2020 Discipline of Chemistry (MLS)

Honours Research Projects Booklet

October 24th 2019
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Welcome To Chemistry Honours

1.1 Chemistry Honours Enrolment

By University Rules, students must have completed a BSc and have a year weighted average in third year of 65% or more to be eligible for Honours. Hence you do need to graduate!! Follow the process described at: http://graduations.curtin.edu.au/graduate/how.cfm.

All eligible Honours students will be admitted to the one year BSc Honours course, BH-SCNCE, majoring in chemistry. Students will enrol in Chemistry Honours Dissertation (CHEM4000, Full Year, 150 credits), Advanced Topics in Chemical Analysis and Spectroscopy (CHEM4002, Trimester 1, 25 credits), and Advanced Topics in Chemistry (CHEM4001, Trimester 1, 25 credits). If you would like to be considered for Chemistry Honours admission please apply here: http://courses.curtin.edu.au/course_overview/undergraduate/science-honours. The Student Services Office will contact the Honours Coordinator for approval of eligibility once the exam results have been confirmed, and then the enrolment process will be initiated. Feel free to contact the Honours Coordinator, or the Student Services Office, if you are concerned about your enrolment.

1.2 Advanced Topics in Chemistry - CHEM4001

Advanced topics in chemistry will be studied to illustrate how fundamental aspects of chemistry underpin the cutting edge of knowledge and research in a wide range of scientific disciplines and applications. Methods that can be used to communicate advanced chemical concepts will be discussed and implemented.
Tuition pattern (weekly): 2 hours lecture + 2 hours workshop.
Assessment: Mid-semester exam, Final exam, oral exam.

1.3 Advanced Topics in Chemical Analysis and Spectroscopy - CHEM4002

This unit will impart skills in independent manipulation of techniques in chemical synthesis, analysis, and computation. Students will solve a problem, first using practical techniques of relevance to the task, and then interpreting the outcome using computational techniques. To achieve these goals, students will be inducted into research laboratory practices by applying electronic note keeping and appropriate occupational health and
safety procedures.
Tuition pattern: 1 hour seminar weekly, 5x6 hours chemistry lab (over 2 weeks), 4x2 hours computer lab (over 4 weeks).
Assessment: assignment, oral exam, final report/lab book.

1.4 Chemistry Honours Dissertation - CHEM4000

Students will be required to conduct an independent research project in the chemical sciences under the guidance of a supervisor, resulting in the preparation, submission, presentation and defence of a dissertation. Students will develop research, technical and professional and communication skills, research autonomy and specialised knowledge through a process of inquiry involving the formulation of research questions and hypotheses; selection of appropriate methodology and experimental design; ethical consideration of the research process; critical review of scientific literature; effective scientific writing; development of a project proposal, and the preparation of a dissertation.
Assessment: two oral presentations, seminars reflections, draft report, final report, viva.

1.5 Honours Timeline

The lab work for CHEM400 can be undertaken only during the green portion of the bar. The first 4 weeks, which overlap with the CHEM4001 and CHEM4002 units can be used for Literature Review, Risk assessment and other preparatory work, which do not require access to the labs. The last two weeks (grey band) will be devoted to the preparation for the viva voce examination.
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Dr Mark Hackett
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Phone: 9266 3102
E-mail:
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CHEM4000 Projects

2.1 Chemistry Honours Projects Allocation

Students should review the list of available Honours projects in this Honours Project Booklet and meet with potential supervisors to discuss the projects on offer, in order to choose their project preferences. Contact details for all Curtin supervisors are provided to assist you in this process. All students are requested to provide five project preferences (in order) to the Honours Coordinator by 30th November 2019. Only one project from a particular supervisor may appear in your list of project preferences (i.e. your list of project preferences should include projects from 5 different supervisors). Project allocations will be confirmed as soon as possible, after eligibility can be confirmed. Please provide an email address through which you can be contacted. Allocation of projects will take into account a number of factors, including student merit, student preferences and interests, as well as allocation of students across available supervisors and workload of supervisors. Select your project preferences carefully, keep an open mind and consult as widely as possible. Please note that late submissions and/or incomplete submissions will result in the student being allocated to remaining projects after everyone else has been allocated, irrespectively of the listed preferences.

2.2 Choice of Project

The Chemical Research Methods 3006 Project Booklet has given you specific information about the choice of research projects for your Chemical Research Methods 3006 unit and your Honours year. This information is provided again here: Please note that any Honours project undertaken is required to be substantially different to your Chemical Research Methods 3006 project (and any summer work that you might undertake). When the time comes, you must ensure that any potential overlap is discussed with your Honours supervisor. To assist the Honours Panel to assess the Honours project appropriately, if there is overlap or potential overlap, your Chemical Research Methods 3006 report will need to be submitted with your Honours Thesis. This is designed to ensure that there is a level playing field for all Honours candidates. Please note it is YOUR responsibility (through appropriate discussion with potential supervisor/s) to ensure that your Chemical Research Methods 3006 project and your Honours project are sufficiently different, or that any overlap is brought to the attention of the Honours Coordinator so that it can be managed appropriately.
2.3 Honours Projects Available in 2020

This Honours Project Booklet describes the research projects in the Department of Chemistry, listed under the name of the primary Curtin supervisor, which are available to students enrolling for Honours in 2020. If you have any questions about this process, please contact the Honours co-ordinator.

After you have reviewed the available projects and discussed with the potential supervisor what are the requirements and what is expected from you during the project, please submit your preferences to the honours coordinator by 30th November. Please ensure that projects from 6 different primary Curtin supervisors are listed. You can provide the information by using this form, or type ALL the information into an email.

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Background – *Making molecular measurements that matter*
Our research is focused on analytical chemistry and its applications based on electrochemical processes, either at liquid-liquid interfaces or at solid electrodes. These methods open up new ways to solve (bio)chemical measurement problems in industry, environment or health. These projects will provide valuable experience in modern analytical chemistry and sensor technology, and each project will be tailored to the interests of each student.

**DA1: Sensors for sulfate**
Water recycling is a reality in Perth, and new sensors will help with efficient management of these processes. Sulfate concentration is used as an indicator of process performance, but lab-based analytical methods are cumbersome, expensive and insensitive. To solve this chemical measurement problem, we are developing new sensors for sulfate detection in collaboration with Water Corporation, University of Sydney and University of Murcia. In this project, you will explore the performance of sensors that combine electrochemistry with supramolecular chemistry to achieve sensitive and selective detection of sulfate. Suitable for both Honours and MRes in Chemistry, and MSc in Water Quality & Treatment.

**DA2: Sensors for PFAS**
Per- and poly-fluoroalkyl substances (PFAS) have emerged in recent years as environmental contaminants of great concern due to their persistence and accumulation in the environment. Contamination of soils and groundwaters from use of PFAS materials in fire-fighting foams has resulted in efforts to clean-up such sites. However, lab-based analyses remain the key measurements of contamination and clean-up effectiveness. By using electrochemistry at liquid-liquid interfaces, we have recently been able to detect perfluorooctanesulfonic acid (PFOS) at concentrations lower than 100 picomolar, which suggests that electrochemistry might be a suitable basis for realtime chemical sensing of PFOS and related PFAS materials. This project aims to explore that opportunity and to achieve a chemical sensor that can be used in the field without the need for sample analysis at a central laboratory. Suitable for both Honours and MRes in Chemistry.

**DA3: Biosensors *wildcard* - food and water quality or safety**
Do know a problem in need of a new (bio)chemical measurement approach? Do you have some thoughts on (bio)chemical sensing that could be developed and used to solve that problem? If yes, talk to me about it and let’s see if we can devise a project that will help you to solve the problem. Suitable for MSc in Water Quality & Treatment and MSc Food Science and Technology.
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Background
Many of the phenomena we see in everyday life and many of the research tools behind the nanotechnology revolution involve interfaces and electrons crossing those interfaces. Our research focuses on the design of experimental surface model systems that are modified with molecular level precision. The ultimate goal is to gain control of chemical reactivity at interfaces for fundamental (e.g. electron transfer studies) and applied research (e.g. heterogeneous catalysis). Students are encouraged to discuss specific projects of interest with Simone.

SC1: many electrodes – one wire. Electrochemistry requires each electrode to be connected to the external circuit by a wire. With many electrodes this means many wires. Wires limit electrode density in arrays and dictate the electrode architecture must be predetermined.
The aim of this project is to remove the need for a wire for each electrode by using light to sequentially connect each electrode to a single wire. This will be achieved using chemically modified silicon electrodes and photo-electrochemical control of reaction kinetics. The research will explore the variables that influence the spatial resolution and apply the ideas to making soft connects for nanoelectronics on semiconducting crystals.

SC2: Smart reagent of the future: Chemical bonding and static electricity (with Dr. Nadim Darwish). Electrostatic catalysis is the least developed form of chemical catalysis. A wealth of knowledge exist on the role of high oscillating fields (i.e. light) on chemical bonding, but virtually nothing is known (experimentally) on the scope of static fields in chemistry. We have just recently shown experimentally how a Diels-Alder reaction can be catalysed by oriented-external-electric-fields. Achieving further insight across chemistry will involve selection of specific chemical problems and application of the knowledge to a scalable system. This Hon project research seeks to investigate a green fluidic technology (vortex fluidic device, in figure) to harness the power of static charging to activate chemical reactions of organic dyes.
Discipline of Chemistry (MLS) – Honours Projects 2020

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Single-molecule Sensors

Background
Single-Molecule Electronics research combines chemistry and electronics for the aim of developing devices from single molecules. In this project, you will learn nanotechnology, electrochemistry and surface science approaches including scanning probe microscopy where you will be able to image and manipulate materials at the scale of single molecules or even individual atoms.

Project Areas

NDSC1: Single Molecule Reactions

Studying chemical reactions at the single-molecule level became a reality thanks to the advancement in nanotechnology. Scanning tunnelling microscopy single-molecule junctions approach is a powerful technique available for aligning and bringing together single molecule reactants between nanoscale electrodes. It has recently provided significant data\textsuperscript{1,2} on the variation of reaction rates and equilibria in response to external stimuli. In this project, scanning tunnelling microscopy junction approaches\textsuperscript{1,2} will be used to test a range of chemical reactions at the single-molecule level. This project has important implications as portable sensors with sensitivity that far exceeds any current sensing technology.

NDSC2: Silicon-Based Single-Molecule Circuits: The ultimate goal in molecular electronics is to use individual molecules as the robust electronic component of a real-world device. For this concept to become reality it will require the field of single molecule electronics to utilize electrode materials that are technologically relevant in the current microelectronics industry such as silicon electrodes.\textsuperscript{3} We have recently developed new methods of wiring molecules onto flat H-terminated silicon-(111) electrodes. This project aims to fabricate single-molecule contacts that mimics solid-state electronics such as diodes, resistors and transistors. This will be achieved using a modified conducting atomic force microscopy, scanning tunneling microscopy junction and mechanically controlled break junction approaches.

References

Background
My research interests are reconstructing past ecosystems and environmental changes from climate variability, molecular fossils & their individual stable C, H, S & N isotopic compositions preserved in the geological record. Some of these events are associated with mass extinction & evolution/ recovery of life (e.g. Grice et al., 2005; Tulipani et al., 2014). In addition, I am interested in studying microbial & fungal ecology, algal communities, plant physiology (including biochemical pathways) in modern environments, biogeochemical cycles (C, H, S & N) including applications of organic & stable isotope geochemistry to natural resources (petroleum & mineral geochemistry) and impacts on the environment & climate.

KG1: What is the makeup of an ancient bryophyte?
The Early Palaeozoic marks a significant period in Earth’s history due to the arrival and expansion of life on land. Plant fossil data shows that vascular plants first appeared in the Late Silurian and by Devonian times had expanded quickly (e.g. Grice et al., 2009; Tulipani et al., 2015; Spaak et al., 2017). However non-vascular plants (bryophytes, Figure) preceding vascular plants are hardly ever preserved as body fossils and the bryophyte microfossil record in the lowermost Palaeozoic is limited. This record thus limits our understanding of life in earliest non-marine environments and the foundation of land plants.

In contrast to microfossils, molecular fossils (biomarkers) are ubiquitous in sedimentary material and have a higher preservation potential, thus providing an important tool to track terrestrial signals when microfossils are absent. Long chain n-alkanes have been used widely applied to in modern and ancient settings to recognise terrestrial contributions to organic matter. By investigating modern bryophytes and sediments (that are thought to contain molecular remains of bryophytes) will be undertaken. The project will involve detailed state-of-the art isotopic, geochemical, analytical and select imaging techniques of modern bryophytes. A novel molecular and isotopic approach of bryophytes can provide a more complete record of early land plants, and also to understand their early evolution.

KG2: Molecules of life in fossilized cells- oldest fluorescing molecules
Concretions are often preserved in sediments and can contain encapsulated fossil remains (e.g., bones, plants and insects). Concretions formed under highly reduced conditions allow for exceptional preservation of soft tissue, cells and biomolecules (e.g., sterols and proteins) (Melendez et al., 2013a, 2013b; Plet et al., 2017). Concretions therefore represent molecular time capsules that may contain evidence of species that evolved or became extinct. With access to concretions from various worldwide locations (e.g., Lower Jurassic Posidonia Shale, NW Germany; The Devonian Gogo Formation, Western Australia; Carboniferous, Mazon Creek, US; and the Cretaceous Santana Formation, Brazil) spanning many geological intervals; the project will involve detailed state-of-the art isotopic, geochemical, analytical, mineralogical and imaging techniques of a unique fossil (horseshoe crab) inside a concretion from a unique geological setting. The intact fluorescing molecules entombed in the concretion will be extracted and analysed from the cuticle layer of the crab and will provide important paleoenvironmental information on the lipid preservation in the horseshoe crab.
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Background
Research in my group is largely based around the rational design and synthesis of small organic molecules to combat infectious diseases and inflammatory disorders. We utilise modern synthetic medicinal chemistry techniques to create novel molecules with unique modes of action that effectively target the infectious agents of interest. The current disease focus is on tuberculosis with collaboration partners in the Center for Tuberculosis Research, Johns Hopkins University, USA. We are also expanding our medicinal chemistry capabilities to synthetic cannabimimetics, aiming for potent and selective cannabinoid type 2 (CB2) receptor agonists as well as brain-penetrant kinase inhibitors. Both projects offered below will be done in collaboration with Dr Alan Payne and A/Prof Mauro Mocerino.

HG1: Molecular Interventions for Tuberculosis
Mycolic acids are integral constituents of the unique, thick lipid-rich cell wall of Mycobacterium tuberculosis (M.tb). The project aims to develop small molecules capable of inhibiting the transport of essential mycolic acid across the cell wall of M.tb. Our group discovered the indoleamides as a novel chemical entity from high throughput screening and elucidated its mechanism of action via whole genome sequencing, namely via inhibition of Mycobacterial membrane protein large 3; MmpL3 [1]. More recently, we are also working on small molecule inhibitors of Pks13, another crucial enzyme involved in the biosynthesis of mycolic acids [2].

HG2: Developing Brain-Penetrant PLK4 Inhibitors
Our group has previously shown that small molecule inhibitors of Polo-like Kinase 4 (PLK4) could be a useful therapeutic option for pediatric brain tumours [3]. This project aims to further extend our preliminary SAR data on the most promising scaffolds, namely the benzofuran-3-yl-(indol-3-yl)maleimides and 3-substituted indazoles. Final compounds will be tested for their in vitro efficacies in collaboration with Ann & Robert H. Lurie Children’s Hospital of Chicago, USA.

Background
Brain disease is a major global health and economic crisis. For example, Alzheimer’s disease cost the Australian government $4.9 billion per year. The development and application of novel biochemical imaging tools may help elucidate the biochemical pathways of brain damage during brain disease, which will allow the development of improved patient therapies.

My research interest is the development and optimization of novel elemental and bio-molecular imaging techniques, which can be routinely applied to the field of neuroscience to study the mechanisms of brain disease. The spectroscopic techniques involved in my research program include Fourier transform infrared spectroscopic imaging (FTIRI), Raman spectroscopic imaging, X-ray fluorescence imaging (XFI) and X-ray absorption spectroscopy (XAS). These techniques can be used to image: lipid and protein oxidation products (FTIRI and Raman); biochemical markers of altered metabolism (FTIRI); hemoglobin oxygenation (Raman); elemental distribution (XFI); transition metal oxidation state (XAS); sulfur oxidation state (XAS).

As a student in my group you will gain a fundamental understanding of applied spectroscopic analysis of biological systems, and excellent technical training on operation of state-of-art spectroscopy instruments and data analysis.

Honours Projects
MJH1 “Lipids and Brain Disease” (with Associate Professor Ryu Takechi and Professor John Mamo, CHIRI): My research group has recently identified biomarkers of altered lipid homeostasis during accelerated ageing, which may contribute to dementia in the elderly. Using several spectroscopic modalities (FTIR, Raman, UV-VIS), this project will extend from the preliminary data, and characterise spectroscopic bio-markers of lipid oxidation, in order to monitor the role of lipids, lipid metabolites and lipid oxidation products in brain disease. This project has scope to be performed in collaboration with the Curtin Health Innovation Research Institute, and would be very well suited to an aspiring chemist with interests in the biological or health sciences.

MJH2 “From Brains to Plants”: Although my primary research interests concern the application of spectroscopic techniques to study the biochemistry of brain disease, the techniques are well suited to investigate chemical biology across a range of systems. This year, my lab commenced studies of leaf surface chemistry, using FTIR and Raman microscopy to characterize the composition of chemicals secreted onto leaf surfaces and to characterize their distribution. Initial results suggest the chemical composition on the leaf surface may provide unique insight to state of health of the plant. This project will aim to extend from the initial investigations and explore the potential of FTIR and Raman spectroscopy for “real-world” applications to monitor plant health, and detect novel natural products.
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Background
My research focuses on the synthesis, assembly and properties of colloidal semiconductor nanocrystals (also called quantum dots), with the particular emphasis on their size, shape, and composition dependent optical and electronic properties. The size-dependent band gap and large surface-to-volume ratio of semiconductor nanocrystals make them have many desirable characteristics that are not processed by their bulk counterparts. Semiconductor nanocrystals find many stimulating applications such as solid-state lighting, bio-imaging and bio-labeling, solar cells, photocatalysis, sensors and nano-transistors.

Honours Projects
GJ1: Atomically thick two-dimensional (2D) metal chalcogenide nanosheets for photocatalysis and optoelectronic devices

Atomically thick 2D metal chalcogenide nanosheets, like grapheme, are important materials and find many applications. This project will focus on the synthesis and optical and electronic properties of atomically thick 2D metal chalcogenide (such as Cu$_2$S, Sb$_2$S$_3$, Bi$_2$S$_3$, Bi$_2$Se$_3$) nanosheets. Our aims of this project are to develop general synthetic routes for atomically thick 2D metal chalcogenide nanosheets, elucidate their growth mechanism and find their applications in photocatalysis and optoelectronic devices.
Background
My research interests are focused on water chemistry, e.g. drinking water quality and treatment and wastewater treatment for the purposes of water recycling, and environmental chemistry.

CJ1: Slow Release of Volatile Organic Compounds as Blowfly Attractants (with A/Prof Anna Heitz and Dr Ina Kristiana (Curtin Chemistry), Nigel West (ChemCentre) and David Cook (WA Govt Dept Primary Industries and Regional Development (DPIRD))
With the decline in bee numbers, other mechanisms to pollinate flowers are being investigated. One example is to use blowflies to transfer pollen. Blowflies are attracted by the smell of decaying meat, hence there is a requirement to attract blowflies with volatile organic compounds (VOCs), such as dimethyltrisulfide and dimethyldisulfide, released from decaying meat. Animal carcasses have successfully been placed in orchards to attract blowflies, however this is not reproducible or safe. In this project, you will undertake research in collaboration with the ChemCentre and DPIRD to investigate a simple slow release blowfly attractant system based on a pressurized cylinder containing the VOC. You will develop your skills in analytical chemistry (e.g. GC-MS analysis and sampling techniques) and in environmental chemistry, including the possibility of field trials of the technology.

CJ2: Developing a New Value-Added Product from Biosolids: Fate of Contaminants (with A/Prof Anna Heitz and Dr Yolanta Gruchlik (Curtin Chemistry), Dr Deb Pritchard (Curtin Agriculture), Michael Hebbard (Trinity Energy))
Transforming wastewater sludge biosolids into value-added fertiliser products using thermal drying represents a new method for water utilities to reduce biosolids volumes by 80%, recycle nutrients (e.g. N, P) back into the environment and secure long-term disposal pathways. However, there is also the potential for contaminants to be released into the environment from any biosolids product. In this project, you will study the fate of nutrients and contaminants in thermally dried biosolids during simulated land application. Thermally dried biosolids will be provided by industry partner Trinity Energy. The dried biosolids will be analysed for heavy metals, nitrogen, phosphorus and poly- and per-fluoroalkyl substances (PFAS) content. Laboratory column studies will be conducted to examine the leachability of nutrients and contaminants in the biosolids, simulating leaching during land application of these products.

CJ3: The Evolution of Drinking Water Treatment in WA: Effect on Disinfection By-Products (with Dr Yolanta Gruchlik and Dr Ina Kristiana (Curtin Chemistry); WA Water Corporation)
Disinfection of drinking water is essential for public health protection, however, unintended chemical disinfection by-products (DBPs) are produced during drinking water treatment via reactions between the disinfectant (e.g. chlorine) and natural organic matter (NOM) and/or bromide which is naturally occurring in some source waters. More than 600 DBPs have been identified in drinking water, and many of them are potentially mutagenic or carcinogenic. Climate change in WA has led to an evolution in drinking water supplies and treatment technologies. In this project, you will investigate the effect of some of these changes on the formation of DBPs. Using sample preconcentration equipment, GC-MS instrumentation and a state-of-the-art halogen-specific total organic halogen analyser, your project will contribute to a better understanding of DBPs currently formed in WA distribution systems.
Background
Crystallization is an important field both from a fundamental and an applied perspective. One aspect in particular that permeates my research is the role of impurities on the crystallization of inorganic and organic species. These projects have broad applications to real life; from understanding how crystals grow in nature to how they grow inside humans! All projects will involve learning a variety of techniques (e.g. Infrared, Raman, AFM, batch morphology experiments, analytical techniques) and developing your problem solving skills. Projects can be somewhat adjusted to suit a particular interest.

**FJ1: New additives for scale inhibition of barium sulfate (collaborators include: Mark Ogden, Peter Roth, George Shimazu, Tom Becker)**
This project is about understanding the role of inhibitors and their impact on crystallization modification. Various additives (small molecules and polymers) will be used to determine the impact on barium sulfate crystallization and the mechanism of interaction through small batch crystallization methods including DLS and conductivity but may move onto more sophisticated methods such as AFM and infrared.

**FJ2: Phosphate nanosolids and their links to cartilage damage (collaborators include: Boris Mizaikoff)**
Calcium phosphate solids have a wide chemistry and are widely formed in humans (teeth and bone for example). Many people with joint pain can be treated with anti-inflammatory medication. The question arises, however, what causes the inflammation? Is the degradation of the cartilage to blame or is there something else going on?

**Other possible projects include:**

i) High resolution AFM investigation of barium sulfate in water and in the presence of small impurities to determine water structure on inorganic solids

ii) oriented attachment mechanisms at high ionic strength
Background
My research interests are focused upon analytical chemistry techniques applied to forensic science, with a particular focus on exchange evidence. Areas of specific interest include: the characterization and interpretation of chemical trace evidence, latent finger mark chemistry and the detection of latent finger marks. Projects in the areas below can be tailored to meet the interests of students.

SWL1: Detection of latent fingermarks (with Dr Georgina Sauzier and Prof Bill van Bronswijk)
Successful development of latent fingermarks relies heavily upon the chemistry of the latent finger mark residue and of the substrate upon which the mark is deposited. Research at Curtin has in recent years investigated a range of approaches to the detection of latent fingermarks on a range of surfaces including gold nanoparticles\(^1\) and near infrared luminescent pigments\(^2\). We have also been investigating the fundamental chemical and physical properties of latent fingermark residue\(^3\,^4\). This research will be carried out with input from the Western Australia Police Forensic Division.

SWL2: Analysis and interpretation of chemical trace evidence (with Dr Georgina Sauzier and Prof Bill van Bronswijk)
There is an increasing demand for scientifically rigorous approaches to the analysis and interpretation of forensic evidence. Over the last few years our group has been collaborating with ChemCentre, the forensic chemistry service provider in Western Australia, on a range of projects relating to the analysis and interpretation of physical evidence. This has included automotive paint\(^5\), explosives\(^6\) and most recently soil\(^7\). Many of these projects have made use of chemometrics, which can ensure quantitative, objective measures of a dataset are obtained; thereby improving reliability, reproducibility and discrimination of the data, whilst simultaneously addressing issues concerning observer bias and other sources of human error in forensic examinations. This project will be carried out in close collaboration with ChemCentre.

Background
We are a synthetic polymer group with interests spanning radical and metal-mediated controlled polymerizations such as reversible addition fragmentation-chain transfer (RAFT) polymerization and Rh-mediated insertion processes, stimulus responsive (‘smart’) polymers, and polymer-related ‘click’ chemistries.

AL1: Synthesis of Star Polymers via Controlled Rh-mediated Insertion Polymerization
We have recently been actively involved in the development of new Rh complexes for the controlled polymerization of phenylacetylenes – a rather unique class of conjugated (conducting) polymer. Building on our recent work[1-3] this project will explore the synthesis of novel star polymers (more accurately nanogels) employing recently developed Rh(I) catalysts, see Scheme. The project predominantly involves polymer synthesis and characterization and will involve training in handling air-sensitive compounds, multinuclear NMR spectroscopy and size exclusion chromatography.

AL2: Tetrazole: A Carboxylic Acid Bioisostere and the Synthesis of Polymeric Protein Mimics (Lowe & Massi)
Tetrazoles are nitrogen-based heterocycles with many interesting properties. However, the tetrazole functional group is largely unexplored in synthetic polymer chemistry despite its properties and potential applications of molecules containing such functionality. One particularly important feature of tetrazoles is their ability to serve as chemical mimics of carboxylic acids. In the field of medicinal chemistry such functional groups are referred to as bioisosteres. This project will focus on the synthesis of a new family of protein-mimetic polymers known as polyampholytes,[4-6] see Scheme; these are polymers that contain, or potentially contain, anionic and cationic charge with the former most commonly being a carboxylic acid. This project will prepare and characterize a new family of such materials based on all-nitrogen building blocks in which the carboxylic acid functionality is replaced with a tetrazole.

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Background
My research in biophysical chemistry uses computational and biophysical methods such as molecular dynamics simulation, molecular modelling, structural bioinformatics, X-ray scattering, surface plasmon resonance and thermometric methods. We investigate biomolecular structure, function and interactions, such as protein folding and aggregation, cell membrane stability, the self-assembly of macromolecular complexes, drug-protein / protein-protein / protein-DNA interactions, drug delivery across membranes, and molecular forces in aqueous systems.

Honours Projects

**RM1: How do electrochemical nanobiosensors detect proteins? (with Prof. D. Arrigan)**
The mechanism of protein adsorption and ion transfer at organic-water interfaces remains largely unknown. Molecular dynamics simulations will be used to look at the way proteins interact at organic-water liquid interfaces in the presence of an electric field, their partial unfolding and aggregation that occur during this process, as well as the ability of hydrophobic anions to interact with these proteins and be transferred at different pH. Understanding these processes will be useful for the optimisation of protein detection in electrochemical nanobiosensors for the diagnosis and tracking of therapeutic approaches.

**RM2: Are diabetes and Alzheimer’s disease linked? Biophysical studies of the aggregation of amyloidogenic proteins.**
Type-2 diabetes (T2D) increases the risk of Alzheimer’s disease (AD). The molecular mechanism responsible remains unknown but is probably mediated by the accumulation and cross-aggregation of amyloid beta (Aβ) and amylin (normally found in the pancreas) in the brain. This project will use surface plasmon resonance, isothermal titration calorimetry and/or molecular dynamics simulations to measure the kinetics and affinity of binding of Aβ and amylin, as well as their interactions as pre-formed oligomers with model cell membranes. The outcomes will shed light into the cross-seeding mechanism behind the synergistic interaction of these two proteins, which could be targeted with anti-aggregation drug molecules to minimize neuronal cell death.

**RM3: Origins of life: how did simple biomolecules stabilize early proto-cell membranes?**
Primordial cells are believed to have combined primitive nucleic acids (most likely RNAs) that acted as catalysts and carriers of genetic information, within a protective membrane made up of amphiphilic molecules. The aggregation of simple amphiphiles like fatty acids leads to the spontaneous formation of vesicles. Recent experiments show that some nucleic acid bases and sugars can stabilize such vesicles against the deleterious effects of high salt concentration that likely existed on Earth 4 billion years ago. This project will use molecular dynamics simulations to study the self-assembly of lipid vesicles made of simple fatty acids with simple sugar molecules and nucleic acid bases. Changes in the stability of these vesicles will show how simple organic molecules were selected by chemical evolution to stabilize these precursors to proto-cells on early Earth.
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Background
The research in our group is centred on the design, synthesis and application of luminescent organic molecules and metal complexes, with an emphasis of assessing them as tools for diagnostic imaging and potential new therapeutic agents. Projects encompass a mixture of synthetic chemistry, photophysical characterisation and application of the prepared compounds in the fields of life science.

MxM1: Discovering new molecular tools for imaging the neurochemistry of brain disease (with Dr Mark Hackett)
There is currently substantial research effort being directed to identify the chemical pathways through which neurodegeneration and neurological disorders manifest and progress. Understanding the neurochemical pathways of brain disease will then help drive rationale therapy development, which could have substantial human health and economic benefits. State-of-the-art microscopy techniques allow imaging of cells and tissue with subcellular resolution. This project will focus on synthesising and testing new luminescent molecules, such as those shown in the figure, that can be exploited for the imaging of brain tissue. The research will be multidisciplinary at the boundary of synthetic chemistry and life science.

MxM2: The molecular approach to discover biochemical processes in live cells
The direct optical visualisation of lipids and lipid trafficking in live cells is challenging due to the drawbacks associated to the currently available markers for lipids. In our studies, we have discovered some unusual molecular species containing metals such as rhenium and iridium that are not only able to localise with polar lipids in cells, but they are also able to track their “movement” between cell compartments. These new tools are proving very valuable to develop new molecular probes and associated protocols for various diseases, and to directly investigate their biochemical progress in cells. In this project, you will design, synthesis and investigate new luminescent species for the study of biological processes and the diagnosis of various pathologies including cancers.

MxM3: The molecular approach to discover biochemical processes in live cells
The scientific community is currently struggling to keep up with the pace at which bacterial infections are evading antibiotics through the development of multidrug resistance. We have recently discovered a Pt complex (shown in the figure) that displays antibacterial and antifungal properties while showing low toxicity to mammalian cells. By synthesising analogous species, this project will seek to investigate whether the structural features of this compound can assist in the discovery of new antibiotics.
Background
My research can be classified into two general areas, synthetic chemistry and chemical education. The synthetic chemistry focuses on the design and synthesis of molecules for specific intermolecular interactions including drug-protein interactions, chiral recognition and corrosion inhibition. My chemical education research focuses on improving our understanding of how students learn and what can be done to improve the learning.

**MM1: Synthesis of potential biologically active agents.**
There are a number of options here that can be tailored to the student's interests. Only one example is given here. Human African Trypanosomiasis (HAT), a disease caused by the parasite *Trypanosoma brucei*, is a neglected tropical disease and without treatment is always fatal. Phenylephrine derivative (1) has inhibitory activity against the parasite when substituted at the phenolic position.\(^1,2\) The project will explore further analogues of (1) to develop a structure activity relationship and assess their potential to be developed into an effective drug.

![Chemical structure of (1)](image1)

**MM2: Synthesis and application of functionalised calixarenes and resorcinarenes**
Only two examples are provided here, others are available. 1. We have developed a practical synthesis of chiral C\(_4\) symmetric resorcin[4]arene baskets [eg (2)] for the transport and enantio-resolution of racemic drugs.\(^3\) This project will extend the synthesis and application of these chiral resorcinarene derivatives and investigate their transport properties. 2. Novel corrosion inhibitors (with K. Lepkova and T. Becker). Acid functionalised calixarenes have been shown to provide excellent inhibition to general CO\(_2\) corrosion.\(^4\) This project will investigate the synthesis of a series of derivatives and determine their utility as corrosion inhibitors, particularly CO\(_2\) corrosion.

**MM3: Enhancing learning in the laboratory (with Alex Yeung)**
Laboratory classes are a key aspect of science courses, with a great potential to contribute to student learning. However, this potential is rarely fully realised. This project will explore and evaluate strategies to enhance the conceptual engagement of students in their laboratory classes.

1. Cullen, Pengon, Rattanajak, Chaplin, Kamchonwongpaisan and Mocerino, *ChemistrySelect*, 2016, 1, 4533 – 4538
Background
Research in the group is currently focused predominantly on lanthanoid coordination chemistry, with the aim to develop new materials for both applications and fundamental understanding. The work is underpinned by an interest in supramolecular chemistry, studying how molecules can be designed to interact selectively with a target species to produce something with useful properties. Projects can be adapted to suit student interests, with the opportunity to develop skills in chemical synthesis and a wide range of characterization techniques.

Honours Projects

**MIO1: Lanthanoid Complexes for Light Emitting Materials (with Max Massi, Mauro Mocerino)**

Lanthanoids have fascinating magnetic and light-emitting properties that lead to a range of current and potential applications. Despite all the research to date, some aspects of their behaviour are still not well understood. For example, while the processes taking place in systems that emit visible light have been made quite clear, emission in the near infrared is still something of a mystery that we are trying to solve. This project will require you to:

- Synthesize known and new ligands, that can act as an antenna for near infrared emitting systems, or form complexes with specific coordination geometries. Possible ligand systems include β-diketonates and calixarenes, amongst many other options.
- Synthesize and characterize lanthanoid complexes of selected ligands.
- Study the photophysical and/or magnetic properties of the complexes.

**MIO2: Calixarene Coordination Chemistry (with Max Massi, Mauro Mocerino)**

Calixarene-based ionophores are useful for a range of applications (e.g. ion selective electrodes), and fundamental science (e.g. metal cluster supporting ligands). We have developed new tetrazole-functionlised calixarenes, which have been found to support novel lanthanoid clusters. The way these ligands interact with other metal ions is not yet known.

This project will require you to:

- Synthesize and characterize calixarene derivatives with systematically varied structures.
- Study metal complexation with the calixarene ligands.

See [https://ogdenresearchgroup.wordpress.com](https://ogdenresearchgroup.wordpress.com) for references and more information.
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**Background**

My research interests lie in new synthesis of organic compounds, with an emphasis on biologically relevant molecules. I am also interested in the interactions of small organic molecules in biology for drug discovery and the agricultural industry. The projects offered will give you experience in a broad range of synthetic organic chemistry to solve problems at the biology-chemistry interface.

**Honours Projects**

**AP1: Plant growth hormones and unusual molecules**

Plant growth hormones are important in all facets of agriculture from increased production, reducing post-harvest waste to herbicides. Surprisingly, these hormones are simple molecules (e.g. ethylene) and their derivatives can be accessed simply through synthesis. The aim of the project will be to make interesting molecules that act as either agonists or antagonists of these hormones, with a focus on applications to reduce post-harvest waste or herbicides. The picture to the right shows the protective effect of an ethylene antagonist toward flower drop caused by ethylene.

**AP2: Natural products of native Western Australian plants**

The resinous coating of many Australian plants contains interesting compounds. This project will isolate and identify compounds, such as clerodanes, from the resinous coating of plants. Their chemistry will then be investigated concentrating on compounds with potentially interesting medicinal properties.

**AP3: Exotic Molecules**

There are many unusual or exotic molecules that have been overlooked by the chemical community. Some of these molecules probe our fundamental understanding of chemical principles and others are useful in making medicinally relevant molecules. Isocoronene (right) and 1,2,3-triazaazulene are molecules that have yet to be made with potentially interesting properties. Another exotic molecule is thiophene-1,1-dioxide which can be used to make medicinally useful compounds. It reacts as a diene in the Diels-Alder reaction (left). After a cycloaddition event, the resultant adduct spontaneously loses sulfur dioxide to generate a new diene, which can either react further in another cycloaddition event or be aromatised to a benzene derivative.
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Background
My research focuses on the development and application of computational techniques to study technologic and fundamental problems in the areas of chemistry, physics and geoscience. I am especially interested in studying the thermodynamics and kinetic aspects of the problems. Examples of my research interests include crystal growth, mineral chemistry and biomineralization.

PR1: Stability of amorphous minerals in aqueous environment
Minerals are ubiquitous materials that are relevant for many industrial and biological processes. The very existence of many marine organisms and vertebrates animals indeed heavily depends on the use of bio-minerals for protection (exoskeleton), movement (bones), feeding (teeth) and even orientation. Calcium carbonate is one of the most common bio-minerals and there is growing evidence that it is often stored in hydrated amorphous nanoparticles prior to its utilization. Amorphous materials are extremely difficult to characterize because of their intrinsic disorder and even more so at the nanoscale, which is beyond the resolution limit of many experimental techniques. Computer simulations therefore have the unique opportunity to provide atomistic insight into the structural and dynamical properties of these materials and assist with the interpretation of the experimental data.

PR2: Atomistic structure of the interface between two immiscible liquids
Solid-solid interfaces have been extensively studied and a lot is known about their mechanical and electronic properties, particularly for semiconductor materials. However, much less are known about liquid-liquid interfaces. This not due to a lack of scientific interest or importance, but because the ever changing arrangement of the atoms at the interface between two fluids makes it almost impossible to build any simple models that can be used to predict the properties of the interface. Due to the high mobility of the molecules the interface between two immiscible liquids is not sharp and fluctuates in time, which greatly reduces the ability of most experimental techniques employing light scattering or atomic force microscopy to identify the structure at the boundary. Here computer simulations can offer a unique insight into the molecular structure of the interface by providing an atomically resolved picture of the two fluids.
Discipline of Chemistry (MLS) – Honours Projects 2020

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Background
My research lies at the boundaries of physical, analytical and materials chemistry. My group uses electrochemical techniques to detect analytes such as toxic gases and explosives dissolved in liquid samples. We employ room temperature ionic liquids (RTILs) as electrolytes/solvents due to their extensive properties, such as non-volatility, high chemical stability, wide electrochemical windows and the ability to dissolve a wide range of compounds. Electrode surfaces can also be modified to enhance the analytical signals, for improved sensing applications.

Honours Projects

DSS1: Detection of Atmospheric Pollutants Using Low Cost Sensors (with Dr Sebastien Allard)
Air pollutants are any substances in the air that harm people or the environment. Air pollution is a health concern in Australia and around the world. The most common air pollutants are particulate matter (PM10 and PM2.3), ozone (O₃), nitrogen dioxide (NO₂), carbon monoxide (CO) and sulphur dioxide (SO₂). It is necessary to have sensors for these harmful gases so that steps can be taken to understand and inform strategies towards improving environmental air quality. In this project, you will characterise the electrochemical behaviour and analytical properties of two atmospheric pollutants – SO₂ and O₃ – in RTILs using low-cost, miniaturised sensors. Different RTILs and different electrode surfaces will be employed to find the best materials for gas detection. The results from this project will provide important information that can be used to design smart electrochemical sensors to monitor air quality.

DSS2: Electrodeposited alloy behaviour in ionic liquids and their application in sensors (with Prof Anthony O'Mullane, Queensland University of Technology)
Platinum (Pt) is commonly the best performing electrode surface for many electrochemical applications, but the high cost of Pt limits its long-term applications in devices. Different Pt structures can be produced by electrodeposition methods (see images below). By adding another cheaper metal to the plating bath, low-cost alloys can be produced, and may retain some of the desirable catalytic properties of Pt. Although alloys have been extensively studied in aqueous solutions, the behaviour of alloys in RTILs is relatively unexplored. In this project, you will deposit various alloys at different ratios and using different metals (e.g. platinum, gold, copper, nickel, palladium, zinc). These alloy materials will then be fully characterised, and employed to detect analyte species such as explosives or toxic gases (e.g. ammonia, hydrogen sulfide) to understand their analytical properties in RTILs.
Background
Chemistry Education is my area of research interest. My broad aim is to improve students’ perceptions and to develop capacity for real change in the depth of their understanding and enjoyment of Chemistry. This year’s projects are just suggested topics, and students who have a particular direction within these broad ideas will be given autonomy to direct the project to match their interests.

DS1: Disruptive or disrupted — what is the role of chemists and chemistry in the 21st century? Technology-led disruption of the workforce is a pressing issue for future employability, with up to 40% of the Australian workforce at significant risk of automation or mechanisation in the next 20 years.¹ Therefore, we must empower the next generation of chemistry graduates with an ability to identify opportunities for advancement of the profession. To achieve this requires a curriculum that supports the knowledge, skills and literacies to enable full participation in the future global workforce. This project will focus on the identifying the skills and knowledge in the chemical sciences that are required for future employment. We will chart the development of these skills throughout the curriculum and develop and evaluate the efficacy of modules designed to build them in a chemistry context.

DS2: Motivation and meaningful learning in chemistry
The primary learning environment in our first-year chemistry units at Curtin is a workshop, where students work together on activities, small assessment tasks, and present their findings to the class. The workshop environment is intended to foster positive student motivation toward meaningful learning. We know a little bit about student attitudes and self-efficacy in this environment,² but not much about how their motivational status might be supported and developed. This project will study students’ individual motivational statuses using two different models of motivation³ and link these to meaningful learning⁴ of chemistry concepts. The outcomes of this project will help us understand how we might support students’ motivations, and how this may be developed as a consequence of learning experiences.

Background
We conduct theoretical, methodological and applied research to improve understanding of soil processes and the drivers of soil and landscape variability at different spatial and temporal scales. Our research aims to quantify, assess and monitor soil functions, which help to deliver ecosystem services that enable life on Earth. The research that we do can help to: create sustainable landscapes and ecosystems, ensure sustainable food, fiber, water and energy production, improve nutrient management, monitor and verify soil carbon (C) sequestration, improve and rehabilitate degraded land, rehabilitate contaminated soil, mitigate climate change.

VR1: Disentangling the composition of soil organic matter with FT-IR and chemometrics
Soil organic matter (SOM) is a vital component of a healthy soil. It is important for soil physical, chemical and biological fertility. It comprises all living soil organisms and all the remains of previous living organisms in their various degrees of decomposition. Non-living organic matter can exist in various forms. It comprises both organic molecules of identifiable structure (proteins and cellulose), and molecules with no identifiable structure (humic and fulvic acids and humin) but which have reactive regions which allow the molecule to bond with other mineral and organic soil components. The aim of this project is to design an experiment to help identify which of these components of SOM might be quantified using infrared spectroscopy and chemometric methods.

VR2: Development of a diagnostic system for the rapid assessment of soil health
Soil health can be defined as the capacity of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. The aim of this project is to develop a ‘digital’ diagnostic system for the rapid assessment of soil health. First, a minimum dataset of key indicators of soil health will be identified and measured. Multivariate statistics will be used to derive the soil health indicators (SHI) for diagnosis. Second, the indicators and the SHI will be modelled with visible–near infrared spectra to derive the diagnostic system. The models will be derived using machine-learning methods. Finally, once validated, the models will use spectra to rapidly provide a (i) diagnosis, (ii) the proportion of false positive /false negative of the diagnosis and (iii) estimates of the causal factors that contributed to the diagnosis.

VR3: Modelling of soil organic C under climate change
Under climate change, soil organic C stocks increase or decrease due to complex interactions of climatic variables, soil type and land use. Here, it is important to improve the prediction of processes and factors that are responsible for the size and direction of changes in soil organic C. Using a soil C model and temporal data on soil organic C pools, this project aims to determine historical changes in soil organic C, to identify key factors affecting soil C dynamics, and to simulate the effects of various climate change scenarios with changing environmental and geophysical controls.
Background
My research area is chemistry education, or more broadly science education. My broad aim is to improve students’ perceptions of chemistry as well as their understanding of chemistry, particularly in a blended learning environment and through science inquiry activities. This is achieved by investigating how students learn chemistry, ways to foster student engagement and ways to improve their learning. Such investigations are also conducted using tools and methods in a rigorous fashion to ensure that results can be used and be of interest to a wide audience.

AY1: Student perceptions of creativity in STEM
There are many definitions of creativity. One can view creativity as the creation of an idea or object that is novel and useful. Creativity is an important aspect of human development and many of the world’s technological developments are a result of productive and innovative people. For this reason, many countries are reviewing science education programs and implementing new pedagogical paradigms that foster creativity\(^1\). This is due to declining enrolments in science courses, possibly because of a public perception that science is not a creative endeavor. Currently, attempts to reframe public perceptions focus on primary and secondary schooling. Limited research has been conducted at university level. This project aims to investigate university level STEM students’ perceptions of creativity, particularly how they believe creativity is used and/or needed in STEM fields. Data collection methods will include the collection of both quantitative data (surveys) and qualitative data (interviews).


AY2: Understanding students’ perceptions of different learning environments
As students progress through their university degrees, it is hoped that they develop a better understanding of themselves as learners and appreciate the different learning environments their lecturers create. For example, Curtin Chemistry utilises active learning environments in 1\(^{st}\) year through to 3\(^{rd}\) year with the view that students will develop the skills required to help them become lifelong learners. This raises many questions such as:

- Do students’ perceptions of active learning environments (or similar) change as they progress through their degrees?
- Do students in first year appreciate the efforts of their lecturers in creating such an environments? Or does an appreciation only eventuate in higher year levels.
- Can we do something more to help students appreciate active learning environments so that they gain the benefits (e.g. improved academic performance) of such environments?

This project will explore students’ perceptions of different learning environments at each year level to investigate ways in which students’ appreciation of such environments can be developed. Data collection methods will include the collection of both quantitative data (surveys, concept tests, exam performance marks, etc) and qualitative data (interviews, observations, dialogue recordings, etc).