to assist the brain recover from inflammation and inflammation induced damage

Inflammation within the brain (neuro-inflammation) can result from prolonged levels of psychological stress, depression, stroke or cardiovascular disease. Importantly, neuro-inflammation can produce significant changes in mood and cognitive function that make recovery from these conditions more difficult. The objective of this research project is to examine, at both the behavioural and biological levels, a variety of practical strategies to combat neuroinflammation. The ultimate objective of this work is to develop strategies that can be used clinically to improve recovery.

vii) Taming the brains immune system

Within the brain a specialized network of cells referred to as microglia protects the brain from insult. The function of this network, however, can be profoundly disrupted by many frequently encountered environmental challenges such as injury and infection. It has now been shown that disrupting microglial activities can make us feel fatigued, flat, and socially disengaged. The objective of this project is to examine pharmacological and behavioural strategies that may increase the resilience of the microglial network, with the objective of using these approaches to assist in the treatment of psychopathology.

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Handedness and Magnetic Resonance Spectroscopy

Measuring the MR spectra of cortical brain regions during activation of the motor areas has yielded differences between measures from dominant and non-dominant cerebral hemispheres. These measures were taken using the 1.5T scanner at the John Hunter Hospital. We now wish to replicate the study using the 3T scanner that will provide better differentiation of metabolic compounds in the spectra.

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i) Judging facial emotions - accuracy and discriminability of emotion expression

ii) Maturation in the Chicken – changes in EEG power during the first 6 weeks of life

iii) Mind control - EEG mu rhythm neurofeedback and control of dynamic visual displays

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Developmental trajectories of cognitive control
Executive control functions are amongst the last to mature – often not reaching peak function until early adulthood. Our research aims at defining maturational pathways of different aspects of cognitive control across childhood to early adulthood. We examine individual variability in developmental trajectories with a view to mapping specific patterns of executive function development to problem behaviours in childhood and adolescence.

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Structural and functional organisation of cognitive control processes
Our research program aims at understanding the cognitive and neural architecture of executive control processes. We use a range of paradigms that allow us to examine the role of voluntary mechanisms vs contextual factors that affect the way we control our intentions and actions. Our program integrates across mathematical models of behaviour and neuroimaging methods such as event-related potentials (ERP) and functional magnetic resonance imaging (fMRI) in order to develop integrative models of cognitive control.

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The role of control processes in cognitive decline in normal ageing and psychopathology
Executive dysfunction is associated with many clinical conditions and normal ageing. Our work aims to examine specific patterns of cognitive control decline in psychopathologies associated with frontal lobe dysfunction and develop cognitive remediation programs targeted to different clinical groups.

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i) Global spatial perceptual processes as cues in coherent motion perception

ii) Local temporal processes as cues in coherent motion perception

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Vision Science - Making Illusory Objects in Motion Seem Stationary
Attention normally improves and speeds performance on a wide variety of tasks. However, we have discovered an illusion in which attention interferes with our sense of motion. This project will study thisphenomena in human subjects.

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Vision Science - Mechanisms Underlying Myopia Inhibition
Myopia (short-sightedness) is a leading cause of blindness in Asia and the incidence has risen dramatically within one generation. It is caused by aberrant visual input during development. This project involves developing ways to inhibit the development of myopia using optical methods. We have developed a mammalian animal model of myopia in which eyes which wear spectacle lenses compensate for the imposed blur of the spectacles becoming long or short-sighted. This compensatory response happens in both humans and animal models, but in the animal models, we can dial up an exact refractive error within one week of specialised spectacle lens exposure; and then test the effect of various methods of inhibiting myopia development. This work has direct relevance to the treatment of human myopia. Suitable for any student who is enthusiastic about working with animals and is meticulous and caring in nature. No specific background is needed.

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Vision Science - Neuronal Plasticity in the Retina
For decades it was believed that adult neural systems were incapable of plasticity until several examples were discovered in the cortex. We have discovered new neuronal connections that are due to visual stimulation in the retina of the eye, which not only overturns the interpretation of how cortical plasticity might arise, but shows an amazing adaptability in this mini-neural system. This project will pinpoint the source, targets and causal neuronal factors underlying this plasticity using immunohistochemistry, pharmacology and optical experiments in young guinea pigs.

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Brain asymmetry in processing the time cues in sound
As we age, many individuals with intact audiograms (normal hearing sensitivity) will experience difficulty hearing speech in noisy environments. One hypothesis for why this occurs is that there is a decline in the ability to track important temporal/timing cue in the speech signal. We have demonstrated that persons with very good temporal processing ability show asymmetry in how the brain responds to these time cues. Persons with poor temporal processing do not show this asymmetry. Similarly, this asymmetry reverses in good temporal processors in noisy listening environments but again, no asymmetry is seen in poor temporal processors. Studies will be conducted to further explore this ability-related asymmetry using electrophysiological, psychophysical and/or neurocognitive measures and it's importance to groups with impaired temporal and speech processing abilities.

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Fixing faulty filters: The building blocks of psychosis
Antipsychotic medications are the principal treatment for schizophrenia. The primary action of most antipsychotic medications is to reduce levels of the chemical dopamine in a brain region called the striatum. The dopaminergic system is critical to our ability to engage in goal-directed activity, to learn and to process the relevance of events in relation to context. The primary functional consequence of the medication-induced change in dopamine is to correct a breakdown in the process by which salience or importance is attributed to events. Correcting salience-coding equates to fixing a "faulty filter" that influences whether events become candidates for the focus of our attention. Recent conceptualisations view abnormal dopamine levels as a secondary consequence of a primary problem in the glutamatergic chemical system. Glutamate is a chemical critical to the acquisition and expression of learning. Problems in glutamate and dopamine in striatal and prefrontal regions of the brain are considered central to core treatment-resistant cognitive deficits observed in schizophrenia.

This stream of research involves the development of protocols using measures of brain activity to test the cognitive processes, mental illness and the pharmacology of the systems associated with how the brain automatically filters relevance in the environment.

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Nicotine and Cognition in Schizophrenia

Whilst nicotine use is declining in the general population (25-30%), it remains very high in individuals with schizophrenia (70-90%). Two hypotheses put forward to explain the high rates of nicotine use in schizophrenia include a focus on self-medication and addiction vulnerability. We are conducting studies to further explore some of the unique effects of nicotine on cognitive abilities in this group.

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Disclaimer

All information is correct as at August 2011, but is subject to change as the content is reviewed and updated. Refer to the Faculty of Science and Information Technology web site for the latest research topics available:

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